Summer 8-24-2015

Women Workin' It in GIS: A Mixed Methods Study of Underrepresentation and the Gendered Experience among Female GIS Practitioners

Livia M. Betancourt Mazur
CUNY Hunter College

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A Mixed Methods Study of Underrepresentation and the Gendered Experience among Female GIS Practitioners

by

Livia Betancourt Mazur

Submitted in partial fulfillment
of the requirements for the degree of
Master of Arts in Geography, Hunter College
The City University of New York

2015

Thesis Sponsor: Jochen Albrecht

7/20/15	Jochen Albrecht
Date	First Reader
7/20/15	Niem Huynh
Date	Second Reader

ABSTRACT

Research points to the underrepresentation of women in scientific and technological professions. While a gender imbalance has also been assumed to exist in the realm of professional geographic information systems (GIS), no data existed to corroborate it. The original survey presented herein was developed by the thesis author to add both quantitative and qualitative research about the numbers and current experience of women in GIS to GIS professions-focused literature, as well as to academic geography and wider science, technology, engineering and mathematics (STEM) discourses, to address gaps in these bodies of knowledge. Four hundred and eighty-four female participants completed the survey providing a healthy sample size and a reliable and informative dataset.

A key finding of this thesis is that women are, overall, not grossly underrepresented in the GIS workforce. By extrapolating the numbers reported by survey participants of their GIS departments to the GIS field at large, it has been found that the GIS professional workforce, in general, is 42% female, which might be considered a healthy representation. However, this does not mean that underrepresentation in more specific areas or that other gender equality issues are not present. For example, survey results show that women in GIS are more underrepresented in certain sectors. The survey further reveals that the participants use a higher proportion of "soft" versus technical skills in their current positions, which suggests that there might be a trend of women in GIS being found more in certain types of positions. The survey also asked participants if they perceive an underrepresentation, and the findings from this and other related questions further point to the possibility that even though gross underrepresentation is not present, other conditions of imbalance exist to create such perceptions. However, despite these potential imbalances, it was found that the participants generally do not face the same obstacles, or at least not to the same degree, as women might in other STEM fields. Based on the research findings, GIS seems like a good field for female participation, with its good work-life balance, strong sense of community, opportunities for networking and mentoring, and importance placed on continuing development.

The data collected as part of this thesis can further add credibility and depth to conversations about diversity in GIS. It is also hoped that this thesis will have practical end uses such as serving as a starting point from which to create career and professional development tools specifically geared towards women pursuing GIS careers. There are many reasons why it is important to enhance gender, as well as racial and ethnic, diversity in GIS. Increased diversity in GIS will enhance women's career opportunities and will also strengthen the discipline through the inclusion of diverse perspectives and approaches. As GIS is both a discipline and a tool that is utilized to deal with a variety of real world issues that affect people, the field of GIS should reflect the diversity of the world at large. Greater diversity in GIS will generate GIS solutions that take diverse viewpoints into account and that will therefore be more equitable and sound.

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I. Introduction

A. Primary research questions and objectives of this project

This thesis grew from two original research questions. The first asks whether there is an underrepresentation of women in the geographic information systems (GIS) professional field, and the second whether women in GIS have experienced gender-based obstacles to career success. It presents original empirical research conducted by the thesis author along with an analysis and interpretation of the results.

In order to be able to answer the research questions that are part of this thesis, the first project goal was to address the lack of relevant data, as there were no existing, publicly available datasets that captured this information. The National Science Foundation (NSF) and Department of Labor (DOL) have compiled many related statistics but it was impossible to extract GIS specific data (see commentary below). Collecting data specifically about women in GIS was important in order to create the first such dataset of its kind. The original data and its analysis presented in this thesis have broad implications beyond this thesis. The first implication is that the data can be used by researchers to answer related questions. The second implication is that the novel research may serve as a foundation to refine future research efforts. The third implication relates to developing a dataset that plays an important role to credibly answer the question of whether, in fact, there is an underrepresentation of women in GIS.

The project's second objective, concerning the experiences of women in GIS careers, addresses deeper and more provocative issues. The confirmation or negation of the hypothesis that there is an underrepresentation of women in GIS would only be worthwhile if it is used to explore related, meaningful concerns. For example, if there is an underrepresentation of women in GIS, how does

that impact the women who participate in the field? If there is not an underrepresentation, are there factors that create a perception and discourse of underrepresentation? What are the experiences of those women who forge paths in the field, and what can we learn from their experiences to make it easier for future participants? Are the experiences of women in GIS similar to those of women in other technical fields? Why or why not?

B. Major hypotheses

Primary research question #1: Is there an underrepresentation of women in the GIS professional sphere?

Primary research question #2: Do women in GIS experience gender-based obstacles to career success? What are the experiences of women in GIS?

Hypothesis #1: Yes, there is an underrepresentation of women in GIS.

Hypothesis #2: It is likely that women in GIS have experienced gender-based obstacles to success. However, it might be that GIS has unique characteristics that distinguish it from other male dominated fields, such as information technology (IT), and which might make female participation in GIS distinct from those fields.

C. Rationale and justification for the research study

Currently, what is known about female participation in the GIS field is largely ad hoc and there are no data that support discussions about this topic. One rationale for the thesis is that the creation and analysis of relevant data will provide the necessary information to support and further enrich conversations regarding women in GIS. In addition to the lack of data, no academic literature was found during preliminary research that specifically addressed the contemporary experience of

women in the *professional* GIS field. One of the purposes of this study was to address this absence. While there is considerable literature on women in STEM (e.g., Blickenstaff 2005; Beede et al. 2011; Hill, Corbett, and St. Rose 2010; Nosek, Banaji, and Greenwald 2002; Xu 2008; Zeldin, Britner, and Pajares 2006), as well as related work on increasing diversity in the discipline of geography (e.g., Domosh 2000; Mcewen et al. 2008; Silva 2010; Solis and Miyares 2013; Solis et al. 2014), there was both a lack of concrete data on the number of women who work in GIS as well as academic works that examine the issues surrounding female participation in professional GIS. This thesis will add both quantitative and qualitative research and writing to GIS professions-focused literature, as well as to academic geography and wider science, technology, engineering and mathematics (STEM) discourses, in order to address gaps in these bodies of knowledge.

Within the longstanding conversations of enhancing diversity, whether in STEM fields or in geography, enhancement within the educational system takes center stage. The main concern of these conversations is to promote diversity in K-12 and in higher education. However, academic conversations on diversity tend to exclude the experiences of those women who pursue professional careers outside of academia. This thesis, in addition to adding valuable research on women in GIS, also extends the discussion of diversity beyond students and academics to encompass the professional workplace.

There is an ample body of literature, which has emerged from feminist geography, on qualitative and mixed GIS methods and on feminist or alternative research applications of GIS (e.g., Elwood 2008; Gilbert and Masucci 1999; Kwan 2002; Pavlovskaya 2009; Schuurman 2002). Interestingly, while much of this work posits that GIS is a useful tool in exploring the experiences of female research objects and other topics related to female or gendered experience (e.g., Gilbert and Masucci 1999; Kwan 2002; Schuurman 2002), there is a lack of research that investigates if women

are equally participating as professional practitioners of GIS and that critically examines the nature of their experience in the field. Pavlovskaya's and St. Martin's "Feminism and Geographic Information Systems: From a Missing Object to a Mapping Subject" (2007) and Schuurman's "Women and Technology in Geography: A Cyborg Manifesto for GIS" (2002) are the only papers encountered that directly talk about women who conduct GIS research and who are GIS practitioners. While feminist geographers' inroads into the issue of who GIS is for, or who can use it as a tool, are powerful and important efforts, a significant additional step needs to be taken in asking the questions that are involved in this thesis. This thesis explores this gap in the existing body of knowledge within the feminist geographic framework.

In addressing the gaps mentioned above, the thesis author hopes that the information presented in this thesis will be used to inform and extend existing efforts to increase the diversity of those pursuing STEM and/or geography studies within the educational system. After all, what good is enhancing the diversity of those who pursue technically oriented education if they experience barriers and disadvantages when they graduate and enter the workforce? The thesis also complements feminist geography research by identifying women as GIS professionals and examining their experiences, thereby accomplishing the task of viewing women as suitable "objects" of research as well as "*subjects"* who perform GIS work (Pavlovskaya and St. Martin 2007).

Also noteworthy is that despite the alignment with computer science and other STEM fields, and even though GIS is beginning to be embraced in STEM conversations, GIS seems to be more anecdotally included in these disciplines' diversity discourses. In the various tables and reports from the NSF and the DOL initially reviewed for the thesis, GIS is not presented as its own category in their occupation or discipline breakdowns. GIS is probably included in many of the categories in the studies reviewed, but nowhere is it directly named. While GIS is recognized as being connected

to STEM, this needs to be reflected more overtly. Given that GIS straddles the geography and STEM worlds without being exclusively part of either puts it in an awkward position – both areas of existing research, literature, and efforts partially apply to GIS, but not perfectly so. This division, and the fact that GIS is a field in its own right, means that GIS requires its own investigation regarding issues in diversity.

The thesis author believes there are practical applications for end uses of the thesis such as serving as a starting point from which to create career and professional development tools specifically geared towards women pursuing GIS careers. For example, in their book *Women Don't Ask: The High Cost of Avoiding Negotiation – and Positive Strategies for Change*, Linda Babcock and Sara Laschever not only provide research findings of why women rarely negotiate in their personal and professional lives, but also give concrete advice on how women can better approach and conquer negotiation. The findings of this thesis, too, may be translated and employed for similar ends.

Lastly, there are many reasons why it is important to address the underrepresentation of women in GIS and, ultimately, to enhance gender (as well as racial and ethnic) diversity in GIS. Increased diversity in GIS will enhance women's career opportunities and will also strengthen the discipline through the inclusion of diverse perspectives and approaches. As GIS is both a discipline and a tool that is utilized to deal with a variety of real world issues that affect people, the field of GIS should reflect the diversity of the world at large. Greater diversity in GIS will generate GIS solutions that take diverse viewpoints into account and that will therefore be more equitable and sound.

D. Overview of research design

The process of completing this thesis involved conducting a literature review, undertaking a pilot study with key informants, designing and widely disseminating a survey, and finally analyzing the results to build the narrative of the core chapter of this thesis.

- **Literature review:** Existing studies and articles in other STEM disciplines were reviewed. The literature review helped to conceptualize and provide a foundation for the design of the empirical research presented herein.
- **Pilot study:** Face-to-face and phone interviews with nine key informants (women in GIS of different backgrounds and with different amounts of experience, focusing on women with a significant amount of experience), along with informal discussions with two consultants, were conducted to inform how the survey should be designed. As the literature review only focused on other STEM disciplines, the pilot study helped to bridge any gaps in information and to help make the survey more appropriate and relevant for GIS participants.
- **Survey:** The questions were drafted and reviewed, and the survey itself was designed and constructed using the on-line tool SurveyGizmo. The survey was announced by general invitation sent through various geography, GIS, and other related listservs, as well as promoted via social media networks by both the thesis author and by invitees.
- **Analysis:** Once the survey results were collected, statistical analysis was performed, including breaking down the survey population into different survey participant categories. Open text analysis was also performed on comments and any other open text questions.
- **Interpretation and discussion:** Overall survey population and survey participant category results were woven into a cohesive narrative.

II. Literature Review

A. Introduction

Despite efforts made by theorists, policy makers, and the actual women who enter STEM career fields, gender parity has not been achieved. According to a 2013 report published by the United States Census Bureau, "Although women make up nearly half of the working population, they remain underrepresented in STEM occupations. In 2011, 26 percent of STEM workers were women and 74 percent were men" (Landivar 2013, 5). There is a body of literature that is dedicated to exploring this fact and the issues behind it. Much of that literature includes four basic lines of reasoning, which provide the structure to this review:

1. Why is it important to increase the number of women working in STEM?
2. Why are women not significantly represented in STEM?
3. What is the status of those women who do work in STEM?
4. How can both the relative absence of women in STEM, as well as problems with the status of those women who do work in these fields, be addressed?

First, why is it a problem that women are underrepresented? Why should women be more included and better represented? Most discussions begin by specifying what constitutes this "why." It is important to pay attention to each author's explanations because this is the element that gives credence and relevancy to the rest of their discussions.

The second element that is presented in most literature is a second "why": why are women not significantly represented in science and technology? It is not a question of why is it important to investigate underrepresentation, but of why it exists. Questions such as why are science and

technology fields inhospitable environments for women or why does science and technology fail to attract women are examples of this second line of questioning.

The third major element in the body of literature looks into the status of those women who currently work in STEM and why, due to uneven numbers and other related factors, they face gender-related challenges. Examples of the types of questions that emerge here include: why are there poor retention rates in the science and technology careers of women; and what are the barriers that women face, not in entering the field, but in navigating and progressing in their careers?

There is a close connection between the reasons that women are not significantly represented in STEM and the status of those who do work in this field. Literature often examines these two questions simultaneously due to the fact that aspects that bar women from entering STEM fields are often one in the same as those that challenge them once they do participate.

The information learned by examining the three elements mentioned above might yield answers on how to address female underrepresentation in STEM, which is the fourth element uncovered in the literature. The first three elements are interconnected, inform one another, and can help point to possible solutions. However, authors' observations about these issues are not always directly expressed as actionable solutions. The conclusion of this literature review is concerned with how the literature helped shape the current thesis study into a body of evidence that can be used to work on concrete solutions. It takes into account authors' recommendations for how research about women in STEM should be approached and synthesizes the general ideas presented.

Since there is little or no literature specifically about women in GIS professional career tracks, the present review relies upon literature regarding women in STEM occupations. Due to GIS's alignment with, and partial basis in, computer science, and the potentially stronger similarity between GIS and IT careers, this review is grounded in and draws more heavily from IT literature.

B. Literature element 1: Explanations of why it is important to increase the number of women in STEM careers

Why is it important to have more women working in STEM fields? Is it simply a matter of equity? Should the motivation be to benefit women and provide them with more opportunities to pursue career paths from which they have traditionally been excluded? Should women not have equal access to the well-paid positions in the IT field (Adam et al. 2006)?

While these seem like straightforward and fair reasons for increasing diversity, equity arguments are not typically employed by the authors of contemporary diversity literature, who instead present different reasons for increasing women's representation in STEM fields. Some are economic in nature (Glover 2002). One idea proposed is that given the shortage of skilled workers in STEM, women and minorities represent an untapped resource (Adam et al. 2006; Ahuja 2002; Beede et al. 2011; George et al. 2001; Sonnert 1999; Trauth 2002). Not only are women a potential resource, but the existing "skills crisis" could even be partially attributed to the lack of inclusion of women and other demographic groups in STEM fields (Trauth 2002, 98). "In Pursuit of a Diverse Science, Technology, Engineering, and Mathematics Workforce," a report written in 2001 by the American Association for the Advancement of Science with support from the NSF, proclaims: "Today the United States is the world leader in the global science, technology, engineering, and, mathematics (STEM) enterprise, but other countries stand ready to challenge this economic strength. One of the main reasons is a shortage of U.S. workers to fill STEM jobs" (George et al. 2001, 2). At the time,

non-U.S. citizens, working on H-1B visas, filled this labor shortage in the U.S. (George et al. 2001). However, according to the report, as other countries become more involved in STEM industries, "this supply of talent could dwindle" (George et al. 2001, 2). Another forecast described in the report predicts that "By 2050 white males are projected to be 26% of the overall workforce," implying that fewer males in the labor pool will further necessitate drawing from the women and minorities who increasingly participate in the labor force (George et al. 2001, 2). According to George et al., underrepresented minorities and women "provide an untapped reservoir of talent that could be used to fill technical jobs" (2001, 2).

The alleged shortage of skilled STEM workers in the United States is puzzling when examined next to 2011 figures from the U.S. Census Bureau that reveal the proportion of employment in STEM versus non-STEM occupations by those holding bachelor degrees in STEM disciplines. According to these figures, only a quarter of men and women with science and engineering bachelor degrees work in STEM (Landivar 2013). Furthermore, when comparing those with STEM degrees who pursue or obtain employment in STEM by sex, the idea of a "skills crisis" and the notion that women could fill that shortage is even more perplexing. Eighty-five percent of women and 70% of men with science and engineering bachelor degrees *do not* end up working in STEM (Landivar 2013). The rate at which both women and men educated in these STEM disciplines do not continue onto STEM careers is staggering, but among women this phenomenon is even more pronounced. These numbers suggest that there are perhaps other issues beyond a shortage of skilled labor – both men and women who are trained in STEM, and who could fulfill the purported scarcity of skilled workers, end up pursuing careers in other fields. Why is this the case? Is their education not appropriately preparing them to enter STEM careers? Is there a lack of opportunities, or are there other barriers to entry?

Labor shortage arguments to increase the participation of women in STEM may not only be implausible, as the statistics above suggest, but may also have other potentially serious flaws. If there is indeed a dearth of skilled STEM workers, then what will happen at some future date when such a shortage has been addressed and there is an ample supply of skilled labor? If women and minorities are seen purely as a stopgap and nothing more, could it be that eventually businesses would lose interest in them once the stopgap is no longer needed? Furthermore, is increasing the supply of skilled women without addressing other possibly unsound policies in the workplace or other issues women face in their careers a truly effective approach? What is the use of increasing the supply of female workers if, once in the field, many leave or are unable to realize their full potential due to factors that inhibit their career progression? Or, what if those women who are trained in STEM do not even continue on to STEM careers in the first place? The Census Bureau statistics above that show that only 15% of women with STEM bachelor degrees continue onto STEM careers highlight the need to answer these questions (Landivar 2013).

The issue of seeing women and minorities as a resource to fill the need for skilled workers is spoken to in Sally Kohlstedt's paper "Sustaining Gains: Reflections on Women in Science and Technology in the 20th Century United States," in which she documents strategies developed by women scientists in the early 20th century to create inroads into science (2004). Kohlstedt posits that understanding the history of women in science is important, not only to shed light on the current situation of women in science, but also to develop a strategy to continue to improve their status (2004). She discusses the status of women in science and engineering during World War II and says, "While the war had raised expectations with its call for "manpower," and companies like Curtiss Wright had recruited women for engineering posts during the war years, within just a few years those women who did work in strategic scientific and technology areas were out of work and back at home" (Kohlstedt 2004, 11; also see Bury 2010 on the first female computer workers during

WWII). This historical example illustrates how arguing for increasing women's participation in science and technology due to a shortage of skilled workers is problematic. If women are called to fill roles because of an alleged shortage, eventually, when there is no longer a shortage, will women be the first to be eliminated?

There are other economic arguments that advocate for increasing the number of women in STEM. Judith Glover, in her 2002 article "Women and Scientific Employment: Current Perspectives from the UK," examines factors affecting the significant underrepresentation of women in science fields in Europe in the mid to late 1990s. Glover's paper calls for the collection of more quantitative and qualitative data on women in science to better understand this underrepresentation, not only by academic researchers but by businesses as well (2002). Glover expresses that in order for businesses to be motivated to collect the needed data, convincing reasons need to be given to drive motivation and action (2002). Pondering how to appeal to the business community, Glover wonders if the following economic arguments might be useful: are businesses "incurring financial losses because they are not retaining particular social groups to whom they have devoted training resources" (Glover 2002, 40-41)? Additionally, companies investigating the reasons for the poor retention of certain employees might lead them to implement better workplace policies that might eventually enhance their profitability (Glover 2002).

Getting businesses on board with collecting more data on women is important. Additionally, providing reasons for business leaders to embrace the collection of such data is also vital. To that end, getting businesses to see their female employees as valuable assets and investments that they do not want to lose seems like a good idea. Nonetheless, there could be unintended outcomes in using only economic arguments in appealing to the business community. What if companies determine that, in fact, they can attain greater profitability without actively seeking to improve

female participation? What if the effort of collecting data and translating that data into policies proves to be less profitable than the alternative of maintaining the status quo?

Another group of arguments in the quantitative category includes the statistical comparison of women in STEM with women in the general workforce. Frequently cited recent statistics that frame the issue show that women make up about half of the overall workforce in the United States while they only make up about a quarter of the STEM workforce (more generalized proportions as well as specific statistics for STEM subfields are also indicated) (Beede et al. 2011; Heilbronner 2012; Landivar 2013; Orser, Riding, and Stanley 2012). The argument is that if women account for half of the workforce, then STEM, in general, as well as top-level managerial and technical positions within STEM, specifically, should reflect the overall labor picture (Ahuja 2002; Beede et al. 2011; Cross and Linehan 2006). If women are well represented in other labor fields then there must be something amiss in STEM if those fields do not mirror the larger workforce. In their article on women in the Irish high-tech sector and the barriers they face in gaining high-level executive or technical positions, Cross and Linehan cite 2003 statistics that show that out of the world's 2.8 billion workers, 40% were women (2006). While these figures portray a vision of nearly equal participation in the global workforce, upon closer investigation, there is a significant lack of women in top-level positions in Ireland (Cross and Linehan 2006). Citing another study, they report that in Ireland only 8% of chief executives and 21% of senior managers were women (Cross and Linehan 2006). Similar disparities are revealed for the United States by 2013 and 2014 statistics from the DOL. The 2014 DOL figures show that women (16 years and over) make up 52% of the U.S. civilian population and 47% of the overall labor force. However, only 26% of chief executives are women (Department of Labor 2014a). Additionally, computer and IT occupations are similarly unrepresentative of the rest of the U.S. labor force – for example, in 2013 women accounted for 29% of computer and information systems managers, 35% of computer systems analysts, and only

8% of computer network architects (Department of Labor 2013). Just as the literature suggests, labor statistics for the United States show that both IT occupations and executive level positions do not mirror the larger labor picture.

Another interesting point that Cross and Linehan bring up is that the high-tech sector in Ireland was relatively new. As of 2006, when they authored their paper, that sector had been established 15 years previously. Cross and Linehan explain that because the high-tech sector had developed after many gains had been made in women's participation in the labor force, it was expected that it would be a "genderless environment in which female managers would emerge in equal numbers to their male counterparts" (Cross and Linehan 2006, 28; also see Ahuja 2002). However, through the statistics that they reference and their research involving interviews with female managers in the Irish high-tech sector, they find that despite the relative newness of this field, previous workplace gender norms were upheld and the environment was far from "genderless" (Cross and Linehan 2006). This is an interesting point to make because despite any prevailing optimistic beliefs about the innovative nature of technology and the professional fields and cultures from which technologies arise, in combination with the fact that women have been actively engaged in the labor force for decades, the diverse workforce that might logically be expected to arise given these two conditions still does not exist.

What are the stubbornly persistent norms and conditions that prevent such diversity in STEM career fields? An example of the conditions that perpetuate the status of women in STEM, despite their active engagement in the labor force, is vertical and horizontal segregation. This can be generally described as the pattern of women being more prevalent at lower levels and in less technical positions, as well as being clustered into certain disciplines and not others (Blickenstaff 2005; Glover 2002; Heilbronner 2012; Kohlstedt 2004; Prescott and Bogg 2011; Sonnert 1999).

The examination of the patterns of clustering and of the exclusion of women from certain niches and ranks is, in part, born of the authors' attempts to better understand the perplexing labor force patterns discussed here. Vertical and horizontal segregation are further discussed throughout the thesis.

Socio-cultural and philosophical arguments are very different in nature from the economic arguments, and could add the needed depth that some economic arguments lack. One contention is that career fields and disciplines themselves could benefit from increased diversity (Adam et al. 2006; Ahuja 2002; Blickenstaff 2005; Glover 2002; Singh et al. 2007; Sonnert 1999). That is, the inclusion of more diverse workers will yield better approaches and novel solutions to research in science and technology. Research agendas and the connection between science and society could improve with the inclusion of a "larger spectrum of society" (Glover 2002, 40). Additionally, "public awareness" of science and its public image could be improved by the fostering of greater female participation (Glover 2002, 39).

Crucial to the idea that STEM disciplines themselves could benefit by including a greater diversity of people is the notion that science is socially constructed (Sonnert 1999). Adding females to the science community would "balance" this construction of what science is (Sonnert 1999, 36). While these ideas might not be readily accepted by all, there are perhaps certain aspects that could be more easily embraced:

> One does not have to be a relativist or social constructionist to see advantages in diversity: The presence of a diverse group of investigators tends to widen the range of topic choice. It also appears to create more varied hypotheses. Finally, it may accelerate the speed with which collective blind spots are scrutinized and eliminated—blind spots that otherwise might linger on for a longer time in a homogeneous research community that shares certain unquestioned preferences and prejudices. (Sonnert 1999, 36)

As long as women are significantly underrepresented in STEM fields, do STEM areas suffer from the loss of contributions that could be made by smart, gifted women who opt to pursue educations and careers in other disciplines (Blickenstaff 2005; also see Rosenbloom et al. 2008)? As indicated in the Census Bureau statistics shown above, 85% of women with a science or engineering undergraduate education do not work in STEM (Landivar 2013), showing that there are indeed more talented women who could be making contributions to STEM.

Regardless of the lines of reasoning employed by authors in answering why the underrepresentation of women in STEM should be addressed, the underrepresentation itself poses an interesting puzzle that is worthy of examination and unraveling. "Given the importance of these technical fields in our modern economy, and the rapid expansion of employment opportunities in technical occupations, the dearth of women in these areas is puzzling from an academic perspective" (Rosenbloom et al. 2008, 544). The following section looks at authors' attempts to explain this perplexing dearth.

C. Literature elements 2 and 3: Underrepresentation and problematic participation of women in STEM careers

The underrepresentation of women in STEM fields is not simply a matter of inferior numerical representation, or about the women who are not yet included; it is also about those women who are already working in the field. Furthermore, the challenges of women who currently work in STEM are closely connected to the barriers that prevent women from entering STEM careers and that are the underlying causes of women's underrepresentation. The literature reviewed shows that women face unique, gender-based challenges throughout their STEM careers. Merely increasing the number of women working in STEM fields will not solve the issue of underrepresentation. It is

also necessary to understand the challenges faced by women currently active in STEM fields and to address them with effective solutions.

This section looks at these two interconnected elements from the literature. As mentioned previously, the literature often handles these two questions together because explanations and descriptions for women's numerical underrepresentation as well as their participation in STEM fields contain conceptual overlaps. However, since the original research that is part of this thesis study is more concerned with gathering information about women who currently work in GIS, this review places more emphasis on investigations into the status of women working in STEM and the factors that condition that status.

First, the landscape of women working in STEM fields is described and then specific barriers that are both part of and that shape the landscape are detailed.

1. Patterns of participation – vertical and horizontal segregation

The literature shows a predominant pattern in both the STEM education and careers of women, in which the higher up the organizational structure one looks, the fewer women one encounters. Many different metaphors and terms are employed to describe this phenomenon – the leaky pipeline, the pyramid structure (Ahuja 2002), the glass ceiling, and vertical (and horizontal) segregation. The leaky pipeline is most often applied to the STEM educational context, describing how even with a relatively abundant supply of female students entering post-secondary STEM programs, their participation nonetheless progressively falls off at higher degree levels. This paradigm holds true for women's participation in academic and non-academic careers, in which fewer females enter STEM career streams due to leakage from the pipeline. Furthermore, as women climb the STEM career ladder, their numbers continue to dwindle.

The leaky pipeline and the glass ceiling, in combination with other barriers and patterns unique to women's participation, work together to create the vertical and horizontal segregation of women at the professional level. In addition to vertical and horizontal segregation describing the pattern of women being less prevalent in highly-technical and high-level executive positions, it also refers to women being found more predominantly in certain STEM disciplines as opposed to others (Blickenstaff 2005; Glover 2002; Heilbronner 2012; Kohlstedt 2004; Prescott and Bogg 2011; Sonnert 1999). Glover explains, "In horizontal segregation, women and men are concentrated in distinctive scientific fields. In vertical segregation, women and men within the scientific fields are not distributed equally in the hierarchy of jobs, with women typically being concentrated in the lower-level jobs and men in the higher-level ones" (2002, 29). Glover's explanation can be extended to other STEM areas as well.

Horizontal segregation, or the clustering of women in certain professional careers, sectors, and academic disciplines, is evidenced by statistics. In regards to the STEM professional sphere in the United States, "In 2011, women were 13 percent of engineers, 27 percent of computer professionals, 41 percent of life and physical scientists, 47 percent of mathematical workers, and 61 percent of social scientists" (Landivar 2013, 5). Utilizing 2009 data from the American Community Survey, the U.S. Department of Commerce, Economics and Statistics Administration (ESA), uncovered similar information regarding STEM workers and their field of degree. They found that out of 2.5 million female STEM workers, 18% had engineering degrees while 57% had physical and life sciences degrees (Beede et al. 2011). This can be compared with the 6.7 million male STEM workers of whom 48% had engineering and 31% had physical and life sciences degrees (Beede et al. 2011). It was also found that women with STEM degrees "are twice as likely as men to work in

education or healthcare. Nearly one in five STEM college-educated women works in healthcare occupations, compared with about one in ten men" (Beede et al. 2011, 6).

Next, looking at vertical segregation helps to drill deeper into the STEM landscape, going beyond identifying the fields in which women work, to looking at the types of roles they occupy. Vertical segregation can also be conceptualized as what another author terms the "pyramid structure," in which women are found in increasingly smaller numbers at top managerial levels as well as in advanced technical positions (Ahuja 2002). In the pyramid structure within IT in the UK, it is more common for women to undertake more "routine and specialist work," in contrast to men, who are much more often found in management and more highly technical roles (Ahuja 2002, 21; also see Orser, Riding, and Stanley (2012) who describe a similar situation for women in the advanced technology sector in Canada). Vertical segregation is also present in the IT sector in Ireland, with women more frequently occupying more traditional female roles, such as support staff or other "unskilled" roles (Cross and Linehan 2006). Similarly, in science fields in the UK, women are more likely than men to be in roles for which they are overqualified, such as technicians or teachers, in their "first destinations" of employment (Glover 2002, 32). Additionally, in academia, women are "overrepresented in researcher positions, which in the UK are typically short-term and relatively poorly-paid" (Glover 2002, 34). Regarding the IT industry in the UK, Ahuja reports that, "In 1990, 86% of all data-entry clerks were female…. 10% of males and only 3% of the females in the survey had achieved senior managerial positions. Research in the UK and US was consistent. In the US, in 1990, 34% of computer programmers, 33.7% of systems analysts (US Department of Labor, 1975-1990) and only 5% of upper management slots in IT industry are estimated to be occupied by women" (2002, 21). More recent DOL statistics for the United States from 2013 and 2014 correspondingly show that 79% of data entry keyers were female (Department of Labor 2014c), whereas they made up only 35% of computer systems analysts (Department of Labor 2013), and

only 21% of computer programmers (Department of Labor 2014a). Another example of vertical segregation is that "only 5% of chief technology officers in Fortune 100 IT companies are women" (Klawe, Whitney, and Simard 2009, 70).

Vertical segregation not only impacts the types of roles women occupy, but also underlies the pay gap between men and women in the same position status (Ahuja 2002; Glover 2002; Prescott and Bogg 2011). In the United States, for example, computer programmers are categorized as one of the top 25 highest paying occupations, yet women's earnings as a percentage of men's is 87% (Department of Labor 2014a). For STEM in general, there is a 14% wage gap between men and women as shown by 2009 statistics – "for every dollar earned by a man, women in STEM earn $0.86" (Beede et al. 2009, 4).

Beyond simply describing what the pyramid structure looks like, Ahuja also puts forth some ideas that might partially explain that structure (2002). Essentially, she outlines what she calls the "stage model of barriers" where a woman's career is comprised of distinct stages (Ahuja 2002). At each stage there are unique, albeit similar, barriers that combine in myriad ways, and as a woman's career path unfolds, the barriers might actually intensify (Ahuja 2002). Different barriers might become more pronounced at later career stages and therefore be more likely to interfere with a woman's success, contributing to the pyramid structure (Ahuja 2002). In addition to the characteristics of STEM fields that pose particular challenges to women, there are also characteristics of their own lives and career development that shape their experiences (Ahuja 2002). Ahuja (2002) finds it useful to break women's life and career paths into stages in order to better understand the challenges they face as they commence and then navigate through their careers, a model employed by other authors as well (for example, see Castaño and Webster 2011 and Glover 2002). In Ahuja's model, a woman moves from the career choices stage to the

persistence and advancement stages while progressing through her IT career (2002). The career choices stage happens "during university education and entry-level jobs" and is characterized by the "'likelihood that a woman will choose IT as a career'" (Ahuja 2002, 22). The persistence stage is characterized by the occurrence of a life event or significant factor, such as beginning a family, which may come in the way of a woman persisting in her job; Ahuja describes this as "the likelihood of not dropping out" of the workforce (2002, 22). Lastly, the advancement stage is "comprised of the later years of one's career during which job status and salary become yardsticks of one's overall career performance. Career advancement is the 'likelihood that a woman will advance in her career in the field of IT'" (Ahuja 2002, 22-23). This type of a stage-based analysis might be useful for understanding, at least in part, what drives vertical segregation. Glover describes very similar career stages, and her discussion of vertical segregation is partially connected to the idea that a woman's life and career have stages that interact with one another (2002). She talks about how much more likely women are than men to leave their jobs within the first two years of employment, often to have children, and that such women often tend not to return to their jobs (Glover 2002). One can deduce that interrupted or abandoned careers create a situation in which women are not progressing to higher-level positions.

An idea uncovered in the literature is that vertical segregation might be, in part, "self-imposed" (Cross and Linehan 2006) or that women "self-select" themselves into certain roles (Ahuja 2002). A "self-imposed glass ceiling," might occur through a woman's "individual choice" when she does a "cost-benefit analysis" of the detriments and gains in advancing to higher levels of management (Cross and Linehan 2006, 37). What aspects of women's personal lives must be sacrificed (for example, work-life balance) to take on certain roles (Cross and Linehan 2006)? These considerations are a major force that might inhibit women's upward mobility (Cross and Linehan 2006). Additionally, "the variety of roles that women assume – wife, mother and caretaker – during

peak periods of their professional and academic careers…. Often result in self-selection into gender-typed professions and positions within professions" (Ahuja 2002, 22). A few other authors describe the conditions that come along with vertical segregation, and one might connect these discussions to ideas about the "self-imposition" of a glass-ceiling, or women's self-selection into certain roles. For example, the IT workforce is predominantly white and male, as well as being competitive and individualistic, all of which serves to increase the vertical divide already present (Tapia and Kvasny 2004). IT workers are expected to prioritize their work life and technical expertise over all other things in their lives (Tapia and Kvasny 2004). Furthermore, those women who do make it to higher management positions within IT often feel highly marginalized, as they are among very few women in such positions (Wentling and Thomas 2009). These points are examples of possible factors that women might take into account when considering taking on high-level, managerial positions – could these conditions dissuade women from *choosing* to become managers? While it seems likely that this might be the case, there are potential flaws with subscribing to the ideas of a "self-imposed" glass ceiling. It is important to view women as autonomous actors who are active in making decisions about their career paths. However, does saying that there is an element of "self-imposition" place undue blame on women and deflect attention away from other possible factors? Furthermore, perhaps women would not be making certain choices if better alternatives were available to them. These discussions suggest that self-selection is a topic requiring a great deal of sensitivity.

"Hybrid" jobs constitute another theme uncovered in literature on women in IT (Guerrier et al. 2009; Roan and Whitehouse 2007), and one that is useful to discuss in parallel to a consideration of gendered roles and disciplines. The theme of "hybrid" IT jobs is one that enters gender diversity in IT literature in the 2000s. Hybrid roles are those that require a mix of technical and interpersonal skills (Guerrier et al. 2009; Roan and Whitehouse 2007). They are described as being a potential

entry-point for women into the IT workforce due to the interpersonal skills women purportedly possess or have had more opportunities to draw upon (Guerrier et al. 2009; Roan and Whitehouse 2007). While hybrid roles have been touted as potential solutions to the underrepresentation dilemma, in fact these jobs seem to have merely propagated the already prevalent biases of the IT field (Guerrier et al. 2009; Roan and Whitehouse 2007). "'Technical, but Not Very….': Constructing Gendered Identities in IT-Related Employment," by Guerrier et al. (2009) discusses the recruitment methods and the design of jobs geared towards attracting females by incorporating the more recent notions of hybrid IT jobs. These jobs require more "soft" skills such as communication, the ability to empathize (largely with clients), and alternative modes of leadership – in combination with technical ability (Guerrier et al. 2009). It is assumed that since these positions require "soft" skills, which women "inherently" possess (and men lack), they will therefore naturally attract women and be a gateway of sorts to the technical realm of IT (Guerrier et al. 2009). These authors do not advocate for these types of hybrid positions, but investigate what the outcomes of these recruitment and hiring practices are, and they explain that the outcomes are not as beneficial or revolutionary as hiring managers might have hoped (Guerrier et al. 2009). In the introduction to the paper the authors explain why there are fewer women in IT in the first place (Guerrier et al. 2009). These explanations support their critique that the manner in which managers approach female recruitment and the related creation of the so-called hybrid jobs simply reinforces normative gender roles (Guerrier et al. 2009). The authors, in their interviews with managers, uncover an additional interesting point regarding the number of women in IT departments. Hiring managers are simply tasked with raising the overall number of women in an IT department, regardless of the nature of the positions (Guerrier et al. 2009). Just as long as the overall ratio of men to women in a department is balanced, it doesn't matter if the women are filling the support roles and men the more technical and managerial roles (Guerrier et al. 2009). It is merely a matter of being "required to achieve diversity targets" (Guerrier et al. 2009, 502).

Roan and Whitehouse critically explore what they call "waves of optimism," views that there are increased opportunities for women to enter IT by utilizing supposedly "feminine" skills and strengths, which include artistic and communication abilities (2007). A "mixed-skills" job would require a blend of "feminine" competencies with more purely technical "masculine" aptitudes (Roan and Whitehouse 2007). Although the authors find statistics that support this "optimistic" view to a limited degree, they find that it does not stand up to a thorough empirical investigation (Roan and Whitehouse 2007). Even if there are slightly promising numbers of women in these new IT roles, they begin to question the true nature of these roles: are they in reality an authentic blend or hybridization of artistic and communication skills with true technical skills, or are they still lopsided, non-inclusive positions (Roan and Whitehouse 2007)? When they examine the situation qualitatively, they find that in reality "mixed-skills" positions are newer versions of traditional technical roles, such as the programmer or software/games designer, in which an artistic leaning or understanding is required, and which are still perceived as "masculine" and filled largely by males (Roan and Whitehouse 2007). Additionally, they find that these positions reproduce the same vertical segregation found elsewhere in the IT sector (Roan and Whitehouse 2007).

The viewpoints examined in the above-cited studies differ from the view that IT would be a genderless field due to its newness and emergence in a time when equal opportunity policies were already prevalent (Ahuja 2002; Cross and Linehan 2006). Instead, given that IT has turned out to be gendered, the authors examine whether new possibilities for women actually emerged through the combining of artistic, or other, more "feminine" skills, with the more technical (Guerrier et al. 2009; Roan and Whitehouse 2007)? Have "mixed-skills" jobs proved to be a way to erode the barricaded "masculine," technical positions, which are dominated by men (Guerrier et al. 2009; Roan and Whitehouse 2007)? Again, this proves not to be the case, due to both the deeply

entrenched, gendered, and socially constructed nature of technological work roles, as well as the existing organizational structures that largely impede women's involvement (at the higher and/or more advanced technical levels) and advancement (Guerrier et al. 2009; Roan and Whitehouse 2007). Roan and Whitehouse conclude that "the implications for research and practice are that we need not only ongoing studies on the way emerging occupations become gendered, but also an ongoing practice of resistance to gendered assumptions about skills and their value" (2007, 31).

2. Drivers of underrepresentation and barriers to participation – Elements that underpin vertical and horizontal segregation

What is it like to participate in a STEM career field for a woman? This subsection examines the factors that both create and perpetuate vertical and horizontal segregation, and that recursively reinforce women's status in STEM.

It is helpful to understand a few theoretical concepts that underpin many concrete explanations of women's status in STEM. The essentialist argument posits that female representation in STEM derives from "fixed, unified, and opposed female and male natures" and that there are "inherent differences between men and women" (Trauth 2002, 100). The essentialist viewpoint is criticized and regarded as being outdated (Blickenstaff 2005; Trauth 2002). Not only are claims of inherent abilities based on gender dubious, but using those explanations is risky because they thwart action (Blickenstaff 2005):

> It is not unusual to hear 'men and women are different, and that's just a fact of life', to explain the current situation for women in society. It seems clear from the literature that whatever biological differences there are between men and women, there is very little difference in scientific or mathematical ability, and certainly not enough to explain the under-representation of women in STEM careers. There is a danger in continuing to emphasize biological differences between men and women because the tendency is to then argue that if unalterable biological differences exist, then no action need be taken to improve the situation for women. (373)

Other points of view demonstrate that women's roles in society are socially constructed, and STEM fields themselves are also socially constructed and are viewed as masculine – and these two constructions are incompatible (Adam et al. 2006; Bastalich et al. 2007; Guerrier et al. 2009; Orser, Riding, and Stanley 2012; Prescott and Bogg 2011; Trauth 2002). "Women's more general exclusion from technology may be seen in terms of the historical and socio-cultural construction of technology as a 'masculine domain'" (Adam et al. 2006, 372). Similarly, in writing about women in engineering, Bastalich et al. explain that there is a picture of engineering as being "masculine" and that women are unsuited for engineering because it conflicts with their roles as caretakers and with their "femininity" (2007). This picture fuels both the idea, which women might hold themselves, that engineering is not for them, as well as the view among men that women are incompatible with the field and as such should be excluded (Bastalich et al. 2007). They describe how the long inventory of explanations for women's underrepresentation in engineering tends to fall into two broader categories: first are those that are "driven by [women's] reproductive roles" and, second, are those that are based on the notion that women are "technically under-confident and unskilled by virtue of their socialization into femininity" (Bastalich et al. 2007, 385). Explanations "driven by [women's] reproductive roles" (Bastalich et al. 2007, 385) make things like work-family conflict deeply linked to the socially and culturally shaped views of women's work and domestic roles. Issues like work-family conflict position women's traditional role as caretakers in opposition to, or as incompatible with, the demands of working in the IT field and in STEM in general (Ahuja 2002; Bastalich et al. 2007; Blickenstaff 2005; Castaño and Webster 2011; Cech and Blair-Loy 2010; Cross and Linehan 2006; Guerrier et al. 2009; Sonnert 1999; Watts 2009; Wentling and Thomas 2009).

Education-based explanations of underrepresentation are also related to the social construction of gender and to the idea of STEM as inherently gendered. For example, at younger ages, girls are encouraged less than boys to use computers (Ahuja 2002; Castaño and Webster 2011). Women

could potentially be less comfortable with and less apt at computer-based communication and other computer-based technologies due in part to the earlier lack of exposure and encouragement (Ahuja 2002). Women might not choose studies in IT because they "fail to see IT as an attractive option and technically ill-equipped to do so" (Ahuja 2002, 23; also see Bastalich et al. 2007 for the socialization of girls away from engineering studies). These relationships to computers and to computer-based education might lead women not to choose IT as a career (Ahuja 2002). "'Technology' is essentially constructed as masculine so men tend to appropriate it and women to distance themselves from it" (Guerrier et al. 2009, 495). This pattern, in terms of female participation in technical fields, begins at school, when girls elect not to take computer and other technical courses (Guerrier et al. 2009). This is then continued through university and career phases, when women are alienated, and possibly also alienate themselves, from IT paths (Guerrier et al. 2009).

The same concepts have been applied to science fields and "Some researchers have argued that women avoid science careers… because girls lack the academic preparation to be successful science students" (Blickenstaff 2005, 374). It is interesting to note that despite what some researchers claim about females' preparation for science education and careers, Blickenstaff uncovers other research that shows that girls are in fact well prepared and that they score well on standardized tests (2005). However, even "when women are equally or better prepared than men for scientific or technical majors, they still drop out of programs at greater rates" (Blickenstaff 2005, 374). Therefore, Blickenstaff wonders what other factors, other than preparedness, might cause this attrition (2005). Blickenstaff's questioning of statistics regarding girls' preparedness to enter scientific educational tracks, and his consideration of other factors that hinder their success, bring up two critical points for readers of this literature to ponder. First, if one focuses only on one element explaining women's underrepresentation, undue weight might be given to it, while other

connected elements go ignored. Second, solving only one aspect of the problems surrounding the underrepresentation of women in STEM fields will not solve the overall situation (Blickenstaff 2005). This is a running theme in much of the literature on women in STEM.

Aside from the social construction (or sociological) explanations and criticisms presented above, some literature also examines more concrete barriers. The concrete barriers often interact with or stem from the social ones, and as such, many of the barriers detailed below refer back to notions presented above.

IT's unique demands require long hours and a work culture that rejects the possibility for part-time or flexible work arrangements (Ahuja 2002; Castaño and Webster 2011; Cross and Linehan 2006; Guerrier et al. 2009; Prescott and Bogg 2011; Orser, Riding, and Stanley 2012; for engineering see Watts 2009). These demands are possibly incompatible with the other life demands of women (Ahuja 2002; Guerrier et al. 2009; Watts 2009). For example, the typical need to travel or to work long hours is something that some women may not be able to do because of other life and family responsibilities (Ahuja 2002). This barrier is influenced by social expectations – such as the widespread expectation that women are caretakers – leading to a general perception that women cannot or will not work long hours, whether or not that is not the case (Ahuja 2002). Jacqueline Watts examines the idea that the perceived total separation of the work and non-work spheres is behind the expectation of long working hours, and that this poses a particular challenge for women (2009). Her analysis is of women civil engineers in the construction industry in the UK and she also highlights how, because there are fewer women in that industry, there is even greater attention drawn to their success or failure in living up to these high expectations of "presenteeism" and that they "are subject to intense scrutiny by the dominant group [men]" (Watts 2009, 41). Although most of the female subjects in the same study critiqued the long-hours situation they encountered,

they nonetheless felt compelled to participate in it, finding it "virtually impossible to avoid this practice" (Watts 2009, 48).

Another aspect of the IT culture is the need for employees to constantly update their skills and to stay current with new technology developments (Ahuja 2002; Castaño and Webster 2011; Guerrier et al. 2009; Orser, Riding, and Stanley 2012). "This can be done more readily by those in the labour market than by those on career breaks," with the implication that this drives a further wedge between male and female workers, with the latter being more likely to spend a greater amount of time out of the workforce (Castaño and Webster 2011, 374).

The lack of mentors is also cited as a barrier to women in IT and STEM (Ahuja 2002; Bastalich et al. 2007; Orser, Riding, and Stanley 2012; Turner, Bernt, and Pecora 2002; Tapia and Kvasny 2004; Wentling and Thomas 2009). The fact that the IT world is male-dominated is the principal cause behind women being unable to find and build suitable mentor relationships (Wentling and Thomas 2009). Furthermore, the individualist culture of the IT workplace is a factor that continues to hinder the access to mentoring networks for women and minorities (Tapia and Kvasny 2004). Even among women who have mentors, some have been reported to feel that they have less access to mentoring opportunities than their male colleagues do (Cross and Linehan 2006). It has also been found that women entering IT identify a specific person or person as influencing them to do so, and subsequently speak of the lack of encouragement and support they encountered while in school (Turner, Bernt, and Pecora 2002).

While finding a mentor of any gender is advantageous, it is possible that women having female mentors might be more beneficial (Cheryan et al. 2011; Orser, Riding, and Stanley 2012). Significant to this is that a result of vertical segregation is that women entering the field have very

few female role models in more prestigious positions (Ahuja 2002; Orser, Riding, and Stanley 2012). "The lack of role models at all levels, particularly at senior levels" could also be "a major problem in attracting and keeping women in computing" (Ahuja 2002, 26). Similar to another point she makes about self-selection, Ahuja wonders if these conditions lead to women "self-select[ing] themselves towards careers in which they observe other women, thus further intensifying the gender-based stereotyping of professions" (Ahuja 2002, 26).

"Mentoring is an intense developmental relationship of relatively long duration in which [a] protégé receives a range of career and psychological help exclusively from one senior manager" (Ahuja 2002, 28). Mentors have proved important to things like creating the relationships needed to resolve issues at work; to settle discrepancies between male and female approaches; or to learn tactics to strike a balance between work and personal demands (Orser, Riding, and Stanley 2012). In one study conducted of women in the advanced technology sector in Canada, "mentoring was identified as a primary means to resolve career challenges" (Orser, Riding, and Stanley 2012, 87). The authors of this study say that this is a significant finding because it confirms what other research says about the importance of mentoring to career development (Orser, Riding, and Stanley 2012). It is also possible that the benefits that mentors provide might be even more impactful for women (Orser, Riding, and Stanley 2012), emphasizing that the lack of mentors specifically for women in IT and STEM is a problem that ought to be addressed.

Most authors tend to agree that networking is also of extreme importance, in addition to that women having insufficient access to informal networks is a problem (Ahuja 2002; Bastalich et al. 2007; Cross and Linehan 2006; Guerrier et al. 2009; Orser, Riding, and Stanley 2012; Wentling and Thomas 2009). There are many overlaps between the benefits of mentoring relationships and networking, but "Peer relationships are different from mentoring relationships in that they often

last longer, are not hierarchical, and involve a two-way helping" (Cross and Linehan 2006, 34). It is problematic that women feel excluded from informal networks because it is through these networks that most opportunities are learned about (Ahuja 2002; Cross and Linehan 2006). Additionally, participating in networks are a key way for people to become better incorporated into the culture of the companies where they work (Ahuja 2002).

Informal networks are also important because of another characteristic of the IT work-world, which is its "lack of clear career structures" (Guerrier et al. 2009, 496; also see Cross and Linehan 2006). Unclear policies and procedures as to what the promotion criteria are in companies are factors that block women's advancement (Castaño and Webster 2011; Cross and Linehan 2006; Guerrier et al. 2009). This can be understood insofar as "getting on can be related to who you know as much as what you know, and where networking and being networked is key" (Guerrier et al. 2009, 496). This statement supports the findings of Cross and Linehan's study, in which women reported feeling that some men received promotions or were given positions based on a connection that they had (2006). Advancement often seems based less on qualifications and more on perceived compatibility (typically, with the other men who dominate the workplace) as well as through participation in informal networks that are largely unavailable to women (Cross and Linehan 2006).

Throughout the literature many authors write about a specific IT culture that both underlies the vertical segregation described above and permeates women's experiences as they navigate their careers. The current IT workplace culture is described as being male-dominated, competitive, results driven and fast-paced (Orser, Riding, and Stanley 2012; Wentling and Thomas 2009). These aspects, and a general resistance to diversity, hinder women's forward progress (Wentling and Thomas 2009). In one study, women noted that they often felt like outsiders who were excluded

from the networking necessary to advancement (Wentling and Thomas 2009). The political aspect of navigating the IT work environment often makes it difficult for female employees to fit in, feel comfortable, and progress through the "informal power structure, primarily because established political systems and networks were composed of men and… not available to women" (Wentling and Thomas 2009, 34). Networks not being available to women further serve to keep them "on the periphery of this dominant culture. Missing out on valuable interaction with faculty and colleagues can translate into missed opportunities for learning and participation in projects" (Ahuja 2002, 26). By remaining on the periphery, with the resulting outcome of missed opportunities, "male domination in higher education in computer-related fields" and the continued exclusion of women is reinforced (Ahuja 2002, 26).

There is much discussion in the literature about the importance of work-life balance (Ahuja 2002; Bastalich et al. 2007; Beede et al. 2011; Blickenstaff 2005; Castaño and Webster 2011; Cech and Blair-Loy 2010; Cross and Linehan 2006; Guerrier et al. 2009; Guthrie, Soe, and Yakura 2009; Hewlett and Luce 2005; Orser, Riding, and Stanley 2012; Roan and Whitehouse 2007; Sonnert 1999; Tapia and Kvasny 2004; Watts 2009; Wentling and Thomas 2009). "Models of work-family conflict suggest that conflict arises when demands of participation in one domain of life are incompatible with demands of participation in another domain and that this conflict can have an important effect on the quality of both work and family life" (Ahuja 2002, 25). What is particularly important in the case of IT is that the nature of the field makes it especially incompatible with the need for work-life balance, due to the long hours and the inability to take time off due to the need to stay current with the ever-evolving nature of technology, both of which are described above. While this can be an issue for men and women alike, it is possible that it is even more of an issue for women due to their traditional role in society as caregivers (Ahuja 2002; Cross and Linehan 2006; also see Bastalich et al. 2007 for engineering):

> It is accepted that women's careers are more complex than those of their male counterparts, stemming mainly from the traditional role played by women in the home…. Women retain a disproportionate responsibility for domestic work and childcare, even in situations where both partners are working. Although research indicates that men have increased their participation in domestic duties, the burden of responsibility is still carried by women. (Cross and Linehan 2006, 32)

Even when companies provide flexible work-arrangements and implement policies to promote greater work-family balance, an additional problem arises when women feel uncomfortable taking advantage of such arrangements (Cross and Linehan 2006; Guthrie, Soe, and Yakura 2009; also see Prescott and Bogg 2011). Due to the workplace cultures prevalent in IT and that men typically do not exploit "family-friendly policies," women could feel insecure in doing so themselves (Cross and Linehan 2006). Beyond the actual feasibility of taking advantage of work-family accommodations, it is also possible that such equality strategies, despite their good intentions, can actually reinforce women's distinct gender roles and lead to fewer paid hours and a perception as being less committed to their work (Watts 2009). Supporting the idea that work-family policies could lead to the reinforcement of gender roles, the majority of the participants in Cross and Linehan's study indicated that work-family was very much viewed as a "women's issue" (2006, 33).

The frequent mentioning of women's traditional roles (both real and perceived) creates a potential tension, due to the fact that women are indeed more "burdened" with these types of responsibilities, while at the same time the very discussion itself aids in perpetuating this concept (Bastalich et al. 2007). Further complications arise in the literature as some authors begin to wonder if certain discussions and analyses about women in STEM only serve to reproduce underrepresentation (Bastalich et al. 2007). For example, Bastalich et al. reiterate throughout their article that various arguments and theories reinforce, or "recirculate," the lack of participation (or problematic participation) of women in engineering (2007). One such example is the point they make that it is problematic to assert that having more "family friendly" practices is the solution for

women's underrepresentation (Bastalich et al. 2007). They argue that these practices and their adoption by businesses should not be associated with women, and should not be thought of as exclusively beneficial to women (Bastalich et al. 2007). It is not to say that these practices and policies are not valuable, but rather that they should be associated with families or people, who need more flexibility, and that the focus should not be on women as the sole recipients of these benefits (Bastalich et al. 2007). To call for more "family-friendly practices" in order to remove barriers to women's participation in engineering only serves to further stigmatize women as different (Bastalich et al. 2007). It reinforces the cultural norm that women should be in the role of the caregiver and that this role is not compatible with the role of an engineer (Bastalich et al. 2007).

A non-STEM related study presented in the Harvard Business Review helps to understand why tackling work-family issues, and related issues of lack of flexible work arrangements, are of critical importance (Hewlett and Luce 2005). The study was conducted in 2004 by a task force put together by the Center for Work-Life Policy and included highly educated professional women, in addition to a smaller sample of highly educated men for comparisons (Hewlett and Luce 2005). Through this study, it was found that 37% of women "off-ramp at some point on their career highway" and that this figure goes up to 43% "among women who have children" (Hewlett and Luce 2005, 3). This is compared to 24% of men, whether or not they had children (Hewlett and Luce 2005). Additionally, 24% of women reported leaving their careers at some point in order to care for elderly or other family members, as compared with 12% of men (Hewlett and Luce 2005). Only 74% of "off-ramped women" who want to go back to work are able to, and only 40% of those obtain professional level full-time work (Hewlett and Luce 2005, 3). Not only this, but many women suffer a "salary penalty" upon their return to work (Hewlett and Luce 2005, 6). "The implication is clear: Off-ramps are around every curve in the road, but once a woman has taken one, on-ramps are few and far between—and extremely costly" (Hewlett and Luce 2005, 3). The study

implores businesses to create part-time positions, provide flexible work arrangements, "remove the stigma" placed upon women for taking advantage of non-traditional work schedules, and foster women's networks to allow women to better participate and persist in their careers (Hewlett and Luce 2005, 1). These conditions and solutions are highly applicable to the STEM sphere.

Addressing just one area determined as being problematic to women's participation will not necessarily lead to the desired levels of diversity or to more completely palatable conditions for diverse participants (Ahuja 2002; Castaño and Webster 2011). The patterns and barriers described in this literature review are entangled in such a way that one issue could be both the basis for and the outcome of another issue. For example, the condition of needing to work long hours interacts conflicts with women's traditional roles outside of work; the demands of women's personal lives could make it impossible for them to participate in informal networks thereby causing women to miss out on certain opportunities. To that end, Ahuja (2002) writes,

> The relationship between social and structural factors is likely to be recursive. For example, job openings are frequently publicized through faculty members (who also act as role models). Faculty members may recommend students with whom they interact. Presence of work–family conflict is likely to reduce female students' interaction with faculty members. Faculty members may also perceive female students with work–family conflict as less suitable to an IT career than those who do have work–family conflict. Thus, work–family conflict may lead to reduced likelihood of being recommended for employment. (27)

Therefore, the issue of informal networks cannot simply be solved by providing women with more opportunities to network, for example. Any other connected issues must be addressed in tandem. The same goes for any other issue to women's participation in STEM.

D. Literature element 4: In search of solutions – Conclusion to review

This literature review, thus far, has covered three broad elements that are typically part of discussions of female underrepresentation and participation in STEM fields. First, the review

explored authors' reasons for the importance of increasing the number of women working in STEM fields. It then explored the pattern of women's participation and examines explanations of why women are not significantly represented and what are some of the obstacles they face once they are working in these fields. However, there is a another area of exploration relating to the topic of women in STEM (and, by extension, in GIS) that was mentioned in the introduction to this literature review, which remains largely unaddressed in both the literature and in this review: how can both the underrepresentation of women in science and technology, as well as problems with the status of women who work in these fields, be resolved?

In the literature reviewed, it was found that authors tend not to make direct recommendations as to what would help fix the issue of women's underrepresentation or problematic participation in male dominated professional fields. In lieu of direct recommendations, often the authors call for continued research and more data to further clarify the issues and to aid in the creation of better workplace policies and conditions enabling women's equal participation. Authors' commentary on their own and others' research, their proposals on how to conduct future research, and the methodologies employed by different authors were all taken into consideration in the formulation of this thesis study. It is hoped that the research conducted and presented herein about women in GIS will have successfully taken on the call for further research and will help lead to solutions to the present issues.

1. How the literature review helped to inform current study: Overarching themes

Two overarching themes emerged from the readings, providing a framework for the thesis author's investigations: the issue of framing women as 'other' (Bastalich et al. 2007; Ullman 2013) and the need to account for diversity *among* women (Cech and Blair-Loy 2010; Trauth 2002).

Is it problematic for a researcher to frame women as 'other'? That is, is attaching the word 'woman' or 'female' to any occupation, for example 'woman scientist' or 'female engineer' enough to cast her as an 'other'? This question was inspired, in part, by the *New York Times* article "How to be a 'Woman Programmer,'" by Ellen Ullman, published May 18, 2013. In the article, Ullman begins by discussing her excellent technical coding skills, but then states that "none of it qualified me as extraordinary in the great programmer scheme of things. What seems to have distinguished me is the fact that I was a 'woman programmer.' The questions that I am often asked about my career tend to concentrate not on how one learns to code but how a woman does" (Ullman 2013). Would saying "women in GIS" make the survey participants feel similarly? While this thesis addresses women in GIS, the thesis author did not want to contribute to a lessening of their status, or emphasize an unwanted, or irrelevant, characteristic by saying "women in GIS."

On the other hand, could omitting the word 'woman' do women a disservice? Bastalich et al., in attempting to look at why there is an underrepresentation of female engineers and why women drop out of the field in greater numbers than men, look at "what it means to be a woman engineer" (2007, 385). They do so through interviews with both male and female engineers. During the course of these interviews, of 10 men and 41 women, the authors observe that two "dominant narratives" emerge among the women (Bastalich et al. 2007). The first they classify as "adaptive narratives," in which women characterize themselves as "'just as good as' men engineers" (Bastalich et al. 2007, 385). The second is a "difference narrative," in which women emphasize how they are different from men but are good engineers in their own right (Bastalich et al. 2007). Would this second group of women prefer to be called "women engineers?" Similarly, would some women in GIS prefer to be called "women in GIS?"

The preference to include or not to include gender in one's professional identity influenced part of

the survey conducted for this thesis, and was addressed by asking whether women in GIS prefer to identify themselves as either a "woman working in GIS" or as a "GIS professional." This issue extends from how a woman does, could, or should identify herself to how an academic or researcher does so.

Beyond women's preferences for how they identify themselves, and how researchers should do so, lies another question about use of the term "women in GIS": does the very act of saying "women in GIS" serve to lump all women who work in GIS into one category, and, if so, is that problematic?

Trauth explains and argues for the emerging theoretical perspective of *individual* differences, versus that of approaching and analyzing women and IT from a *group* perspective (2002). She argues that women in IT, and women in general, are not a monolithic group that share the same set of experiences and societal shaping and, as such, that the current status of women in IT should be examined on a more individual basis (Trauth 2002). That is, each woman has her own distinct background and character (Trauth 2002). Unique sets of cultural, familial, educational, and career experiences shape each woman's relationship to technology and to working in IT (Trauth 2002).

Trauth argues for the importance of empirical research, and conducts qualitative interviews to support her theory that women should be addressed, or talked about, as individuals (2002). The results of her interviews support her theory (Trauth 2002):

> These results show that women who work in the IT profession represent considerable variation. Women who are IT professionals do not all experience the same influences, nor do they all respond in the same ways. Each individual woman is shaped by the cultural assumptions of the countries which formed her, by her parents, family and teachers, and by significant others and events. And each of these women has responded in individual ways to these socio-cultural influences. (114)

A similar note to Trauth is made by Cech and Blair-Loy (2010). In their study of gender inequality in science and technology, these authors examine subjects' perceptions of such inequality (Cech and Blair-Loy 2010). Their subjects are relatively high-level women in professional roles in science, technology and related fields, and the authors hypothesize that their perceptions of gender inequality will be mixed and will depend on their particular life circumstances and context (Cech and Blair-Loy 2010). The authors attempt to find answers by conducting a detailed survey of women who belong to a professional organization whose members are high-level women in science and technology fields (Cech and Blair-Loy 2010). Ultimately, by showing how highly variable aspects of one's unique biography influence how one perceives barriers to advancement, the authors call on policymakers to take such complex factors into consideration as they take action to address inequality (Cech and Blair-Loy 2010).

During the pilot study conducted for this thesis, it was similarly observed that women in GIS are not a monolithic group and that there were a range of experiences and responses shared by the pilot study subjects. This confirmed what was learned in the literature review of the importance of incorporating a research approach that would allow different women to share different experiences, as well as conducting the analysis in such a way that the diversity of participants is taken into consideration. As such, the design of the survey included allowing participants to submit comments for many of the questions (and the subsequent attention put into each woman's comments in the analysis stage of the thesis) as well as analyzing all survey results by breaking down the overall population into discrete categories. This is discussed in greater detail in the Methods Chapter.

2. How the literature review helped to inform current study: Formulation of specific questions

There are two broad primary research questions that underpin this thesis study. First, is there an underrepresentation of women in GIS? Second, do women in GIS experience gender-based obstacles to success? The literature review provided the background information needed for formulating supplemental research questions that would help address the primary questions as well as gather additional related information.

For instance, in addition to being able to provide a definitive numeric response to the question of is there an underrepresentation of women in GIS, the literature review showed the thesis author what kinds of supplemental research questions, as well as associated survey questions, would be needed to depict the nature of the participation of women in GIS as specifically linked to their possible underrepresentation. For example, learning whether vertical or horizontal segregation exist in GIS, as they do in STEM, would help to better understand the consequences of a potential underrepresentation. Or, alternatively, learning that such segregation exists even when there is equal representation of women might show whether other "uneven" conditions exist, regardless of proportionate female representation in the field.

Additionally, in order to answer the second research question about whether women in GIS experience gender-based obstacles, the thesis author had to ascertain what these obstacles might be in the first place. For example, do women have to work long hours and, if so, would this need potentially conflict with other non-work responsibilities? Do women in GIS have to constantly update their skills? Are women satisfied with their levels of work-life balance? These are all questions specifically derived from the literature review that the thesis author would not have known to ask.

The following are supplemental research questions that came out of the literature review, and they were developed and included to help answer the primary research questions:

- Is GIS similar or dissimilar to IT in terms of its culture and women's experience of it? Would the work conditions in IT – having to work long hours, inflexible work arrangements, the need to constantly update skills, and the presence of a male-dominated, exclusionary culture – also be present in GIS?
- Are vertical and horizontal segregation as prevalent in GIS as they are in IT and in science professions? For example, would women in GIS be in roles where certain skills would be more utilized than others ("soft" versus technical skills)? Can knowledge learned about the skills used by women in GIS be utilized to compare GIS work to other "hybrid" jobs discussed in the literature?
- What are the experiences and preferences of women in GIS in regard to mentoring relationships and to networking? Do women in GIS face similar issues as women in other STEM fields in finding mentors? Do women in GIS leverage the power of mentoring and networking?
- Do women in GIS have a good level of work-life balance? What are their opinions on issues uncovered in the literature review? For example, do they think that work-life policies that specifically address them alienate them?
- Does breaking down survey results by different demographic categories have any impact on responses given to survey questions? This is influenced by the recommendation made by some authors (and refined through analysis of the pilot study results) not to view women in STEM fields as a monolithic group.

- Is putting the word "Women" in front of "GIS" to derive the phrase "Women in GIS" wrong? Does the mere act of saying this simply serve to reinforce women's alienation and their being seen as 'other'?

In conclusion, this review focused on literature examining the status of women's participation in STEM fields, since no applicable literature existed examining women in professional GIS. The goal of the literature review was twofold. First, it sought to understand what women's representation looks like in other fields potentially similar to GIS and, second, it sought to define the challenges women working in those fields face. Would understanding female participation in other fields help to understand the participation of women in the field of GIS? To that end, this literature review presents information from selected publications that the thesis author believed to be most applicable to GIS, and that also made the complex nature of female underrepresentation and participation in male dominated fields most easily understood. However, while the literature examined was useful in and of itself, it was also of great importance for its contribution to the second goal shaping the original research presented in this thesis. In order for the thesis author to contribute a body of work meaningful to professional GIS, the concepts learned in the literature review needed to be translated and applied to fit women in GIS. The following chapters detail the translation and application of these concepts to GIS.

III. Methods

A. Overview

This thesis was undertaken in five stages:

The process began with a review of existing studies and articles from other STEM disciplines. The readings provided a comparable basis for understanding female underrepresentation in other fields, as no applicable literature existed specifically about women in GIS. The next stage was a pilot study with key informants, who are largely women who work in GIS. The insights they provided helped bridge the information learned from the literature review concerning female representation in STEM disciplines to the field of GIS. Information gathered through the literature review and the pilot study was then synthesized to design a survey. Once the survey had been disseminated and a significant amount of responses had been collected, the survey results were analyzed. The findings are presented as the main body of the thesis and provide a contextual narrative to understand survey findings.

Please note that the thesis author completed the International Review Board (IRB) approval process in order to conduct interviews for the pilot study and then for conducting the survey (IRBNet Project Number: 534568-3).

The following sections of this thesis chapter provide details on the design of the pilot study and the survey, and the methods employed to analyze the survey results.

B. Pilot study

The pilot study enhanced the overall design of the thesis by narrowing the research agenda and therefore leading to a better survey design. This was especially helpful in light of the fact that the literature review, which concerned women's experiences in other STEM fields, uncovered many diverse lines of thought that were potentially relevant to the present research questions. The pilot study also allowed the thesis author to gain the expert advice of professional women active in the GIS field, which helped to ensure the survey questions' relevance and fit with the research agenda. Importantly, the insights shared by the key informants led to additional questions not derived from the literature review being included in the survey.

1. Pilot study details

The pilot study involved one-on-one interviews with nine key informants, women who work in GIS in the United States, many of whom are well-established in their careers and who have had firsthand experience with the thesis topic. Most of the subjects in the pilot group were women with significant amounts of GIS experience (up to 26 years), who had lengthy exposure to the GIS professional field and who could give the thesis author guidance and input on the research agenda. Two additional women, one who has led a roundtable discussion on the topic of women in GIS and who is actively interested in the topic, and the other a professor who had recently collected data on women in GIS through a crowdsourced map (Dr. Linda Loubert), were also consulted. The duration of the pilot was approximately one month and the length of subject participation was a one-time 30-45 minute interview, conducted in person, via Skype, or by phone.

Once the interviews and consultations were completed, the thesis author transcribed the recorded interview sessions, compiled notes based on the transcriptions, and synthesized the information shared by subjects. One of the pilot questions (see Appendix A) served to elicit advice and opinions

from the subjects on the research purposes and questions. Recordings and other identifiable information from the pilot study participants were destroyed once the necessary information was extracted, in compliance with IRB stipulations.

2. Lessons learned from pilot study

Only the main lessons learned from the pilot are included here, as the objective of the pilot study was to help shape the survey and narrow the research agenda, as opposed to providing additional data or further analysis.

The pilot study not only helped to shape the survey section of the thesis, but also to confirm and partially reframe one of the original primary research questions and some of the underlying expectations. Prior to the pilot study, the original primary research questions were: 1) Is there an underrepresentation of women in the GIS professional sphere and 2) What is the experience of struggle, if any, of women in the GIS field? The importance and relevance of the first research question regarding the numerical underrepresentation of women in GIS was confirmed. The women who participated in the pilot were asked, "Do you think there is an underrepresentation of women in GIS?" All pilot study participants answered affirmatively on some level – ranging from categorical "yes" responses, to speculating probably yes (and interested in determining definitively), to speculating that women in certain roles were likely underrepresented (e.g., women in more highly technical roles), and including responses that expressed a perception that the situation is changing. The fact that all women in the pilot study considered women to be, to some degree and in different ways, underrepresented in GIS confirmed that it was central to the thesis to determine whether women actually are underrepresented in GIS. Furthermore, it is of great relevance even to those women who already participate in the field. The strong opinions that this question provoked further confirmed that this same question ("Do you think there is an

underrepresentation of women in GIS") should also be included in the survey. Not only was it important to find out if there was a numerical underrepresentation, but also whether women perceived such an underrepresentation.

Caveats to "yes" answers, such as the perception that women's representation is changing over time and that women's representation in certain roles might be uneven, helped to guide two further components of the survey. First, it was decided that survey population analysis filters based on years of experience in GIS should be applied in examining the survey results, since women with a greater amount of GIS experience could potentially have different views than newcomers to GIS (and generally respond to the survey questions differently). Second, the information uncovered in the pilot study confirmed what was learned in the literature review regarding women's specific underrepresentation in technical and managerial roles, and it was therefore decided to include questions to measure what skills women use more or less frequently at work (for example, would women use their technical skills in equal measure to other workplace or communication skills?).

Through the pilot, it was also found that the wording of the second, original thesis question, "What is the experience of struggle, if any, of women in the GIS field?" was inappropriate. The women who participated in the pilot study were asked how they came to their GIS careers and if they had experienced any challenges. While some had experienced challenges, the word "struggle" was an incorrect way to assess their experiences. All of the women interviewed in the pilot study could be seen as highly successful and some as also progressing through their careers with "ease." Thus, it was decided that the word "struggle" contained bias and would not allow for the full range of women's experiences in GIS, including positive experiences. To make this research question more neutral it was amended to "Do women in GIS experience gender-based obstacles to success? What are the experiences of women in GIS?"

Another element from the pilot study that influenced the survey concerned the educational background of the pilot participants. Of the nine interviewees, eight had geography degrees (and most had heard about GIS through their geography programs). Three women came to GIS before formal education in GIS was available and learned GIS on the job (two of whom had geography degrees and the other an environmental science and planning degree). This led to wondering if most women who work in GIS come to the field through geography education or, if not, then by what other pathways? Additionally, it was seen again that the women who had the most experience and who came to GIS when the profession was first emerging had different types of experiences as compared with newcomers.

Mentoring and networking were other themes that emerged as being important to the topic of women in GIS, and as two themes that should be included in the survey. The importance of mentoring and networking had already become clear through the literature review and the pilot study helped to confirm this. Seven of the women in the pilot study spoke about mentors who helped them in either school or at work. Two women mentioned that they had not had mentors, but one added that she is a mentor to others. These two were women with many years of GIS experience and who had come to the GIS professional field in its earliest days, which pointed to the greater potential difficulty in finding mentors as one reaches higher levels in the field (and once again the likely uniqueness of those women with the most experience in GIS). In terms of networking, seven of the nine women mentioned that they participate in professional organizations. All of the pilot participants except one shared that they enjoy networking or at least think that it is important. Partially pertinent to networking and also relating to what can help women obtain GIS jobs, three of the pilot study interviewees had internships that led to full-time GIS jobs, and one woman specifically mentioned getting a job through a personal connection. The

pilot made it clear that mentoring and networking was important to and for women in GIS, and questions about those two topics should also be included in the survey.

There were other specific questions that appeared in the survey that were inspired by the pilot study and that are not discussed in the paragraphs above. These questions reflect commentary made by multiple or individual women in the pilot study:

- Regarding feelings of isolation and possible desire to connect with other women:
    - Do you feel that there are enough women in your department?
    - Do you feel that you would like to meet other women who work in GIS?
    - Have you ever been the only woman in the room (at meetings, events, etc.)? Has that made you uncomfortable? Please explain
- Regarding opportunities to learn on the job (as possibly impacting job satisfaction and opportunities for growth or career movement):
    - Does your position have many learning opportunities?
    - Are you required to accomplish tasks that push you to learn new things?
    - If so, do you enjoy that aspect or is it a hardship?

C. Survey

1. Survey design, research procedures, and dissemination

The survey was designed to collect quantitative and qualitative information. Once the questions were drafted and reviewed by the thesis author and her advisor, they were built into a survey using the online tool SurveyGizmo.

The survey was announced through a general invitation sent through various listservs, as well as promoted via social media networks by both the thesis author and by invitees. Please see Appendix B for a sample email invitation. The target audience was adult professional females who work in the field of geographic information systems.

Table 1. Listservs, forums, and website postings where survey announced

Name	Type	Address
Association of American Geographers (AAG) GIS Specialty Group	Forum Posting	http://community.aag.org/home
Cartotalk (North American Cartographic Information Society)	Forum Posting	http://www.cartotalk.com/
GIS Lounge	Website Posting	http://www.gislounge.com/women-gis-survey-masters-thesis/
Hunter College Geography Department	Listserv	GEO-L@hunter.listserv.cuny.edu
NYC Geospatial Information Systems and Mapping Organization (GISMO)	Listserv	gismonyc@yahoogroups.com
NYS GIS Association	Website Posting	http://www.nysgis.net/women-in-gis-survey/
Society for Conservation GIS (SCGIS)	Listserv	SCGIS@listserv.uri.edu
The New York State GIS List (GISNY-L)	Listserv	GISNY-L@listserv.nysed.gov
University Consortium for Geographic Information Science (UCGIS)	Listserv	http://ucgis.org/ (Listserv posting sent by thesis advisor)
Urban and Regional Information Systems Association (URISA)	Listserv	http://www.urisa.org/ (Listserv posting sent by thesis advisor)
Women GIS in DC	Listserv	dc-women-in-gis@googlegroups.com

The social media efforts made specifically by the thesis author were through a Women in GIS Facebook Group (posting made by owner of the group on thesis author's behalf), a LinkedIn Women in GIS Group, and on Twitter (tweeted by thesis author and several others). During the time that the survey was available online it "went viral" – women who participated in the survey tweeted about the survey (or shared it through other social media networks), and many other people (men included) retweeted or shared it through other social media postings. From the items

listed in the Table 1, the GIS Lounge website posting was particularly fruitful – at least 20% of the completed survey responses came from this source.

It was uncertain how many women would respond, and it was hoped that 200 participants would complete the survey. This goal was more than doubled, with a surprisingly high response of 484 completed surveys.

The survey participants were provided with a link to the survey and answered the questions on-line. The first page of the survey was the consent section, in which it was explained that participating in the survey was completely voluntary and anonymous (no personally identifiable information was collected, including the IP addresses of the survey participants), that participants could skip any questions they did not want to answer, and that they could quit the survey at any point. The survey questions were grouped into logical and thematic groups on one survey page each. Each page included a quick introduction to allow the survey taker to understand why those questions were being asked. Survey participants proceeded through each page (again, being allowed to skip any questions) and at the end of the survey, pressed submit to send their responses to the survey database.

The survey was available online from June 30, 2014 through September 26, 2014 and, while originally intended to be posted for a shorter period of time, was left open due to the continued submission of responses. It was estimated that the survey would take on average 30-45 minutes for a survey taker to complete. Once closed, the survey database was downloaded at one time and output as a CSV document. Each survey question was exported as a column header in the CSV document, and the responses of each survey taker were contained in a single row (again, with no identifiable information).

2. Analyzing survey results

The large number of completed surveys provided a statistically significant sample size which enabled the thesis author to accomplish the goal of analyzing the status of women working in the professional GIS field. The discussion of the survey results helped to address the primary and supplemental research questions (supplemental research questions are listed in the beginning of Chapter IV), and to make meaningful connections between the results of different survey questions.

The examination of the survey questions in the following chapter includes presenting, analyzing, and discussing the results of the survey population as a whole and broken down by certain filters. These filters include sector, race/ethnicity, number of years working in GIS, and age groups. As "women in GIS" does not constitute a monolithic group, filtering survey responses helps to determine whether there is any variation in the data and, if so, whether any meaningful patterns arise. Not only are the filters helpful for the topic "women in GIS," but some are also useful for learning more about the field of GIS itself (particularly the sector filters). Both statistical and qualitative data analyses are presented and discussed.

For each survey question, first the hypothesis is stated. Then the question format is listed. The survey utilized a range of question formats, including radio buttons, multiple choice, likert scales (for example, "Strongly agree," "Agree," Neutral," "Disagree," and "Strongly disagree"), and slider bars (to indicate on a scale from 1 to 5). Comment boxes were also frequently provided to allow for open text responses. The specific methods used to analyze the results are as follows:

a) Statistics

The overall results (raw numbers, percentages, total responses, and number of those who left the question unanswered) for each question are presented beneath the other preliminary survey

question details (hypothesis and question format). Statistics that measure the probability of a trial were performed on categorical questions (primarily the radio button questions) to test if results were observed by chance. This was done to see if each hypothesis was verified by the experiment. For binary questions, a binomial distribution formula was utilized, and for questions that had more than two categories of response the Pearson's chi-squared test was used. In the survey analysis chapter, p-values (derived from the binomial distribution formula or the Pearson's chi-squared test) are presented within the table that shows overall raw number results and percentages for each survey question. In the discussion pertaining to each question and any additional tables, the appropriate probability statistics are shown (that is, the p-values mentioned in text and supporting tables are either the binomial distribution for binary questions or chi-squared test for the others).

Excel was used to perform the statistics and the following are the formulas and other details that this software package utilizes.

Binomial distribution:

Syntax in Excel cell: BINOM.DIST.RANGE(trials,probability_s,number_s,[number_s2])

The calculation requires that the number of trials (number of given responses), probability (0.5 used for all questions of this thesis), and number of "successes" (number of responses that confirmed hypothesis).

The formula underlying the syntax that Excel utilizes is:

$$\sum_{k=S}^{S2} \binom{N}{k} p^k (1-p)^{N-k}$$

Figure 1. Binomial distribution formula
From: https://support.office.com/en-ie/article/BINOMDISTRANGE-function-17331329-74c7-4053-bb4c-6653a7421595 (accessed 5/6/2015).

Chi-squared test:

Syntax in Excel cell: CHISQ.TEST(actual_range,expected_range)

The calculation requires the actual range (actual observed values) and the expected range (ratio of total number of categories).

The formula underlying the syntax that Excel utilizes is:

$$\chi^2 = \sum_{i=1}^{r} \sum_{j=1}^{c} \frac{\left(A_{ij} - E_{ij}\right)^2}{E_{ij}}$$

Figure 2. Chi-squared test formula

From: https://support.office.com/en-us/article/CHISQTEST-function-9a68917f-2305-42b6-a6c3-5fe33e79a703 (accessed 5/6/2015).

For both probability statistics a p-value < 0.05 was considered significant, indicating that the observed values were not observed by chance.

b) Open text analysis

For the questions that were open text or for other questions that allowed comments, open text analysis was performed. SurveyGizmo has open text analysis functionality that allows the creation of comment categories, or labels, and for the researcher to review and paginate through open text questions and comments, and to then assign labels to each response (methodology inspired from grounded theory; see Charmaz 2003). The thesis author allowed for multiple labels to be assigned to each response to best capture the nature of responses, including when responses included multiple sets of ideas. All labels assigned were collected into the survey database, and were output along with the other survey results into the CSV file that was used for the statistical analysis. For any questions that include open text analysis, there is a separate sub-section for the open text analysis that shows the results of that analysis and provides any other necessary details on the open text analysis process.

IV. Survey Results and Discussion

Survey Question Navigation (click on links to jump to questions)

Research Question A. Is geographic information systems (GIS) similar or dissimilar to Information Technology IT) in terms of its culture and women's experience of it?

Question 1: Are you required to work long hours?
Question 2: Does your work have flexible work arrangements (for example, telecommuting, alternative work schedules, etc.)?
Question 3: Is there a need to update your GIS skills regularly (i.e., Learn new software/methods)?
Question 4: Do you need to take continuing education courses and/or other trainings to update knowledge?
Question 5: What is the gender ratio of your department in general? Balanced between males and females? Enter two numbers to provide a ratio
Question 6: If there is an imbalanced ratio, with more men, do you feel that there is a male-dominated culture? For example, a "boys club" type situation? Do you feel excluded in any way from activities?
Question 7-11: 7) Do people in your department socialize after work? 8) Do people in your department (or company) go to GIS-related meetups? 9) Do you participate in these activities? Which ones? 10) Why or why not? 11) If you do participate, what is the benefit of doing so?
Summary of Research Question A

Research Question B. Is vertical (and horizontal) segregation as prevalent in GIS as it is in IT and in science professions? Are women relegated to the lower ranks across GIS niches? Are they more represented in certain niches (e.g., more programmers versus analysts)? Are they more represented in certain industries/sectors (i.e., more in state government but less in startups)?

Question 1: What sector is your position in (state, federal, local government, non-profit, startup…)?
Question 2: More specific sector: e.g., Transportation, environmental, education, etc.
Question 3: How would you categorize your work (programming, analysis, cartography, administrator, other)?
Question 4: How many people are working in your GIS section?
Question 5: How many of those are full-time, how many are part-time?
Question 6: How many women and how many men work in GIS departments? (Is there an underrepresentation of women in GIS?)
Question 7: Do you feel that there are enough women in your department?
Summary of Research Question B

Research Question C. To gather information that might help in forming and influencing thought on mentoring relationships and networking groups

Question 1: If you chose to participate in a formal mentoring program, would you prefer to have a male or female mentor?
Question 2: Would it be the same for informal mentoring (meaning, would you prefer to network with other females)?
Question 3: Female professional groups
Question 4: Is your supervisor male (Yes) or female (No)?
Question 5: Do you feel that you would like to meet other women who work in GIS?
Question 6: Have you ever been the only woman in the room (at meetings, events, etc.)?
Question 7: Have you ever obtained a job through a personal connection?
Question 8: Have you had difficulties finding a mentor?
Summary of Research Question C

Research Question D. GIS's "Hybrid" Nature

Question 1: Do you consider your position to combine multiple skills? That is, do the tasks that you perform require diverse skills and affinities? On a scale from 1 to 5, indicate which skills are required in your daily activities:
- Technical skills - data acquisition
- Technical skills - analysis and modeling
- Technical skills - software and application development
- Knowledge base - core geospatial and abilities and knowledge
- Communication and workplace skills - teamwork
- Communication and workplace skills - creative thinking
- Communication and workplace skills - planning and organizing
- Communication and workplace skills - problem solving/decision making
- Management competencies
- List skills if desired

Question 2: What are your greatest skills?
Question 3: What are your areas of weakness?
Question 4: What skills would you recommend that female newcomers to GIS focus on?
Summary of Research Question D

Research Question E. Pipelines to GIS

Question 1: What is your highest degree in? If multiple degrees, what are they and in what disciplines? Up to 3 combinations of drop-down menus of attainment levels and disciplines.
Question 2: How did you hear about GIS?
Question 3: Have you ever had a GIS internship?
Question 4: If so, did that internship lead to a full-time position?
Question 5: Feel free to add comments about any other way(s) internship may have been beneficial
Summary of Research Question E

Research Question F. Does the number of years in the GIS field have any bearing on the results of the survey questions? Specifically, do women with more years in GIS have different perceptions of the status of women in GIS – will they respond differently to questions such as "Do you think there in underrepresentation of women in GIS" or "Do women face bias as GIS professionals?" Additionally, will women with more years in GIS have different experiences than newcomers (thereby altering their

perceptions)? Do the observations derived from these questions point to a change in the GIS field over time (to a field that is becoming increasingly better for women)?

Question 1: How many years have you been working in a professional setting?
Question 2: Of those years, how many have been in GIS?
Question 3: Do you think there is an underrepresentation of women in GIS?
Question 4: Do women face bias as GIS professionals?
Question 5: Is this bias unique to GIS (Yes) or is it more general (No)?
Question 6: Was getting to where you are in your career easy (Yes) or difficult (No)?
Question 7: Do you view attaining the next step in your career as having challenges?
Question 8: Does your gender play a role in what you view those challenges to be?
Summary of Research Question F

Research Question G. Exploration of factors relating to work-life balance. Is this important to women in GIS? Do GIS jobs allow for flexible arrangements that might enhance work-life? What are women's opinions about work-life/family?

Question 1: Is work-life balance an important characteristic of a job? How important is it to you? Why or why not?
Question 2: Would you say that in your current job you have a good level of work-life balance?
Question 3: Are work-family issues more relevant to women than to men?
Question 4: Do you think that women are more responsible (than men) for caring for children and elderly family members?
Question 5: Do you think more policies should be implemented geared specifically towards women that would allow for better work-family balance? If you disagreed with the above, why?
Question 6: Is work-life and work-family an issue for men and women alike?
Question 7: Do you feel that gearing work-family policies with women in mind alienates women?
Question 8: If your company does have flexible work arrangements available, do you avail yourself of them? Do you feel comfortable doing so? Why or why not?
Summary of Research Question G

Research Question H. Demographic information.

Question 1: Race/ethnicity
Question 2: Age
Summary of Research Question H

Research Question I. Is continuing education an important aspect of enhancing GIS careers that is both encouraged by employers and that is taken advantage of by women? Are women GIS professionals being given opportunities to get the knowledge and training that they need?

Question 1: Do you feel that taking continuing education classes is necessary to your current work?
Question 2: Do you feel that taking continuing education classes would be necessary to obtaining a different position?
Question 3: Learning and current position
a. Does your position have many learning opportunities?

b. Are you required to accomplish tasks that push you to learn new things?
c. If so, do you enjoy that aspect or is it a hardship?

Summary of Research Question I

Research Question J. Is putting the word "Women" in front of "GIS" to come up with the phrase "Women in GIS" wrong? Does the mere saying of this just serve to reinforce women's alienation and their being seen as other?

Question 1: The term "Women in GIS" is a good way to categorize, or describe, women who work in GIS (Strongly agree, disagree, etc.)
Question 2: The term "Women in GIS" is not a good thing - it separates and alienates women who work in GIS from men.
Question 3: "You identify yourself as a (if you had to pick one): (a)"woman in GIS" (b) GIS professional (no gender)"

Summary of Research Question J

A. Research Question: Is GIS similar or dissimilar to IT in terms of its culture and women's experience of it?

Survey Page Header *(page 3 on survey): Is the professional GIS sphere, and its demands and challenges, similar or dissimilar to that of IT?*

Context for survey participants: *There is not much existing research or literature regarding the status of female GIS professionals. Due to potential similarities between the fields of GIS and IT, literature regarding women in IT has been studied to provide a background on some of the challenges that women face in technically oriented career paths.* ***The following questions are being posed to validate the thesis author's belief that lessons learned from research conducted on women in IT might be applicable to women in GIS, and vice versa. Also, the thesis author would like to learn if GIS is unique in any ways to IT in terms of its culture and women's experience of it.***

It is not the intention of this thesis to prove that IT and GIS are the same. However, it is hypothesized that, in general, IT and GIS do share some characteristics, and that these similar characteristics have a similar impact on women who work in these fields. If IT and GIS are found to be similar, then it might be the case that IT literature is applicable to GIS. If it is found that IT and GIS are dissimilar (at least in the variables that are part of this survey), then this proves that GIS is a unique field requiring its own literature and analyses.

SURVEY QUESTIONS:

1. Are you required to work long hours?

Hypothesis: Yes, people (women in this case) in GIS work long hours.

Question format: Radio – Binary (yes/no)

Table 2. Are you required to work long hours? (No category filters)

Value	Count	Percent
Yes	158	33.0%
No	321	67.0%
Statistics		
Total responses	479	
Unanswered	5	
Binomial probability of trial result: 1.9936E-14*		

*** Throughout this chapter, an asterisk (*) denotes significant p-value.**

Interpretation: A characteristic of the IT field is the need to work long hours (Ahuja 2002; Castaño and Webster 2011; Cross and Linehan 2006; Guerrier et al. 2009; Prescott and Bogg 2011; Orser, Riding, and Stanley 2012; for engineering see Watts 2009). It was expected that the same would apply in the field of GIS. The survey results yielded an unexpected outcome, with more participants answering that they are not required to work long hours – only 33% of participants indicated that long hours are required, while 67% responded that long hours are not required. The p-value is extremely small, indicating that the observed values were not observed by chance and that the number of participants not working long hours is significant, giving strong evidence that the hypothesis for this question is not true.

However, there is some variability in the responses to this question when the responses are examined by certain sub-groups of the survey population. For example, a higher percentage of those who work in the private and higher education sectors report having to work long hours (private sector = 41% and higher education = 51%; with those in the private sector having a more significant p-value). While the reported numbers for these two sectors do not necessarily confirm the original hypothesis, they do show that certain sectors require working longer hours than others. Participants in local government, on the other hand, are those who are least required to work long hours with only 16% reporting that they do.

Table 3. Are you required to work long hours? (By sector)

Sector	# Responses	# Yes	# No	% Yes	% No	P-value
Federal Gov.	43	13	30	30.2%	69.8%	0.004158306*
State Gov.	75	29	46	38.7%	61.3%	0.013497506*
Regional Gov.[1]	5	1	4	20%	80%	n/a
Local Gov.	107	17	90	15.9%	84.1%	1.43041E-13*
Non-Profit	37	9	28	24.3%	75.7%	0.000905155*
Private	144	59	85	41.0%	59.0%	0.00637045*
Start-Up	11	4	7	36.4%	63.6%	0.161132813
Higher education	39	20	19	51.3%	48.7%	0.125370688

Number of years working in GIS is another filter by which the survey population can be broken down into smaller groups. As the number of years in GIS increases, so does the number of those who report that they are required to work longer hours. Only 25% of the participants with 0-3 years of GIS experience, steadily increasing up to 45% of participants with 20-30 years of GIS experience, report having to work long hours.

Table 4. Are you required to work long hours? (By number of years in GIS)

Number of Years in GIS	# Responses	# Yes	# No	% Yes	% No	P-value
0-3 yrs.	104	26	78	25%	75%	1.11185E-07*
>3 and <=10 yrs.	182	60	122	33.0%	67.0%	1.31386E-06*
>10 and <=20 yrs.	144	50	94	34.7%	65.3%	7.52568E-05*
>20 and <=30 yrs.	42	19	23	45.2%	54.8%	0.101584945*
>30 yrs.[2]	3	1	2	33.3%	66.7%	n/a

While the two patterns above are more easily understandable, there is a puzzling variability across race/ethnicity. Of the black/African American participants, 88% report that they are required to work long hours. If these numbers are truly reflective of this demographic group, what might be the cause of this?

[1] The numbers for the Regional Government group are presented in this and any subsequent tables, but are generally not incorporated into the discussion, as it is such a small group.

[2] "Greater than 30 years" category only has a total of three participants so the numbers in this table might not be truly indicative of the larger population who have worked in GIS for more than 30 years. The numbers for this group are presented in this and any subsequent tables, but are generally not incorporated into the discussion, as it is such a small group.

Table 5. Are you required to work long hours? (By race/ethnicity)

Race/Ethnicity	# Responses	# Yes	# No	% Yes	% No	P-value
Hispanic	24	11	13	45.8%	54.2%	0.148781776
Black/African American	8	7	1	87.5%	12.5%	0.03125*
White	374	113	261	30.2%	69.8%	3.80057E-15*
Asian	25	12	13	48 %	52%	0.154981017
Am. Indian/Alas. Nat[3]	4	1	3	25%	75%	n/a
Nat. Haw./Pac. Is.[3]	3	0	3	0%	100%	n/a

When broken down by age groups the numbers mimic the trend in the numbers of years in GIS groups. Fewer of the younger participants, who are most likely to be in the group with the least years in GIS and to hold most of the entry level positions in GIS, report being required to work long hours – 29% of 21-30 year olds are required to work long hours versus 52% of 51-60 year olds.

Table 6. Are you required to work long hours? (By age bracket)

Age Bracket	# Responses	# Yes	# No	% Yes	% No	P-value
21-30	120	35	85	29.2%	70.8%	1.72886E-06*
31-40	184	57	127	31%	69%	7.4435E-08*
41-50	94	30	64	31.9%	68.1%	0.000163109*
51-60	56	29	27	51.8%	48.2%	0.102486667
61-70	10	1	9	10%	90%	0.009765625*

2. Does your work have flexible work arrangements (for example, telecommuting, alternative work schedules, etc.)?

Hypothesis: No, flexible work arrangements are not widely available.

Question format: Radio – Binary (yes/no)

Table 7. Does your work have flexible work arrangements? (No category filters)

Value	Count	Percent
Yes	361	75.7%
No	116	24.3%
Statistics		
Total responses	477	
Unanswered	7	
Binomial probability of trial result: 8.98633E-31*		

[3] American Indian/Alaskan Native and Native Hawaiian/Pacific Islander categories only have a total of four and three participants respectively so the numbers in this table might not be truly indicative of the larger population of those two racial/ethnic categories. The numbers for these two group are presented in this and any subsequent tables, but are generally not incorporated into the discussion, as they are such small groups.

(Note: Work-life balance is explored in-depth under Research Question G below, including the role gender might play.)

Interpretation: Much of the literature regarding IT describes that IT does not boast flexible work arrangements (Ahuja 2002; Castaño and Webster 2011; Cross and Linehan 2006; Guerrier et al. 2009; Prescott and Bogg 2011; Orser, Riding, and Stanley 2012; for engineering see Watts 2009). While it was expected that the same would apply in the field of GIS, 76% of participants indicated that their workplaces have flexible work arrangements, while only 24% said the opposite. The p-value is extremely small, indicating that the observed values were not observed by chance and that the number of participants who have flexible work arrangements is significant, giving strong evidence that the hypothesis for this question is not true.

The higher education sector has the most flexible work arrangements with 92% of participants saying "yes" to this question and the non-profit and federal government sectors the second highest with 84% of participants also saying "yes." Even those in the private sector report that they have flexible work arrangements (77%). Local government has the least amount of women (62%) reporting that their work has flexible work arrangements, so while this group has the best "score" when it comes to not having to work long hours, they are the ones with the least flexible work arrangements.

Table 8. Does your work have flexible work arrangements? (By sector)

Sector	# Responses	# Yes	# No	% Yes	% No	P-value
Federal Gov.	43	36	7	83.7%	16.3%	3.66346E-06*
State Gov.	76	57	19	75%	25%	5.06183E-06*
Regional Gov.[1]	5	4	1	80%	20%	n/a
Local Gov.	106	66	40	62.3%	37.7%	0.003181208*
Non-Profit	37	31	6	83.8%	16.2%	1.6915E-05*
Private	142	109	33	76.8%	23.2%	3.85609E-11*
Start-Up	11	8	3	72.7%	27.3%	0.080566406
Higher education	39	36	3	92.3%	7.7%	1.66237E-08*

Similar to the survey question about having to work long hours, black/African American participants answered this question differently than the other sub-groups of participants – only 50% report having flexible work arrangements. While the p-value indicates that these numbers might have been observed by chance, it is still interesting to consider. Between 63% and 65% of Hispanic and Asian participants and 77% of white participants report having flexible work arrangements. Please note that the thesis author is aware that the non-white race/ethnicity groups in this survey are much smaller than the white group and thus many of the associated p-values might not reflect significance.

Table 9. Does your work have flexible work arrangements? (By race/ethnicity)

Race/Ethnicity	# Responses	# Yes	# No	% Yes	% No	P-value
Hispanic	24	15	9	62.5%	37.5%	0.077933311
Black/African American	8	4	4	50%	50%	0.2734375
White	371	288	83	77.6%	22.4%	4.60226E-28*
Asian	26	17	9	65.4%	34.6%	0.046559423*
Am. Indian/Alas. Nat.[3]	4	2	2	50%	50%	n/a
Nat. Haw./Pac. Is.[3]	3	2	1	66.7%	33.3%	n/a

Additionally, the more years worked in GIS, the progressively higher the numbers of those reporting flexible work arrangements. The trend starts with 70% of those who have only worked in GIS for up to three years reporting that they have flexible work arrangements, and progresses to 86% of those with 20-30 years in GIS. Even though those working in GIS for a longer period of time report that they must work long hours, they conversely have the advantage of having more flexible work arrangements.

Theorists claim that having to work long hours and the lack of flexible work arrangements, which are characteristics of the IT field, are not conducive to female participation (Ahuja 2002; Cross and Linehan 2006; Watts 2009). It is not conducive to women in particular due to their traditional role in society as caregivers (Ahuja 2002; Cross and Linehan 2006; also see Bastalich et al. 2007). So far in the survey results for Women in GIS, it seems that GIS is not as similar to IT as might have been

expected. Women in GIS are reporting both *not* having to work long hours and also having flexible work arrangements. When digging a little deeper, there is some variability – for example, in certain sectors like local government not working long hours comes at the expense of having less flexible work arrangements, while the opposite holds true for participants with more years in GIS. They must work long hours, but have flexibility. However, overall, GIS working conditions thus seem far better, and might even be conceived as being more favorable for women's participation.

3. Is there a need to update your GIS skills regularly (i.e., learn new software/methods)?

Hypothesis: Yes, there is a need to update one's skills regularly.

Question format: Radio – Binary (yes/no) plus comments

Table 10. Is there a need to update your GIS skills regularly? (No category filters)

Value	Count	Percent
Yes	436	91.2%
No	42	8.8%
Statistics		
Total responses	478	
Unanswered	6	
Binomial probability of trial result: 4.89784E-84*		

Interpretation: In addition to the need to work long hours and the lack of flexible work arrangements, another attribute of the IT field is the constant need to update skills (Ahuja 2002; Castaño and Webster 2011; Guerrier et al. 2009; Orser, Riding, and Stanley 2012). IT is a field where having up-to-date skills is paramount due to the ever-changing nature of technology, the rapid release of new software and software versions, and requirements for a vast and diverse skillset. GIS technology is also ever-evolving; there are frequent new versions and new types of GIS software made available, and GIS is a field that requires many different types of skills, from design to programming to sophisticated analysis and beyond (and often these are expected from one

individual). The need to update skills regularly is not seen as a negative – it can be a positive situation in which GIS professionals are constantly learning and growing, which can be exciting and rewarding. However, it is also possible that having to update skills regularly could be a burden, especially if updating skills must happen during non-work hours and if it heightens the competitive nature of the field.

91% of participants indicate that they must regularly update their GIS skills. The statistics of the responses strongly support the hypothesis. The p-value is extremely small, indicating that the observed values were not observed by chance, giving strong evidence that the hypothesis for this question is true.

The responses given by black/African American participants are not consistent with the larger population. Seventy-five percent say that there is a need to update GIS skills regularly (p-value= 0.109375, indicating that values might have been observed by chance for this group). While this is consistent with the hypothesis, it is still 15% less than the overall result.

Also, similar to the two questions above, with more time in the GIS field, the more people report that there is a need to update GIS skills regularly – from 83% (from those with 0-3 years in GIS) to 100% (from those with 20-30 years).

Open text analysis for comments: (125 comments)

This question gave participants the opportunity to provide comments. Comments are a starting place from which to more deeply understand the context of having to regularly update GIS skills. In terms of how GIS and IT might be similar, the comment categories that are bolded in the Table 11 show that, similar to IT, GIS is an ever-evolving field that relies on constantly changing technology.

Therefore, the need to update skills is imperative and supports the linkage, if only partial, between GIS and IT.

Table 11. Is there a need to update your GIS skills regularly? (Open text analysis)

Comment Category	Raw #	Percent (of 125)
Inherent aspect of GIS	18	**14.4%**
New versions of software	18	**14.4%**
Not required, but do it for personal benefit	14	11.2%
Self -provided/motivated	10	10%
Technology constantly changing	12	**9.6%**
Company provided and/or encouraged	11	8.8%
Needed - but no company support	11	8.8%
Left behind - stay ahead language -maybe competition	8	6.4%
Difficult to do so (too busy, etc.)	7	5.6%
Inherent aspect of technology field	6	**4.8%**
Relying on web-based learning opportunities	6	4.8%
Not gender specific	2	1.6%
Job pressure motivated	1	.8%

(There are many categories presented above. In future analysis, these categories may be further refined, but here they are all presented to show the rich variety of responses and to also show potential ideas for further exploration.)

Through the comments, it was discovered that six of the 42 participants that answered "no" to the question "Is there a need to update your GIS skills regularly (i.e., learn new software/methods)," still commented that they do update their skills but not because they are required to but rather for "personal benefit."

Another interesting set of comments, even though there were only six (4.8%), had to do with relying on web-based learning opportunities such as Coursera and Code Academy (these two were mentioned specifically), and other webinars and online courses. This is a useful advantage for GIS in general, not just for women. One participant commented, "However, I have found that Python is becoming more and more valuable in the workplace, but we don't have any work sponsored

workshops for that and instead, we learn it on our own time via Coursera and Code [A]cademy." On the one hand it is a negative that companies are not offering these types of professional development activities, but on the other hand it is useful that free trainings are available online. Also noteworthy, is the need for individuals to "learn it on [their] own time."

The comments that were more on the negative side, or indicating difficulty, include things like being too busy, boss/company doesn't understand the benefit, and being hard to keep up. One participant said, "It is constant and hard to keep up with changes in data formats, software changes, both open source and commercial, desktop and web, and with the increasing types of (mostly) online mapping tools and programs such as GeoCommons, MangoMap, ArcGIS Online." This ties into the constantly changing nature of technology/GIS and the constant emergence of new software and new versions – while exciting, this is also a potential burden.

The need to update skills can be viewed as a positive. One participant commented, "The need to keep abreast of new developments and techniques, and to participate in their development, is part of the joys of the field. Likewise, the "need" to update skills is supported through the home agency, and partnerships, with classes, training, books, and professional gatherings and interest groups."

4. Do you need to take continuing education courses and/or other trainings to update knowledge?

Hypothesis: Yes, there is a need to take continuing education courses and/or other trainings to update knowledge.

Question format: Radio – Binary (yes/no)

Table 12. Do you need to take continuing education courses and/or other trainings to update knowledge? (No category filters)

Value	Count	Percent
Yes	333	69.8%
No	144	30.2%
Statistics		
Total responses	477	
Unanswered	7	
Binomial probability of trial result: 7.64385E-19*		

Interpretation: As IT is a field that requires the constant updating of knowledge and skills (as is GIS, supported by the statistics displayed in the preceding question), it might be assumed that taking continuing education courses and/or other trainings would be necessary. Seventy percent of participants indicated that they do need to take continuing education and/or trainings, and 30% said no. The p-value is extremely small, indicating that the observed values were not observed by chance, giving strong evidence that the hypothesis for this question is true.

As mentioned above, while having to learn new skills can be seen as a positive, it is also possible that having to update skills regularly could be a burden, especially if updating skills must happen during non-work hours. Do the continuing education courses and trainings that participants report feeling the need to take, take place during working hours? Some of the comments provided for the previous question show that continuing education and other trainings must and do occur during personal time.

In state and local government, 77-78% of the participants said that they need to take continuing education courses and other trainings to update their knowledge, as compared with only 58% of participants in the private sector. Why is this the case? In response to Question 3 ("Is there a need to update your GIS skills regularly?"), 94% of those in state government, 90% of those in local

government, and 91% of those in the private sector said "yes," which would suggest that participants in these three sectors would need to take continuing education to the same degree. Do government sectors encourage and support (both financially and work schedule-wise) their employees more to take continuing education and other forms of training? For government employees, is there value or ranking associated with credentials provided by continuing education classes? Or is there more informal, on-the-job learning in the private sector that alleviates the need to take formalized training? Other studies whose focus is more on professional development might be interested in further exploring this variable.

Table 13. Do you need to take continuing education courses and/or other trainings to update knowledge? (By sector)

Sector	# Responses	# Yes	# No	% Yes	% No	P-value
Federal Gov.	43	30	13	69.8%	30.2%	0.004158306*
State Gov.	74	58	16	78.4%	21.6%	3.56073E-07*
Regional Gov.[1]	5	4	1	80%	20%	n/a
Local Gov.	106	82	24	77.4%	22.6%	4.79048E-09*
Non-Profit	37	25	12	67.6%	32.4%	0.013478588*
Private	144	84	60	58.3%	41.7%	0.009024804*
Start-Up	11	7	4	63.6%	36.4%	0.161132813
Higher education	39	28	11	71.8%	28.2%	0.003048728*

Other variations in the responses to this question occur among the different categories of experience in years in GIS. Only 60% of those with 0-3 years of GIS experience say that they need to take continuing education and/or other trainings, as opposed to 78% of those with 20-30 years of experience.

Table 14. Do you need to take continuing education courses and/or other trainings to update knowledge? (By number of years in GIS)

Number of Years in GIS	# Responses	# Yes	# No	% Yes	% No	P-value
0-3 yrs.	104	62	42	59.6%	40.4%	0.011484223*
>3 and <=10 yrs.	182	126	56	69.2%	30.8%	6.40099E-08*
>10 and <=20 yrs.	144	108	36	75%	25%	5.05083E-10*
>20 and <=30 yrs.	40	31	9	77.5%	22.5%	0.000248691*
>30 yrs.[2]	3	2	1	66.7%	33.3%	n/a

5. What is the gender ratio of your department in general? Balanced between males and females? Enter two numbers to provide a ratio.

Hypothesis: None. This question asks the gender ratio for the department in general (not just GIS employees). Because it is a more general department ratio rather than GIS specific, it is expected (even though there is no hypothesis) that gender will probably be more balanced than that between males and females of the GIS units (for this, see Research Question B, Survey Question 4). However, while this is the expectation, this question was asked more to acquire background information on the departments in which the survey participants work rather than to confirm a hypothesis.

Question format: Integer/Integer

Table 15. What is the gender ratio of your department in general? (No category filters)

	Women	Men
Average	0.410	0.590
Min	0.020	0.000
Max	1.000	0.980
Median	0.395	0.605
Statistics		
Total responses	469	
Unanswered	15	

Interpretation: On average, participants reported working in an environment that was 40% female (ranging from 2-100%). This does not quite support the expectation that participants would work in perfectly gender-balanced departments. However, at an on average 40% female representation, women are still fairly well-represented in the departments in which they work.

In this study sample, the proportion of women to men across sectors is fairly consistent, with non-profits having the most gender-balanced departments (54% female) and start-ups being the least gender balanced (36% female).

Table 16. What is the gender ratio of your department in general? (By sector)

Sector	# Responses	Average (Female)	Average (Male)
Federal Gov.	43	0.400	0.600
State Gov.	73	0.395	0.605
Regional Gov.[1]	5	0.476	0.524
Local Gov.	105	0.420	0.580
Non-Profit	35	0.543	0.457
Private	143	0.382	0.618
Start-Up	11	0.356	0.644
Higher education	37	0.420	0.580

Again, this question is about the overall proportion of women to men in the departments that the survey participants work in, not just their GIS-specific units. While it can be argued that it is more important for women in GIS to be surrounded by other female GIS colleagues, having a gender-balanced department overall could also be beneficial. Having other women in the broader department, even women without GIS knowledge or experience, could provide more opportunities for mentorship and creating networks, and potentially neutralize some of the obstacles that can arise from a less gender-balanced environment.

6. **If there is an imbalanced ratio, with more men, do you feel that there is a male-dominated culture? For example, "boys club" type situation? Do you feel excluded in any way from activities?**

Hypothesis: Yes, if there is an imbalanced ratio in the department in general, participants will perceive a "boys club" type situation and/or feel excluded.

Question format: Radio – yes/no/not applicable

Table 17. If there is an imbalanced ratio, with more men, do you feel that there is a male-dominated culture? (No category filters)

Value	Count	Percent
Yes	125	26.3%
No	258	54.3%
Not applicable	92	19.4%
Statistics		
Total responses	475	
Unanswered	9	
Chi-squared test: 6.58135E-22*		

Interpretation: Another aspect of the IT field that is not positive for women's equal participation is the prevalence of a male dominated culture and/or a "boys club" type situation that excludes women (Ahuja 2002; Bastalich et al. 2007; Cross and Linehan 2006; Tapia and Kvasny 2004; Wentling and Thomas 2014). An example of a problem that is connected to a male dominated culture is that women can be excluded from informal networks that are essential for learning about new opportunities (Ahuja 2002; Cross and Linehan 2006). In the continued attempt to investigate how IT and GIS might be similar in relation to women's experiences and participation, the survey asked women if they perceive a male dominated culture and/or if they feel excluded in any way. It was expected that participants would answer this "yes." Only 26% indicated that they feel there is a male dominated culture in their workplace and 54% indicated that they do not feel this way. The p-value is extremely small, indicating that the observed values were not observed by chance, giving strong evidence that the hypothesis for this question is not true.

There is a notable pattern in the difference of the percentage of participants responding yes, they perceive a dominant male culture and/or feel excluded, as the number of years in GIS increases. Twenty-one percent of participants with 0-3 years of GIS experience reported that they sense a male dominated culture and/or feel excluded ramping up to 33% of participants with 20-30 years of GIS experience. While these numbers still don't validate the hypothesis, it is interesting to note

and consider what factors make women with more years in GIS increasingly sense a male dominated culture and/or feel more excluded. Is it due to the presence of a glass ceiling? Or, was the representation of women in GIS different when they first entered the field thereby making their perceptions of the current situation different than those of newcomers to GIS (that is, they continue to sense a male dominated culture due to their first impressions)? Or, could attitudes toward age be involved?

Table 18. If there is an imbalanced ratio, with more men, do you feel that there is a male-dominated culture? (By number of years in GIS)

Number of Years in GIS	# Responses	# Yes	# No	# N/A	% Yes	% No	% N/A	P-value
0-3 yrs.	100	21	55	24	**21.0%**	55.0%	24.0%	2.41796E-05*
>3 and <=10 yrs.	183	44	105	34	**24.0%**	57.4%	18.6%	3.05055E-11*
>10 and <=20 yrs.	143	45	74	24	**31.5%**	51.7%	16.8%	1.80712E-06*
>20 and <=30 yrs.	40	13	19	8	**32.5%**	47.5%	20.0%	0.102796908
>30 yrs.[2]	3	0	1	2	0%	66.7%	33.3%	n/a

Even though certain participants might have a higher perception of a male dominated culture and/or feel excluded from the culture and activities of the departments in which they work, overall most participants either do not feel that way or they are in gender balanced departments. This is another way in which GIS is dissimilar to IT – in addition to the lower likelihood of having to work long hours and the greater occurrence of flexible work arrangements, it appears that a "boys club" culture is less present, or at least less evident, in the GIS realm. Thus far, the only strong commonality between IT and GIS that has been uncovered by the survey results is the need to update skills regularly.

(QUESTIONS 7-11 WERE ASKED AS CLUSTER OF QUESTIONS IN THE SURVEY. DISCUSSION OF ALL ARE PRESENTED UNDER QUESTION 11.)

7. Do people in your department socialize after work?
8. Do people in your department (or company) go to GIS-related meetups?
9. Do you participate in these activities? Which ones?
10. Why or why not?
11. If you do participate, what is the benefit of doing so?

Hypothesis: Both general department and GIS specific socializing is prevalent and important. However, there might be some factors that impede women's participation.

Question format: Open text

Note: Due to the wording of this set of questions and subjective nature of the responses, the analysis, while providing good insights, is not quantitatively verifiable.

Open text analysis: (469 comments/responses)

Table 19. Socializing

Do people in your department socialize after work?	**Raw #**	**Percent (of 469)**
Yes	189	40.9%
No	172	36.7%
Occasionally	63	13.4%
Infrequently	30	6.9%
Don't know	5	1.1%
N/A – includes: one person department, self-employed	7	1.5%
Do people in your department (or company) go to GIS-related meetups?	**Raw #**	**Percent (of 467)**
Yes	229	47.3%
No	159	32.9%
Occasionally	35	7.2%
Infrequently	23	4.8%
Don't know	9	1.9%
N/A – includes: one person department, self-employed, works in a non-GIS centric department/company	12	2.8%

Interpretation: Just about half of the participants (54%, including those who said "yes" and "occasionally") report that people in their departments socialize after work. About the same amount (55%, including those who said "yes" and "occasionally") report that people in their departments or companies go to GIS-related meetups. Both of these percentages are not enough to confirm that after-work socializing and attending GIS-related meetups is the norm, but they are enough to confirm that social gatherings, GIS-related or not, are common. Participating in these

social events might be deemed important and beneficial – enough women report their occurrence to suggest that the events themselves are of value.

The last two questions in this cluster were posed to collect more information about the benefits participants perceive, as well as to ask participants why they might not participate. The qualitative aspects of this suite of questions (such as asking why one does or doesn't participate; what are the benefits of doing so) are captured below. As mentioned above, it was not possible to statistically quantify these responses. There was not a baseline from which to base the percentages, therefore only raw numbers are presented.

Motivating factors:

- Networking = 152
- Fun = 24
- Social = 46
- Community (GIS specific) = 37
- Meet new people outside of work = 6
- Learning = 119
- New software/technology = 15
- Coworker relationships = 51
- Not to feel isolated (general) = 2
- Not to feel isolated (woman specific) = 1

Dissuading factors:

- Time constraints = 20
- Child/family care issue (includes "I'd rather spend my time with family" responses) = 27
- Other work-life balance issue = 2
- Location (e.g., Too far from home/work) = 10
- Age difference (respondent felt older than others) = 1
- Just not interested = 7
- Feels discouraged from participating = 6
- Feels discouraged from participating (woman specific) = 5
- Is a manager (so does not participate in department/work socializing) = 1
- Is the only GIS person in department (so department specific GIS socializing not applicable) = 5

The comments were broadly assigned to one of two categories: motivating or dissuading factors. This gave a useful starting point from which to understand why women, or people in general, might, or might not, participate in after-work social gatherings. Overwhelmingly, the women commented on the fun and social nature of these gatherings, and that they really enjoy participating. Beyond the fun aspects, the GIS-related gatherings are also great places to learn new skills and be exposed

to new ideas. Additionally, some participants spoke of a GIS community. That seems to be one of the exceptional things about working in GIS – there is a community of people who enjoy spending time together and sharing their knowledge. Regarding why they might not participate, time is a factor that impedes women's participation. Examples of comments that fall into this and related categories are the difficulty of working a full-time schedule and then having to make time after work to spend more time with coworkers, or time at social events is time that conflicts with family time. Even location is a time related dissuading factor – the distance and inconvenience of the locations where events occur is impractical for some participants.

SUMMARY OF RESEARCH QUESTION A

Is GIS similar or dissimilar to IT in terms of its culture and women's experience of it?

While IT and GIS share some similarities, they differ in many respects. As far as dissimilarities go, the survey responses show that those who work in GIS are not required to work long hours as is common in IT, and also that GIS workplaces allow for more flexible work arrangements. However, IT and GIS are very similar in their constant need to update knowledge and skills. This seems to be an inherent aspect of technology itself – and since technology constantly evolves, GIS workers too must constantly evolve. The survey results also disprove the hypothesis that a male dominated culture is present and/or perceived in GIS.

Regarding socializing after work in GIS-related meetups and general departmental outings, many participants report taking part in such activities. In order to determine to what degree women participate further testing through other research studies would be required. However, many women seem to participate in socializing and list many benefits. Some participants have also listed helpful reasons why they do not participate, which might aid social group leaders in future planning. It would be beneficial to determine the degree to which women participate in work-

related social gatherings, given the importance placed on such activities for participating in the "dominant culture" and to avoiding missing out on opportunities, as discussed in the literature reviewed for this thesis (Ahuja 2002).

Essentially, through the findings of this portion of the survey, there is enough information to conclude that while GIS and IT are both technical fields, GIS differs in its work conditions and work culture, as well as in women's experience of it. Therefore, GIS is a field that requires its own research and body of diversity literature. Another conclusion is that GIS seems to provide an overall better environment, in terms of schedule, flexibility, and gender balanced culture, not only for women, but for people in general.

B. Research Question/Purpose: Is vertical (and horizontal) segregation as prevalent in GIS as it is in IT and in science professions?

Are women relegated to the lower ranks across GIS niches? Are they more represented in certain niches (e.g., more programmers versus analysts)? Are they better represented in certain industries/sectors (e.g., more in state government but less in startups)? Questions in this survey section also help to answer if there is an underrepresentation of women in GIS.

Survey page header (page 4 on survey): *Is there clustering (non-spatial!) of women in GIS?*

Context for survey participants: *According to literature regarding women in science and technology careers, women are more frequently found in certain types of positions – both in "horizontal" (spread unevenly in different sub-fields) and in "vertical" (at different levels) senses. In science, it is contended that women are more active in certain disciplines (biology instead of physics, for example), and in IT related careers, there are higher numbers of women in non-highly technical roles. Is this pattern also present in GIS?*

The section of this survey that focuses on the hybrid nature of GIS (see below) provides further insights that help to answer this research question, and further relevant discussion is presented there.

SURVEY QUESTIONS:

1. **What sector is your position in (state, federal, local government, non-profit, startup, etc.)?**

Hypothesis: None – this question was asked to learn where people (women) in GIS work. However, it is expected that women will be clustered somewhere.

Question format: Radio plus "Other"

Table 20. What sector is your position in? (No category filters)

Value	Count	Percent
Federal Government	43	9.0%
State Government	76	15.9%
Regional Government[4]	5	1.0%
Local Government	107	22.3%
Non-profit	37	7.7%
Start-up	11	2.3%
For profit ("Private")	144	30.1%
Higher education	39	8.1%
Other	17	3.5%
Statistics		
Total responses	479	
Unanswered	5	
Chi-squared test: 7.59793E-67*		

Interpretation: According to the literature, a characteristic of women in science and technology is that they are clustered in certain disciplines (Blickenstaff 2005; Glover 2002; Heilbronner 2012; Kohlstedt 2004; Prescott and Bogg 2011; Sonnert 1999). While the categories shown here are sectors and not disciplines, by seeing what sectors of GIS women work in, one can start to examine if there is clustering or prevalence of women in certain areas and not in others. It is possible that certain sectors might simply have more GIS positions, and that more women are found in certain sectors might not have anything to do with gender-based clustering – it might simply have to do with the availability of jobs.

A majority of the participants (48%) work in government, 22% of which are in local government, and the next highest group is in private companies, at 30%. Contrast this with the non-profit sector with only 8% of the survey participants and start-ups with only 2%. The p-value is extremely small,

[4] Regional government includes county; For-profit ("Private") includes private consulting, corporate/commercial/industry, GIS vendor, software, mining, utility, engineering, energy; Higher education includes university, academic, higher education, education; Other – not able to categorize.

indicating that the observed values were not observed by chance. While there is no hypothesis for this question, the results do show that the participants are more heavily clustered into certain sectors, which can be a starting point to determine if there is horizontal segregation of women into certain sectors. Again, further data would need to be collected about how many people, men and women, are working in these sectors to begin with (Survey Question 5 of this section does collect information about male to female ratios for GIS departments, and is a good starting point to examine this information; however GIS surveys that include both male and female participants would be beneficial).

Please note that sectors are further broken down in other places in this chapter to analyze their composition by race/ethnicity, age, and by number of women with certain amounts of GIS experience.

2. More specific sector: e.g. transportation, environmental, education, etc.

Hypothesis: None. This question asked to learn where people (women) in GIS work.

Question format: Multiple choice plus "Other"

Table 21. More specific sector (No category filters)

Value	Count	Percent
Transportation	62	13.3%
Environmental	161	34.6%
Education	78	16.7%
Other	290	62.2%

Interpretation: In testimony to the diversity of GIS positions, **75** unique sectors were mentioned by participants responding to this question. Due to the large amount of unique sectors, all are listed below but are not quantified in any manner. Some sectors were more common than others (such as Oil and Gas or Urban Planning). Nonetheless, there was not enough of a pattern or quantity of any industry to justify the coding of this question. However, the diverse sectors/industries that people

find themselves in is interesting in and of itself – it says a lot about GIS fields and other fields in which GIS is utilized).

More specific sectors mentioned:

- Advertising
- Archeology
- Architecture
- Bike and pedestrian planning
- Cadastral
- City government
- Coastal safety
- Conservation
- Consulting
- County government
- Database/data management
- Defense
- Earth observation
- Economic development
- Elections
- Emergency management and/or preparedness
- Energy
- Engineering consulting
- Environment
- Fire
- Food production
- Forestry
- Geography
- Geospatial coordination
- GIS data clearinghouse
- Health/Public health
- Historic preservation
- History
- Hydrology
- Imaging
- Insurance
- International development
- IT
- K-12 Education/Student Transportation
- Land use
- Landscape architecture
- Law enforcement
- Make survey equipment
- Mapping equipment sales
- Marine
- Marketing
- Military contractor
- Mining
- Multiple/interdisciplinary
- Municipal government
- Natural Resources
- Oceanography
- Oil and gas
- Parks and recreation
- Physical science
- Policy development
- Population/census
- Public safety
- Public works
- Real estate
- Remote sensing
- Research
- Sales
- Sewer
- Social equity
- Software development
- Soil science
- Surveying
- Tax and accounting
- Telecommunication
- Timber inventory
- Tourism
- Urban planning or planning
- Utilities
- Water, wastewater or water infrastructure

3. **How would you categorize your work (programming, analysis, cartography, administrator, other)?**

Hypothesis: Based on the literature review, it is hypothesized that there will be an uneven number of women doing different kinds of GIS work. Specifically, it is expected that there will be fewer women doing certain types of tasks that men have traditionally done, such as programming.

Informal observations based on knowledge gained in GIS meetings and from working in the field further lead to the expectation that women will more likely lean towards analysis rather than programming. The following shows the broad types of work reported by participants. Specific skills and tasks are covered in more detail in the section below on the hybrid nature of GIS.

Question format: Multiple choice plus "Other"

Table 22. How would you categorize your work? (No category filters)

Value	Count	Percent
Programming	110	23.1%
Analysis	337	70.7%
Cartography	276	57.9%
Administrator	138	28.9%
Other	225	47.2%
Statistics		
Total responses	477	
Unanswered	7	

Chi-square test was not done on this question because these categories are not mutually exclusive.

Interpretation: The IT-focused literature review describes a situation in which women tend to be found in lower-level positions within IT or in positions that are less technical in focus (Ahuja 2002; Cross and Linehan 2006; Glover 2002; Tapia and Kvasny 2004; Wentling and Thomas 2014). In the IT fields, this means that fewer women are seen in high-level management positions, and are more likely to be specialists in using and supporting productivity applications than, say, managing networks or working as database administrators. This question aims to be a starting point from which to see if a similar situation exists in GIS (the imbalance of women filling higher level positions is not directly assessed in the current analysis, however the degree to which women use management skills is explored in the section below on the hybrid nature of GIS).

The numbers gathered through this question show that there is a pattern of women doing more analysis and cartography work than doing programming work. Seventy-one percent of the

participants categorize their work as analysis and 58% as cartography. Only 23% of participants categorize their work as programming. While a p-value was not computed for this question due to the non-mutually exclusive categories, the percentages support the hypothesis.

Analysis, cartography, and programming are all highly technical and require advanced analytical skills. What is driving women more towards analysis and cartography and less towards programming? How are the technical aspects of analysis and cartography different from those of programming? Can the differences help explain the trend? Better understanding of the differences among these GIS technical domains, beyond aiding in possibly explaining this trend, would further help in determining if women's clustering within these areas of specialization truly has something to do with gender-based horizontal segregation, or if this trend is due to some other cause. Additionally, learning the spread of what men in GIS do would be a helpful comparison – perhaps men would report a similar trend.

Do participants change how they categorize their work over the span of their careers? The percentage of participants who categorize their work as programming, analysis, and/or cartography peaks among those with 3-10 years of GIS experience. Meanwhile, the percentage of those that categorize their work as "administrator" increases with more years in GIS.

Table 23. How would you categorize your work? (By number of years in GIS)

Number of Years in GIS	Programming	Analysis	Cartography	Administrator
0-3 yrs.	20.4%	68.0%	55.3%	14.6%
>3 and <=10 yrs.	24.6%	79.2%	67.2%	26.2%
>10 and <=20 yrs.	23.8%	65.7%	52.4%	38.5%
>20 and <=30 yrs.	19.0%	57.1%	42.9%	45.2%
>30 yrs.[2]	33.3%	33.3%	33.3%	0.0%

Open text analysis for "Other": The multiple choices for this question only included "programming," "analysis," "cartography," and "administrator." Because GIS work entails much

more than these four categories, the survey participants were allowed to submit text responses under "Other." Similar to the responses that were given to the question about their specific sector, the "Other" work option yielded many diverse answers, as shown below:

- **People-centric: 55 (11.6%)**
  - Help desk
  - Instructor
  - Sales
  - Support
  - Customer service
  - Training
  - Education
  - Outreach
- **Manager: 38 (7.9%)**
  - Project or Program Manager
  - Manager
    GIS Manager
- **Other** (not quantified since very disparate):
  - Executive/Director
  - Lead (i.e., "Strategic lead")
  - Data management (including processing, mining, etc.) and database administration
  - Coordinator/coordinating
  - Data collection
  - Professor/Faculty (only 5 responded with this)
  - Design (includes maps/graphics/infographics/etc.)
  - Marketing
  - Research
  - Planning
  - Consulting
  - Mix

Again, under the hybrid nature of GIS section, there is further discussion on GIS tasks and the skills women leverage to perform their work.

4. How many people are working in your GIS section?

See questions 5 and 6

5. How many of those are full-time, how many are part-time?

Hypothesis: None. This question was asked to gauge how many part-time positions there are in comparison to full-time jobs, and if there is a pattern as to who might be in these jobs (more men or women?). While there is no hypothesis, it is expected that there are not many part-time positions in GIS overall.

Question format: Integer/Integer

Table 24. Full-time and part-time positions (No category filters)

Value	Count	Percent
Full-time	10712	96.8%
Part-time	354	3.2%
TOTAL	11066	
Statistics		
Total Responses	457	
Unanswered	27	

Table 25. Full-time and part-time positions – Men vs. Women (No category filters and by sector)

	TOTAL (FT and PT)	FT Total	PT Total	FT Women	FT Men	PT Women	PT Men
All (No Filter)	11066	10712	354	4403 41%	6309 59%	198 56%	156 44%
Sector	**TOTAL (FT and PT)**	**FT Total**	**PT Total**	**FT Women**	**FT Men**	**PT Women**	**PT Men**
Federal Gov.	1387	1340 96.6%	47 3.4%	487 36.3%	853 63.7%	21 44.7%	26 55.3%
State Gov.	396	349 88.1%	47 11.9%	133 38.1%	216 61.9%	30 63.8%	17 36.2%
Regional Gov.[1]	19	16 84.2%	3 15.8%	7 43.8%	9 56.3%	1 33.3%	2 66.7%
Local Gov.	3136	3092 98.6%	44 **1.4%**	1861 60.2%	1231 39.8%	29 65.9%	15 34.1%
Non-Profit	237	206 86.9%	31 13.1%	91 44.2%	115 55.8%	16 51.6%	15 48.4%
Private	5035	4969 98.7%	66 **1.3%**	1576 31.7%	3393 68.3%	54 **81.8%**	12 18.2%
Start-Up	54	44 81.5%	10 **18.5%**	11 25%	33 75%	4 40%	6 **60%**
Higher education	217	172 79.3%	45 20.7%	58 33.7%	114 66.3%	17 37.8%	28 62.2%
Other	585	524 89.6%	61 10.4%	179 34.2%	345 65.8%	26 42.6%	35 57.4%

The percentages presented in this table are per the color coded columns.

Interpretation: Overall, there are not many part-time positions in GIS – of the total positions that were reported by participants, only 3% are part-time. The interest in the availability of part-time jobs partially stems from the flexibility that they might offer. Literature suggests that part-time positions or flexible work arrangements are not widely available in IT (Ahuja 2002; Castaño and Webster 2011; Cross and Linehan 2006; Guerrier et al. 2009; Prescott and Bogg 2011; Orser, Riding, and Stanley 2012.) However, survey participants do report that flexible work arrangements

are available to them under Research Question A. Yet the low frequency of people reported as having part-time positions suggests that part-time work, specifically, is not commonly offered as a flexible work arrangement. Providing part-time work is suggested for aiding women who leave work to care for family members to then more easily and successfully return to the professional sphere (Hewlett and Luce 2005). The creation of more GIS positions might be beneficial for such cases.

The start-up sector is the one boasting the largest percentage of part-time jobs (19%; excluding discussion of higher education as it is expected that this sector would have many non-full-time schedules), while the local government sector is the one with the fewest part-time jobs (1.4%). In terms of who is holding the part-time positions within the sectors, many of the sectors have more women holding the part-time positions, versus men, such as state government (64%), local government (66%), and the private sector with the most at 82%. The sectors in which there are more men holding part-time positions than women are the federal government (55%), start-ups (60%, please note these numbers might have been observed by chance), and the higher education sector (62%).

6. How many women and how many men work in GIS departments?

Is there an underrepresentation of women in GIS?

(Question posed in survey: "How many of them are women (full-time or part-time)?")

Hypothesis: There will be fewer women than men in the GIS departments of the survey participants. Through these results it can be extrapolated that women are underrepresented in GIS.

Question format: Integer/Integer (Note: aggregate of full and part-time values was used to come up with the total number of men and women in GIS)

Table 26. How many women and how many men work in GIS departments? (No category filters)

Value	Count	Percent
Men	6465	58.4%
Women	4601	41.6%
TOTAL	11066	
Statistics		
Total responses	457	
Unanswered	27	
Chi-squared test: 2.96727E-70*		

Interpretation: Are there fewer women in GIS than men? Yes, but perhaps not enough so to indicate an underrepresentation. The survey results show that of the GIS universe described by the survey participants, 58% are men and 42% are women. The p-value is extremely small, indicating that the observed values were not observed by chance. While this gives evidence that the hypothesis for this question is true (that the split is not 50-50), there are still a considerable number of women in GIS.

Table 27 below shows how the results vary by sector. Certain sectors, such as state government and non-profits have a more "balanced" representation (state government = 59% male, 41% female; non-profit = 55% male, 45% female), while others do not. At one end of the spectrum are start-ups, which have 72% male representation, and at the other end is local government, which has greater female representation than male representation with 60% women. Even within government there is a lot of variation – federal government only has 37% female representation, while, again, local government has 60% women.

Table 27. How many women and how many men work in GIS departments? (By sector)

Sector	# Responses	Total (men and women)	Men	Women	% Men	% Women	P-value
Federal Gov.	43	1387	879	508	*63.4%*	*36.6%*	2.24081E-23*
State Gov.	72	396	233	163	*58.8%*	*41.2%*	0.000435415*
Regional Gov.[1]	5	19	11	8	*57.9%*	*42.1%*	0.491297124
Local Gov.	106	3136	1246	1890	*39.7%*	*60.3%*	1.31915E-30*
Non-Profit	36	237	130	107	*54.9%*	*45.1%*	0.135172863
Private	134	5035	3405	1630	*67.6%*	*32.4%*	4.2101E-138*
Start-Up	10	54	39	15	*72.2%*	*27.8%*	0.001090835*
Higher education	35	217	142	75	*65.4%*	*34.6%*	5.40922E-06*
Other	16	585	380	205	*65.0%*	*35.0%*	--

When broken down by sectors, the data provide further insights for the first question in this section, regarding whether more women would be found in certain sectors than others. Although more women might be found in certain sectors than others, this does not mean that they will necessarily be well represented within those sectors in comparison to men. The two sectors where the largest percentage of participants work are the private sector (30%) and the local government sector (22%). However, while the local government sector has more women than it does men, women are poorly represented in the private sector (there are 68% men and 32% women). Meanwhile, only 8% of the survey participants work in non-profits, but there they make up 45% of the workforce. What deductions can be made by comparing and combining both of these sets of information? Perhaps it verifies the idea that there are simply more jobs in certain sectors and that it does not indicate a clustering of women into certain sectors due to gender-related factors.

Also of note is that the results of this question are quite similar to the results from Survey Question 5, Research Question A, which asked "What is the gender ratio of your department in general?" Again, participants reported working in an environment that was on average 40% female (overall departments, not just GIS specific units). Either the ratio of males to females in GIS units is in line with the male/female ratio in larger, non-GIS specific departments, or a majority of the survey participants works in GIS specific departments (that are not housed within other larger

departments). This distinction could be meaningful if it is an indication that the GIS department gender ratios are proportional to other non-GIS departments. This could potentially mean that gender imbalance is not a GIS specific issue, but a workplace issue in general.

While balanced ratios are important, balanced representation goes beyond numbers. For example, in literature regarding women in IT, information was uncovered that in attempts to attain mandatory "diversity targets," hiring managers sometimes make sure *overall* department gender ratios are balanced, regardless of the nature of specific positions (Guerrier et al. 2009). That is, as long as the overall departmental ratio is balanced, it doesn't matter if women are filling the support roles and men the more technical and managerial roles (Guerrier et al. 2009). An awareness of these types of practices, whether intentional or accidental, is important when examining things like gender balance in professional GIS. Just because women make up 42% of the GIS workforce, a closer look needs to be taken at the *nature* of the positions they hold.

To that end, other survey results can also be combined with the findings of this question to better understand female representation. For example, "Is your supervisor male or female," (Question 4 of the following section). As is expanded on below, more participants have male supervisors – suggesting that while there may not be an overall gross underrepresentation of women in GIS, there is still some unevenness to account for. That is to say that even if women are numerically well represented in the field, is the distribution of types of jobs held by men and women evenly balanced? Are women doing the same types of GIS work as men are? The extent that women use certain skills is examined through a number of skills-related questions under Research Question D below in order to better address not only the question of whether there is an underrepresentation, but also to determine what the representation looks like.

7. Do you feel that there are enough women in your department?

Hypothesis: No, women will not feel that there are enough women in their department.

Question format: Likert plus comments

Table 28. Do you feel that there are enough women in your department? (No category filters)

Value	Count	Percent
Definitely not	60	12.9%
Probably not	89	19.2%
Ambivalent	148	31.9%
Probably yes	101	21.8%
Definitely yes	66	14.2%
Statistics		
Total responses	464	
Unanswered	20	
Chi-squared test: 8.33E-11*		

Interpretation: It was expected that women would feel that there are not enough other women in the departments in which they work. "Enough" for what? This question was asked as a counterpoint to the questions above about how many people work in GIS departments, and, of those, how many are women. While those questions aim at numerically determining if there is an underrepresentation of women in GIS, this question aims to understand whether women *perceive* an underrepresentation.

The responses to the question "Do you feel that there are enough women in your GIS section" are pretty evenly spread out – with 32% leaning towards thinking that there are not enough women ("definitely not" and "probably not" combined) compared with 36% leaning towards yes, there are enough women ("definitely yes" and "probably yes" combined). The p-value is extremely small, indicating that the observed values were not observed by chance. However due to the spread of numbers, the hypothesis is neither confirmed nor disproved.

Most groupings of participants (by sector and by race/ethnicity) answered this question fairly consistently. However, some interesting variability occurs by number of years in GIS groups. With more years in GIS, those saying "definitely yes" drop off. Seventeen percent of those with 0-3 years of GIS experience say "definitely yes," falling to only 8% of those with 20-30 years in GIS. This is one example in the survey where it is seen that participants with more than 20 years of GIS experience have different views than their more junior counterparts. Results such as this suggest that the first generation of women in GIS are possibly either pushing against a glass ceiling or may have memories of the GIS field from when they entered it (probably one that had even fewer women).

Table 29. Do you feel that there are enough women in your department? (By number of years in GIS)

Number of Years in GIS	# Responses	Def. not	Prob. not	Ambiva-lent	Prob. yes	Def. yes	P-value
0-3 yrs.	99	10 10.1%	17 17.2%	33 33.3%	22 22.2%	17 17.2%	0.005396744*
>3 and <=10 yrs.	180	20 11.1%	32 17.8%	57 31.7%	43 23.9%	28 15.6%	0.000129904*
>10 and <=20 yrs.	137	24 17.5%	33 24.1%	38 27.7%	26 19.0%	16 11.7%	0.033049284*
>20 and <=30 yrs.	40	5 12.5%	7 17.5%	17 42.5%	8 20.0%	3 7.5%	0.005858939*
>30 yrs.[2]	3	0 0%	0 0%	2 66.7%	1 33.3%	0 0%	n/a

Open text analysis for comments:

The comments participants submitted for this question yielded no landslide categories. However, one comment that is particularly relevant to and supports the notion that the first female GIS generation has had a different experience than newer women to GIS is: "Most of the older people here in GIS are men. The spread of men/women just among the newer younger recruits is more even." Also relating to an age related factor, one woman commented, "The men are all higher level, the women lower... but the women are also all younger than the men."

Another comment from another survey question reviewed further below ("If you chose to participate in a formal mentoring program, would you prefer to have a male or female mentor?") that is relevant to the change in women's participation in GIS over time is, "When I first started my GIS career in the mid 1990's I was almost always the only female at meetings, working groups and conferences/training. In the last few years it seems that the number of women in the GIS field has exploded and this is very apparent whenever I attend GIS gatherings now."

SUMMARY OF RESEARCH QUESTION B

Is vertical (and horizontal) segregation as prevalent in GIS as it is in IT and in science professions? Are women relegated to the lower ranks across GIS niches? Are they more represented in certain niches (e.g. more programmers versus analysts)? Are they more represented in certain industries/sectors (i.e. more in state government but less in startups)?

The questions in this survey section serve several purposes. The most important purpose was to address the primary research question of "Is there an underrepresentation of women in GIS?" It was found that the GIS professional workforce (reflected by the GIS departments of the survey participants) is 42% female. While this is not a 50-50 balance, 42% could be considered a good level of representation, especially in light of the fact that according to 2014 DOL figures women make up 47% of the overall labor force. Authors of diversity in STEM literature suggest that women's representation in STEM ought to reflect their representation in the larger labor pool (Ahuja 2002; Beede et al. 2011; Cross and Linehan 2006), and it appears that women's representation in GIS closely does. However, representation varies by sector. There seems to be a greater issue in start-ups and the greater private sector, which only have 28% and 32% female representation, respectively. But other sectors like state government and non-profits have a better

balanced representation (state government = 41% female; non-profit = 45% female). Local government has *greater* female representation than male representation with 60% women.

This section also served the purpose of finding out more about where women in GIS work – in what sectors and in what specialized areas are women predominantly found? The above paragraph talks about the proportion of women to men *within* sectors, this asks the spread of the participants *across* sectors. More participants work in certain sectors such as local government or in private companies. However, while more women might be found in these sectors as compared to others, it is not guaranteed that they will be represented in equal measure to men. For example, while the largest portion of participants (30%) works in the private sector, that sector is made up of 68% men and only 32% women. Through individual questions and by combining data from several questions, important observations can be made about the proportion of women across and within sectors. Additionally, the information about sectors is utilized to filter survey responses, providing a glimpse into what, if any, differences there are in responses per sector.

Next, the question, "How would you categorize your work (programming, analysis, cartography…)," serves to offer a preliminary sense of how many women are doing specific kinds of GIS work. It was found that the participants do analysis much more than programming, and, by establishing this pattern, the question emerged of why more women do one type of technical task compared to another. The skills that women use in work are explored in greater depth in Research Question D below. Research Question D is crucial to understanding whether GIS displays the same tendency found in IT in which women fill fewer technical or management-level jobs (which is connected to the idea of horizontal and vertical segregation).

The last question, "Do you feel that there are enough women in your department," is one of the first questions in the survey that starts to address whether women *perceive* an underrepresentation, as

opposed to trying to ascertain whether such an underrepresentation exists in reality. Thirty-two percent of the participants answered that there are not enough women ("definitely not" and "probably not" combined) and 36% responded there are enough women ("definitely yes" and "probably yes" combined). As is explored through this and other questions in the survey, whether or not there is a significant underrepresentation of women in GIS, "uneven" representation (for example, with more male managers or with fewer women in highly technical roles) might well increase women's perceptions that such an underrepresentation does exist.

Returning to the research questions that were posed at the beginning of this section, one of the aims of the survey was to uncover if vertical and horizontal segregation exist in GIS as they do in other STEM fields. Specifically, the survey sought to determine if women are in or are performing managerial roles and tasks and whether women are called upon to leverage highly technical skills (in addition to what are termed "soft" skills). The responses from Research Question D below are necessary to fully explore these issues and, as such, the discussion of vertical and horizontal segregation will continue there.

C. Research Question/Purpose: To gather information that might help in forming and influencing thought on mentoring relationships and networking groups.

Survey Page Header (page 5 on survey): *Mentoring and networking*

Context for survey participants: *Is it better for women to have female or male mentors? What is the value of female-focused GIS and other professional groups?* ***The purpose of the questions below are to gather information that might help in forming and influencing thought on mentoring relationships and networking groups.***

SURVEY QUESTIONS:

1. If you chose to participate in a formal mentoring program, would you prefer to have a male or female mentor? Why?

Hypothesis: Women would prefer to have a female mentor. However, the main aim of this question is to see if women do have a preference, and, if so, what that preference is, in order to influence both the authors of mentoring and networking research and other bodies that create mentoring and mentoring opportunities.

Question format: Radio plus textbox for "Why?"

Table 30. If you chose to participate in a formal mentoring program, would you prefer to have a male or female mentor? (No category filters)

Value	Count	Percent
I would prefer a female mentor.	86	18.0%
I would prefer a male mentor.	22	4.6%
I don't have a preference.	370	77.4%
Statistics		
Total responses	478	
Unanswered	6	
Chi-squared test: 3.04182E-94*		

Interpretation: Is it possible that women might be more interested in having (and that it would be better to have) female mentors (Cheryan et al. 2011; Orser, Riding, and Stanley 2012)? Would women might feel more comfortable with female mentors because they would be able to better relate to one another? Would women in managerial or executive roles can provide a good source of inspiration and a positive example of successful navigation of a potentially male dominated work environment? Conversely, would it be better for women to have male mentors, whereby such mentorships could facilitate a positive experience for the male mentor and the female mentee alike? Male mentors, by mentoring female colleagues, might become more aware of the capacities and potential challenges faced by their female counterparts. Female mentees on the other hand, if receiving the guidance and support of a higher-level male colleague, might gain greater confidence to participate in male dominated workspaces. Additionally, women with male mentors might gain greater access to those male networks from which they might otherwise be excluded. These lines of thought could be extended to include participation in informal mentoring situations and networking as well. Despite the potential compelling reasons to have a male mentor, it was hypothesized that women in GIS would prefer to have female mentors largely based on the possibility that women might simply feel more comfortable with other women.

Only 18% of the survey participants said that they would like a female mentor. Even less are interested in having a male mentor – only 5% say that this would be their preference. A grand majority of the participants, 77%, do not have a preference. The p-value is extremely small, indicating that the observed values were not observed by chance, and giving strong evidence that the hypothesis for this question is not true.

With more years in GIS, it seems that the percentage of those who specifically want a female mentor lessens dramatically, and the percentage of those who want a male mentor increases somewhat.

Twenty-one percent of participants with 0-3 years of GIS experience would prefer to have a female mentor, while only 5% of those with 20-30 years would want the same. Conversely, only 3% of the group with 0-3 years of experience, as compared with 7% of the 20-30 years group, would prefer a male mentor. While this is not an extreme variation, even this small amount could be meaningful if those who have between 20-30 years of experience are the ones vying for senior level positions. Having a male mentor at that specific point in their careers (when they might be competing with more males) could be even more beneficial than in earlier career stages.

Table 31. If you chose to participate in a formal mentoring program, would you prefer to have a male or female mentor? (By number of years in GIS)

Number of Years in GIS	# Responses	Female Mentor	Male Mentor	No Preference	P-value
0-3 yrs.	103	22 21.4%	3 2.9%	78 75.7%	5.87173E-20*
>3 and <=10 yrs.	183	34 18.6%	7 3.8%	142 77.6%	4.66417E-37*
>10 and <=20 yrs.	144	28 19.4%	9 6.3%	107 74.3%	3.6466E-25*
>20 and <=30 yrs.	42	2 4.8%	3 7.1%	37 88.1%	4.83782E-13*
>30 yrs.[2]	3	0 0%	0 0%	3 100%	n/a

The occurrence of selecting "no preference" increases the older the participants are. What are the other possible causes for this? Despite the potentially greater career hurdles over which one might have to jump the farther one goes in her career, perhaps with age the less value one attaches to the notion of a mentor and, with that, perhaps less value to the gender of that mentor?

Table 32. If you chose to participate in a formal mentoring program, would you prefer to have a male or female mentor? (By age bracket)

Age Bracket	# Responses	Female Mentor	Male Mentor	No Preference	P-value
21-30	121	28 23.1%	4 3.3%	89 73.6%	2.10164E-21*
31-40	184	36 19.6%	10 5.4%	138 75%	3.87627E-33*
41-50	94	15 16%	2 2.1%	77 81.9%	5.43848E-23*
51-60	55	6 10.9%	2 3.6%	47 85.5%	2.01862E-15*
61-70	10	0 0%	1 10%	9 90%	0.000675539*

Open text analysis for comments: (275 comments)

Participants were able to submit comments for this question – why would they prefer a male or female mentor? Why do many not have a preference? The top comment category, capturing 54% of the total comments, is that skills are the most important thing to look for in a mentor regardless of their gender. This explains why such a large amount of participants responded as having no preference to the gender of a possible mentor. Eighteen percent of the comments also show that personality compatibility between a mentor and a mentee is important. Of the comments on the benefits of having a female mentor, 15% indicated that women would be more likely to understand unique career challenges of women. Seven percent of the comments observed that there are benefits to having male mentors, including having more opportunities to network and greater potential to receive good advice, and that female mentor relationships might be charged with a competitive quality.

Table 33. If you chose to participate in a formal mentoring program, would you prefer to have a male or female mentor?

Comment Categories	Raw #	Percent (of 275)
Skills are the most important thing in looking for a mentor	149	54.2%
There are benefits to having a female mentor	50	18.2%
Personality fit is key to good mentoring	49	17.8%
Benefits to both sexes	45	16.4%
Women more likely to understand unique career challenges of women	42	15.3%
There are benefits to having a male mentor	19	6.9%
Limited opportunities to have a female mentor	14	5.1%
Women can be "catty" [direct quote] or hard to work with; men can be more straightforward	10	3.6%
Women have better communications skills	9	3.3%
Special connections through male mentors (access to boys club)	6	2.2%
Women aware of/relate to the fact of sexual harassment in the workplace	2	0.7%

Selected comments supporting the "no preference" to gender:

> "Depends on goals for the mentoring and what the mentor can offer."

> "I think mentoring is more related to skills and insights into the tasks and political culture of a place. So it's better to find a person who has that insight regardless of their sex."

"I've moved into a leadership role and would appreciate a mentor. A female mentor would probably provide me with insights into things that a male mentor would not, but at this point I'd appreciate anyone who could give me guidance in my new role, gender not important."

"I want the best person for me. Picking based on gender eliminates half the population."

"Both males and females can be gender-sensitive or not, a good mentor needs to be aware of challenges for women in a GIS career whether female or male."

Selected comments about the benefits of a female mentor:

"I think it is useful to have a mentor that understands the inherent challenges of being female in a male-dominated field -- challenges of which men are often unaware."

"All things equal, I'd prefer a female who understands challenges and opportunities in the profession and life particular to women (will he shake your hand upon introduction?, pay and other equality issues, women receiving awards and being invited/able to speak at conferences, receiving scholarships, and other promotions, what it's like to be a mother and working full-time."

"I find that men -- in IT in general -- tend to be arrogant and over-represent their skill-set. Women on the other hand, tend to downplay their skills and usually know more than the men. They are just hesitant to speak out. They do not display the self-confidence that the majority of men have."

Selected comments about the benefits of a male mentor:

"While a female mentor may be able to help other women navigate the system, sometimes the visibility of having a female mentor only reiterates to other people in the workplace that men and women are inherently different and require different needs (such as a female mentor rather than a male mentor)."

"I have personally received better career advice and experienced less competitiveness from my male managers than from my female managers. There are a lot of women in my division and I think it has led to increased drama as far as office politics are concerned."
"Good to have male advocate in boys club circles."

Selected comment about the benefits of both a female and a male mentor:

"I have had a female and male mentor before and both have great experiences to bring to the table. Women generally have more life experience with family work balance to offer and how to rise as a woman. Men generally have a better view as to the black and white picture of the office environment. Meaning lessons learned and seem more laid back. My experience with both though may be a little different than most. I working for the marine corps right out of college and the female mentor I had pushed me more because women that advance their career as a civilian for the marine corps is a very small percentage. The male mentors I have had have been more influenced by the good ole boys club. Sometimes I was treated like I was naive and not very smart. Very annoying. But I did get to network quite a bit with the male mentor."

2. Would it be the same for informal mentoring (meaning, would you prefer to network with other females)?

Hypothesis: Women would prefer to network with both men and women.

Question format: Radio

Table 34. Would it be the same for informal mentoring? (No category filters)

Value	Count	Percent
I would prefer to network with other women.	32	6.7%
I would prefer to network with men.	8	1.7%
I don't have a preference whether I network with males or females.	175	36.8%
I would like to network with both men and women.	260	54.7%
Statistics		
Total responses	475	
Unanswered	9	
Chi-squared test: 5.27767E-78*		

Interpretation: Because networking is more informal than a mentoring relationship, and because networking with both males and females increases the general pool of people that one might know in the field of GIS (one of the benefits being learning about more jobs and opportunities), it is expected that women would like to both network with males and females.

Fifty-five percent of the participants responded that they would like to network with both men and women, 40% say that they do not have a preference, and 7% would prefer to network with women, and only 2% with men. The p-value is extremely small, indicating that the observed values were not observed by chance and gives strong evidence that the hypothesis for this question is true. An interpretation of true takes into consideration the 55% said that they would like to prefer with both men and women and the 40% that don't have a preference.

There is some variation when observing the responses by sector. Non-profits and start-ups are where most participants (about 64%) would like to network with both men and women. None of the participants in most sectors would prefer to exclusively network with men, except in the local government and private sectors, in which 3% of women would prefer to network with men.

Table 35. Would it be the same for informal mentoring? (By sector)

Sector	# Responses	Women	Men	No Preference	Both	P-value
Federal Gov.	42	2 4.8%	0 0%	15 35.7%	25 59.5%	1.47518E-08*
State Gov.	75	6 8%	1 1.3%	33 44%	35 46.7%	6.60919E-11*
Regional Gov.[1]	5	1 20%	0 0%	3 60%	1 20%	n/a
Local Gov.	104	9 8.7%	3 2.9%	43 41.3%	49 47.1%	1.39482E-13*
Non-Profit	37	3 8.1%	0 0%	10 27%	24 64.9%	4.48179E-08*
Private	144	8 5.6%	4 2.8%	47 32.6%	85 59%	6.72376E-26*
Start-Up	11	0 0%	0 0%	4 36.4%	7 63.6%	0.005492773*
Higher-education	39	1 2.6%	0 0%	17 43.6%	21 53.8%	7.58244E-08*

There is no significant impact when looking at the responses by number of years in GIS, other than that those with fewer years in GIS would prefer to network with both men and women more.

Table 36. Would it be the same for informal mentoring? (By number of years in GIS)

Number of Years in GIS	# Responses	Women	Men	No Preference	Both	P-value
0-3 yrs.	101	4 4%	1 1%	34 33.7%	62 61.4%	4.86935E-21*
>3 and <=10 yrs.	182	18 9.9%	3 1.6%	64 35.2%	97 53.3%	2.68083E-26*
>10 and <=20 yrs.	142	6 4.2%	3 2.1%	57 40.1%	76 53.5%	1.94321E-24*
>20 and <=30 yrs.	42	4 9.5%	1 2.4%	17 40.5%	20 47.6%	1.3768E-05*
>30 yrs.[2]	3	0 0%	0 0%	0 0%	3 100%	n/a

Black/African American participants responded very differently than the majority – 88% of this group indicated that they would like to network with both men and women. Hispanic participants are the most interested in networking with other women, with 13% of this group responding that this is their preference.

Table 37. Would it be the same for informal mentoring? (By race/ethnicity)

Race/Ethnicity	# Responses	Women	Men	No Pref.	Both	P-value
Hispanic	24	3 12.5%	1 4.2%	8 33.3%	12 50%	0.006324314*
Black/African American	8	0 0%	0 0%	1 12.5%	7 87.5%	0.000706742*
White	372	22 5.9%	6 1.6%	139 37.4%	205 55.1%	2.90964E-63*
Asian	25	0 0%	0 0%	9 36%	16 64%	2.32781E-06*
Am. Indian/Alas. Nat.[3]	4	0 0%	0 0%	2 50%	2 50%	n/a
Nat. Haw./Pac. Is.[3]	3	0 0%	0 0%	3 100%	0 0%	n/a

3. Female professional groups:
Good (Yes)? Bad (No)?
Are you part of any?
Would you like to be?

Hypotheses:

Female professional groups are good.

Women do not widely participate in these groups (due to lack of availability/awareness).

Yes, they would like to be part of a female professional group.

Question format: Open text

Table 38. Female Professional Groups – Good (Yes)? Bad (No)? (No category filters)

Value	Count	Percent
Yes (Good)	368	84.8%
No (Bad)	66	15.2%
Statistics		
Total responses	434	
Unanswered	50	
Binomial probability of trial result: 2.67931E-52*		

Table 39. Female Professional Groups – Are you part of any? (No category filters)

Value	Count	Percent
Yes	134	28.7%
No	333	71.3%
Statistics		
Total responses	467	
Unanswered	17	
Binomial probability of trial result: 3.93093E-21*		

Table 40. Female Professional Groups – Would you like to be part of any? (No category filters)

Value	Count	Percent
Yes	293	73.3%
No	107	26.8%
Statistics		
Total responses	400	
Unanswered	84	
Binomial probability of trial result: 1.34637E-21*		

Interpretation: (for all three questions that are part of this cluster)

Eighty-five percent of participants think female professional groups are good. The p-value is extremely small, indicating that the observed values were not observed by chance and giving strong evidence that the hypothesis for this question is true.

Only 30% of the survey participants participate in female professional groups. The p-value is extremely small, indicating that the observed values were not observed by chance and giving strong evidence that the hypothesis for this question is true. Of the participants who said professional groups are good (exclusively those that responded "yes" to the question of whether female groups are good), 66% do not participate in any such groups, suggesting that the reason that they do not participate does not derive from any negative views of female professional groups.

Seventy-three percent of the participants would like to be in a female professional group. The p-value is extremely small, indicating that the observed values were not observed by chance and giving strong evidence that the hypothesis for this question is true. The 73% value includes anyone who responded "yes" to this part of the question (including if she left any of the other two questions in the cluster blank). When filtering by those who responded "no" to the question "Are you part of any [such groups]?" 61% said that they would like to be. That is to say, 61% of participants who explicitly say that they currently do not participate in female professional groups would like to do so.

The results for the first and last question indicate that by and large women in GIS value female professional groups – they think that they are good and they would like to participate. However, the number of women who actually participate is not in line with the value that women place on these groups. What are the reasons for this lack of participation? Is it merely due to the scarcity of such groups, or does it have something to do with obstacles to participation? As indicated by one of the figures above, for most of the women who do not participate in female professional groups, non-participation is not based on thinking that female professional groups are bad. Since only 32% of participants who think female professional groups are good actually participate in these types of groups, non-participation is likely due to some other reason.

In non-profit and private sectors there is generally a greater positive view of female professional groups (about 90% of both of these groups say female professional groups are good). Fewer survey participants in start-ups (64%) have a positive view; nonetheless, they are the group that has the highest percentage of women participating in female professional groups. On the other hand, only 18% of participants from higher education participate, despite the fact that 64% of them view female groups as good (in addition to 65% wanting to be part of one).

Table 41. Female Professional Groups – Good (Yes)? Bad (No)? (By sector)

Sector	# Responses	# Yes	# No	% Yes	% No	P-value
Federal Gov.	36	30	6	83.3%	16.7%	2.83441E-05*
State Gov.	67	56	11	83.6%	16.4%	8.70793E-09*
Regional Gov.[1]	4	3	1	75%	25%	n/a
Local Gov.	95	80	15	84.2%	15.8%	2.78627E-12*
Non-Profit	35	32	3	91.4%	8.6%	1.90485E-07*
Private	134	123	11	91.8%	8.2%	1.88745E-25*
Start-Up	11	7	4	63.6%	36.4%	0.161132813
Higher education	36	25	11	69.4%	30.6%	0.008742868*

Table 42. Female Professional Groups – Are you part of any? (By sector)

Sector	# Responses	# Yes	# No	% Yes	% No	P-value
Federal Gov.	41	12	29	29.3%	70.7%	0.003591892*
State Gov.	72	20	52	27.8%	72.2%	6.6079E-05*
Regional Gov.[1]	4	1	3	25%	75%	n/a
Local Gov.	102	27	75	26.5%	73.5%	7.01893E-07*
Non-Profit	37	10	27	27%	73%	0.002534435*
Private	143	49	94	34.3%	65.7%	5.22617E-05*
Start-Up	11	5	6	45.5%	64.5%	0.225585938
Higher education	39	7	32	17.9%	82.1%	2.79778E-05*

Table 43. Female Professional Groups – Would you like to be part of any? (By sector)

Sector	# Responses	# Yes	# No	% Yes	% No	P-value
Federal Gov.	35	26	9	74.3%	25.7%	0.002054948*
State Gov.	63	43	20	68.3%	31.7%	0.001462433*
Regional Gov.[1]	4	2	2	50%	50%	n/a
Local Gov.	80	52	28	65%	35%	7.9121E-05*
Non-Profit	31	26	5	83.9%	16.1%	7.9121E-05*
Private	126	103	23	81.7%	18.3%	1.08921E-13*
Start-Up	10	7	3	70%	30%	0.1171875
Higher education	35	23	12	65.7%	34.3%	0.024285744*

There is greater interest among more junior survey participants, with 90% with 0-3 years in GIS thinking professional groups are good. Yet only 24% of these survey takers participate in any such groups, while 77% say that they would like to. Participation in groups is the highest among those with 10-20 years of experience, but still only 32% of these survey participants taking part. Participation and interest decrease among those survey takers with more than 20 years of experience. If a positive outcome of female professional groups is the opportunity to meet more senior level GIS women, how could these groups appeal to women with the most GIS experience to

participate? Their participation would be key for mentoring/networking opportunities and for greater diversity (in age and rank) among the groups.

Table 44. Female Professional Groups – Good (Yes)? Bad (No)? (By number of years in GIS)

Number of Years in GIS	# Responses	# Yes	# No	% Yes	% No	P-value
0-3 yrs.	96	86	10	89.6%	10.4%	1.42373E-16*
>3 and <=10 yrs.	168	142	26	84.5%	15.5%	6.21113E-21*
>10 and <=20 yrs.	131	111	20	84.7%	15.3%	7.25554E-17*
>20 and <=30 yrs.	34	25	9	73.5%	26.5%	0.003053065*
>30 yrs.[2]	2	2	0	100%	0%	n/a

Table 45. Female Professional Groups – Are you part of any? (By number of years in GIS)

Number of Years in GIS	# Responses	# Yes	# No	% Yes	% No	P-value
0-3 yrs.	103	25	78	24.3%	75.7%	5.55925E-08*
>3 and <=10 yrs.	174	50	124	28.7%	71.3%	5.8579E-09*
>10 and <=20 yrs.	143	45	98	31.5%	68.5%	3.06538E-06*
>20 and <=30 yrs.	41	11	30	26.8%	73.2%	0.001436757*
>30 yrs.[2]	3	2	1	66.7%	33.3%	n/a

Table 46. Female Professional Groups – Would you like to be part of any? (By number of years in GIS)

Number of Years in GIS	# Responses	# Yes	# No	% Yes	% No	P-value
0-3 yrs.	93	7	21	77.4%	22.6%	3.73352E-08*
>3 and <=10 yrs.	154	120	34	77.9%	22.1%	6.85091E-13*
>10 and <=20 yrs.	119	83	36	69.7%	36%	5.71483E-06*
>20 and <=30 yrs.	31	17	14	54.8%	45.2%	0.123485236
>30 yrs. [2]	1	0	1	0%	100%	n/a

Some variation also occurs by race/ethnicity. Black/African American participants form the group that has the most positive view of female professional groups and which most participates. All of the participants in this group say that female professional groups are good and 63% participate (p-value for participation is 0.21875 suggesting that this result might have been observed by chance). As for other variations by race/ethnicity, Asian participants are the group with the highest percentage (29%) of those saying female GIS groups are bad. White participants are those who least participate (25%) in female professional groups and who are the least interested in participating (73%) in any.

Table 47. Female Professional Groups – Good (Yes)? Bad (No)? (By race/ethnicity)

Race/Ethnicity	# Responses	# Yes	# No	% Yes	% No	P-value
Hispanic	21	18	3	85.7%	14.3%	0.000634193*
Black/African American	8	8	0	100%	0%	0.00390625*
White	339	286	53	84.4%	15.6%	3.59922E-40*
Asian	24	17	7	70.8%	29.2%	0.020629406*
Am. Indian/Alas. Nat.[3]	4	4	0	100%	0%	n/a
Nat. Haw./Pac. Is.[3]	2	2	0	100%	0%	n/a

Table 48. Female Professional Groups – Are you part of any? (By race/ethnicity)

Race/Ethnicity	# Responses	# Yes	# No	% Yes	% No	P-value
Hispanic	24	8	16	33.3%	66.7%	0.043837488*
Black/African American	8	5	3	62.5%	37.5%	0.21875
White	365	100	265	27.4%	72.6%	7.42719E-19*
Asian	24	8	16	33.3%	66.7%	0.043837488*
Am. Indian/Alas. Nat.[3]	4	1	3	25%	75%	n/a
Nat. Haw./Pac. Is.[3]	3	0	3	0%	100%	n/a

Table 49. Female Professional Groups – Would you like to be part of any? (By race/ethnicity)

Race/Ethnicity	# Responses	# Yes	# No	% Yes	% No	P-value
Hispanic	18	14	4	77.7%	22.2%	0.011672974*
Black/African American	7	7	0	100%	0%	0.0078125*
White	315	227	88	72.1%	27.9%	8.13554E-16*
Asian	22	17	5	77.3%	22.7%	0.006278515*
Am. Indian/Alas. Nat.[3]	4	4	0	100%	0%	n/a
Nat. Haw./Pac. Is.[3]	2	1	1	50%	50%	n/a

Comparing the tables above within and between different groups of women helps provide a better sense of who is participating and who wants to participate, in addition to seeing if different groups of women regard female professional groups differently. In terms of the desire to participate, perhaps the groups that are the most interested in participating are a good starting place from which to generate momentum for the creation and expansion of these sorts of groups.

Open text analysis for comments: (145 comments)

Comments were collected for this question to gain more insight into what the participants think about female professional groups. For example, could the comments help elucidate why 15% of

participants say that female professional groups are bad? Regarding negative views of female professional groups, 8% of the comments reflected that these types of groups further separate and alienate women, and 4% said that female groups are exclusionary.

Some comments were critical, but still contained useful information for improving female professional groups. One such comment was that male participation should be encouraged in female focused groups, in order to help make men "aware of gender dimensions." Another comment implied that some women might not understand what female professional groups are for ("It depends. Are they just there to talk about how women are lower [than] men? Or are they there to get stuff done?"). One woman wrote, "I went to an all-female tech meetup once, and the speakers were really empowering, but the networking and socializing was really intimidating." These last two comments suggest that female professional groups might do a better job of making their purpose(s) known and might make the social aspects of the groups more welcoming.

Positive commentary about female professional groups included statements that female professional groups are good because they promote female participation in GIS and they are good for networking (4% of comments). Other comments favoring female professional groups included statements that women feel more comfortable and more confident around other women. One woman who started a group wrote:

> "I started one. It's kind of awesome to have men looking in from the outside saying, I want to be in the club. It's a different experience for them! We are going to let them join starting our 2nd year, but starting out just as women has really helped my confidence, my professional portfolio and my perspective!"

Another woman shared:

> "I'm not against female professional groups because I think they can help create an unspoken atmosphere of solidarity and support where co-ed groups might exhibit underlying tones of men vs women that have plagued women since the dawn of time. However, I think diversity brings the greatest opportunities for learning and advancing. I don't think I would join a professional group just because it was female; however, if all things were equal I would join a female professional group over a co-ed group because I personally find it easier to converse with women on general topics."

The only comment categories that alluded to barriers to participating were regarding not having time to participate (only 3%; one women specifically mentioned child care) and two women mentioned that they don't know of any female groups. As mentioned above, of the survey takers who say that they do not participate in groups, 61% say that they would like to. More comments regarding what barriers to participation are would be helpful to addressing any issues that bar women from the participation that they desire.

Another interesting comment category reveals that women participate in non-GIS specific women's groups (9%). As GIS positions might be in varied fields (such as an engineering or urban planning firm) or because someone might be a GIS professional within another type of specialization or body of knowledge (such as oceanography or geology), it is not surprising that women would participate in other types of female professional groups.

Table 50. Female Professional Groups (Open text analysis)

Comment Categories	Raw #	Percent (of 145)
More neutral: prefer not to segregate by gender	13	9%
Part of a non-GIS women's group	13	9%
Negative: further separates/segregates	12	8.3%
Positive: nice to share experiences with other women	11	7.6%
Semi-ambivalent: would participate depending on nature of group	8	5.5%
Positive: promote female participation GIS/good for networking	6	4.1%
Critical: exclusionary in nature	6	4.1%
Doesn't participate, but sees their value	4	2.7%
No time to participate	4	2.7%
More neutral: prefer to participate in gender mixed	2	1.4%
Participates in both female and mixed groups	2	1.4%
Don't know of any	2	1.4%
Doesn't see their benefit	2	1.4%
Benefit is not only professional, but personal	2	1.4%

4. Is your supervisor male (Yes) or female (No)?

Hypothesis: There will be more women with male supervisors.

Question format: Radio – yes/no/not applicable

Table 51. Is your supervisor male (Yes) or female (No)? (No category filters)

Value	Count	Percent
Yes	336	70.1%
No	121	25.3%
Not applicable	22	4.6%
Statistics		
Total responses	479	
Unanswered	5	
Chi-squared test: 8.02616E-71*		

Interpretation: Seventy percent of participants report that they have male supervisors. The p-value is extremely small, indicating that the observed values were not observed by chance and giving strong evidence that the hypothesis for this question is true.

Does the prevalence of women having male bosses change depending on what sector they are in? The highest percentage of participants reporting male bosses occurs in the federal government (84%) and in start-ups (82%). However, in the start-up group, 18% indicate "N/A" suggesting that they might be the owners or heads of these start-ups. Higher education and local government were the two groups reporting the highest amount of female bosses at 36% each.

Table 52. Is your supervisor male (Yes) or female (No)? (By sector)

Sector	# Responses	Male Supervisor	Female Supervisor	N/A	P-value
Federal Gov.	43	36 83.7%	7 16.3%	0 0%	9.13777E-12*
State Gov.	75	53 70.7%	19 25.3%	3 4%	4.71628E-12*
Regional Gov.[1]	5	4 80%	1 20%	0 0%	n/a
Local Gov.	107	64 59.8%	38 35.5%	5 4.7%	2.25786E-11*
Non-Profit	37	26 70.3%	11 29.7%	0 0%	9.67671E-07*
Private	144	112 77.8%	27 18.8%	5 3.5%	1.28935E-29*
Start-Up	11	9 81.8%	0 0%	2 18.2%	0.00226335*
Higher education	39	21 53.8%	14 35.9%	4 10.3%	0.003641409*

How does the prevalence of male versus female supervisors compare depending on the number of years in GIS? One might expect that the higher one climbs in her career, the more likely it would be that she might have a male supervisor (if it is also expected that those in the highest level executive positions are mostly male). However, it is the participants who have between 10 and 20 years of GIS experience who have the highest percentage of women (74%) reporting male supervisors. The group above them with 20-30 years of GIS experience has the fewest number of women reporting male supervisors (62%). If you combine the two groups of women who have 20-30 years of GIS experience and those with more than 30 years to create a group of women with more than 20 years of GIS experience, 60% have male supervisors, 29% have female supervisors, and 11% say "n/a." This group has fewer male supervisors and more female supervisors than the group with 10-20 years of GIS experience. Additionally, for those that say "n/a," it is possible that they do not have anyone above them, suggesting that they might be at the highest rank possible. As far as the entry level participants go, 29% indicate that they have female supervisors. While this is not significantly higher than the two groups above them (25% of 3-10 years and 22% of 10-20 years have female supervisors), this trend might indicate that as more and more women are joining the ranks, having female supervisors might become more prevalent.

Table 53. Is your supervisor male (Yes) or female (No)? (By number of years in GIS)

Number of Years in GIS	# Responses	Male Supervisor	Female Supervisor	N/A	P-value
0-3 yrs.	104	73 70.2%	30 28.8%	1 1%	3.62617E-17*
>3 and <=10 yrs.	183	128 69.9%	45 24.6%	10 5.5%	7.07582E-27*
>10 and <=20 yrs.	144	106 73.6%	32 22.2%	6 4.2%	4.39863E-25*
>20 and <=30 yrs.	42	26 61.9%	12 28.6%	4 9.5%	0.000142361*
>30 yrs. [2]	3	1 33.3%	1 33.3%	1 33.3%	n/a

The prevalence of male supervisors is also presented in Table 54 by age categories.

Table 54. Is your supervisor male (Yes) or female (No)? (By age bracket)

Age Bracket	# Responses	Male Supervisor	Female Supervisor	N/A	P-value
21-30	121	81 66.9%	37 30.6%	3 2.5%	3.40959E-17*
31-40	184	139 75.5%	38 20.7%	7 3.8%	1.83776E-34*
41-50	94	63 67%	27 28.7%	4 4.3%	5.53008E-13*
51-60	56	40 71.4%	13 23.2%	3 5.4%	2.99896E-09*
61-70	10	2 20%	3 30%	5 50%	0.496585304

5. Do you feel that you would like to meet other women who work in GIS? Why or why not?

Hypothesis: Yes, women would like to meet other women that work in GIS.

Question format: Radio – Binary (yes/no) plus comments (Why or why not?)

Table 55. Do you feel that you would like to meet other women who work in GIS? (No category filters)

Value	Count	Percent
Yes	406	87.1%
No	60	12.9%
Statistics		
Total responses	466	
Unanswered	18	
Binomial probability of trial result: 1.50787E-64*		

Interpretation: This question was inspired by the pilot study. The consensus of the nine women who were interviewed was that meeting women in GIS is a highly valuable experience both from a social and career perspectives. The responses to this survey question offer further support for the creation of female GIS professional groups and other networking events, as well as help to gauge whether women might feel isolated or just want to interact with other women who are in the same field as them.

Eighty-seven percent of the participants say that they would like to meet other women who work in GIS. The p-value is extremely small, indicating that the observed values were not observed by chance, and gives strong evidence that the hypothesis for this question is true.

While there is not much variation in the responses to this question by sector, there is some variation when examined by race/ethnicity, number of years in GIS, and age groups. All of black/African American and 96% of Hispanic participants would like to meet other women who work in GIS, while only 83% of Asian women do.

Table 56. Do you feel that you would like to meet other women who work in GIS? (By race/ethnicity)

Race/Ethnicity	# Responses	# Yes	# No	% Yes	% No	P-value
Hispanic	24	23	1	95.8%	4.2%	1.43051E-06*
Black/African American	8	8	0	100%	0%	0.00390625*
White	364	315	49	86.5%	13.5%	4.62388E-49*
Asian	24	20	4	83.3%	16.7%	0.000633359*
Am. Indian/Alas. Nat.[3]	4	4	0	100%	0%	n/a
Nat. Haw./Pac. Is.[3]	3	2	1	66.7%	33.3%	n/a

Ninety-three percent of participants with more than 20 years of GIS experience (bottom two groups of the Table 57 combined) would like to meet other women who work in GIS. This might reflect the possible isolation of this first GIS generation of women. This is among the clues given by the survey results that suggest that the first women who came to the GIS field, over 20 years ago, have different experiences and views than do the newcomers.

Table 57. Do you feel that you would like to meet other women who work in GIS? (By number of years in GIS)

Number of Years in GIS	# Responses	# Yes	# No	% Yes	% No	P-value
0-3 yrs.	101	87	14	86.1%	13.9%	2.02333E-14*
>3 and <=10 yrs.	179	159	20	88.8%	11.2%	2.03174E-28*
>10 and <=20 yrs.	139	117	22	84.2%	15.8%	3.09216E-17*
>20 and <=30 yrs.	41	38	3	92.7%	7.3%	4.84761E-09*
>30 yrs.[2]	3	3	0	100%	0%	n/a

Similar to number of years in GIS, participants over the age of 50 have an even keener desire to meet other women who work in GIS (over 90%).

Table 58. Do you feel that you would like to meet other women who work in GIS? (By age bracket)

Age Bracket	# Responses	# Yes	# No	% Yes	% No	P-value
21-30	119	102	17	85.7%	14.3%	2.45273E-16*
31-40	178	156	22	87.6%	12.4%	1.93802E-26*
41-50	91	77	14	84.6%	15.4%	4.31443E-12*
51-60	55	52	3	94.5%	5.5%	7.28168E-13*
61-70	10	9	1	90%	10%	0.009765625*

Open text analysis for comments: (232 comments)

As far as this question being used to gauge if women in GIS feel isolated, some of the comments that participants provided do convey this sense, as well as conveying that women would like to meet other women in GIS due to a gender issue-specific reason. The comment category of "I would like to share experiences unique to women" was the largest with 34% of comments. Other comments that are specifically related to women's issues are those that said it is difficult to deal with men and that women are easier to relate to (15%; "It's difficult dealing with male egos" and "Women are easier to relate to" combined); and women seeking advice about their careers and about work-life and work-family from other women (5%).

Table 59. Do you feel that you would like to meet other women who work in GIS? (Open text analysis)

Comment Category	Raw #	Percent (of 232)
I would like to share experiences unique to women	**78**	**34%**
I would like to meet men and women	63	27%
I already know women	37	16%
I am interested in networking	21	9%
I am interested in technical advice	22	9%
It's difficult dealing with male egos	**20**	**9%**
Women are easier to relate to	**13**	**6%**
I am looking for career advice and/or would like to meet women in leadership positions	**7**	**3%**
I am interested in support and advice with work/life, family balance	**5**	**2%**
I'm interested in making GIS a more diverse field	**4**	**2%**

6. Have you ever been the only woman in the room (at meetings, events, etc.)? If so, how did that make you feel?

Hypothesis: Many women will have been the only woman in the room. Moreover, that has been an uncomfortable situation.

Question format: Radio – Binary (yes/no) plus comments ("If so, how did that make you feel?")

Table 60. Have you ever been the only woman in the room (at meetings, events, etc.)? (No category filters)

Value	Count	Percent
Yes	401	84.2%
No	75	15.8%
Statistics		
Total responses	476	
Unanswered	8	
Binomial probability of trial result: 2.88574E-55*		

Interpretation: This question was also inspired by the pilot study. One of the pilot study participants spoke about experiences of attending meetings and being the "only woman in the room." Not only had she been the only woman, but she said that there were times where it was assumed that she was not only not a technical person, but that she might even be a secretary. "Being the only woman in a room" seemed like a symbolic experience, one in which any discomfort with regard to being a woman in a male dominated career field might be intensified and crystalized. This question was incorporated into the survey to see if any other women also had similar experiences, and if the statement "the only woman in the room" resonated with any of them.

Eighty-four percent of the participants said that they have experienced being the only woman in the room. The p-value is extremely small, indicating that the observed values were not observed by chance, and gives strong evidence that the hypothesis for this question is true. However, without inspecting the comments, women's "yes" responses do not necessarily indicate anything beyond

what the question is literally asking. They might have been the only women in the room, but what did that mean for them?

Open text analysis for comments: (321 comments)

This question allowed for participants to submit comments about how that made them feel. Comments were mixed between being either more on the positive or more on the negative side. Fifty percent of comments reflected that being the only woman in the room was an okay thing that did not make the women feel uncomfortable. Some participants (12%) even said that it is an empowering experience to be the only woman in the room. For those that said being the only woman in the room is an uncomfortable experience, 19% said that it makes them feel intimidated and frustrated, 17% that it makes them feel self-conscious, and some (5%) even reporting feeling voiceless and disempowered. Please note that these comment categories are not mutually exclusive. Some comments fell into multiple categories – in some cases some comments were both positive and negative: some participants said that at times it makes them feel empowered, while other times it makes them feel awkward.

Table 61. Have you ever been the only woman in the room (at meetings, events, etc.)? (Open text analysis)

Comment categories:	Raw #	Percent (of 321)
I am used to it/it doesn't make me uncomfortable	161	50.2%
Makes me uncomfortable/intimidated/frustrated	60	18.7%
I feel self-conscious	53	16.5%
I feel empowered/special/proud/capable	38	11.8%
I feel voiceless/disempowered	17	5.3%
I am in a male dominated field	15	4.7%
Male chauvinism and/or banter is frustrating	10	3.1%
It's entertaining	2	0.6%

7. Have you ever obtained a job through a personal connection? Please explain.

Hypothesis: None. This question was asked to gauge how many women find jobs through personal connections.

Question format: Integer plus comments ("Please explain")

Table 62. Have you ever obtained a job through a personal connection? (No category filters)

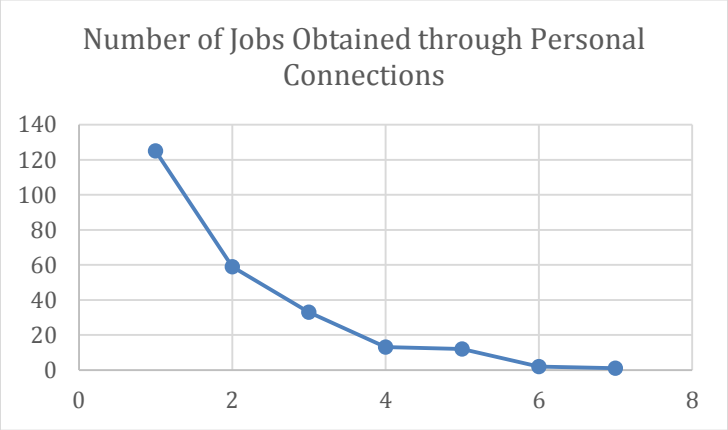
Value	Count	Percent
Yes (>0)	245	53.1%
No (0)	216	46.9%
Statistics		
Total responses	461	
Unanswered	8	
Binomial probability of trial result: 0.014938656*		

245 unique participants have obtained a job through a personal connection.
473 total jobs obtained through personal connections.

Interpretation: This is another question that was inspired by the pilot study. Several of the women who participated in the pilot mentioned that they obtained their current or previous jobs through personal connections. Beyond the pilot, it is a well-known fact that it is easier to obtain jobs through personal connections. In order to continue to collect information to support the notion that networking is of extreme importance, this question was posed to see how many women in GIS have found jobs through personal connections. If it is found that many women have found jobs through personal connections, this might be a good motivator for women to continue to network to meet more individuals who could aid them in the learning about and acquisition of new jobs.

Just over half of the participants have found at least one job through a personal connection. While it is not a majority, it is still a significant percentage of women who have found jobs via personal connections. Some participants have even found more than one job in this way. Those reporting more jobs obtained through personal connections may be referring to either full-time jobs or to contract work or projects. This could suggest that networking is even more important to women who work as freelancers in GIS.

Table 63. Have you ever obtained a job through a personal connection? (Scatterplot)



Open text analysis for comments: (207 comments)

The participants were also allowed to submit comments for this question to describe through what type of personal connection they found jobs. Networking was the number one way with 27% of participants indicating this is how they found jobs. Some participants even clarified whether the personal connection through which they found a job was male or female. Sixteen participants indicated a female connection and 23 indicated a male connection. Since not all participants made this indication, percentages are not tallied. However, both of these raw numbers further support the importance of networking with men and women alike. Internships are also mentioned in the comments – there is a separate survey question in Research Question E that deals with internships.

Table 64. Have you ever obtained a job through a personal connection? (Open text analysis)

Comment Categories:	Raw #	Percent (of 207)
Through networking	56	27.1%
Through a colleague	41	19.3%
Through a fellow student	31	15%
Through a friend	28	13.5%
Through a professor	25	12.1%
Through a family member	20	9.7%
Through an internship	19	9.2%
Through consulting/contracting	10	4.8%
Through volunteering	3	1.4%

8. Have you had difficulties finding a mentor? Please provide details if so.

Hypothesis: Yes, more women have difficulties finding a mentor.

Question format: Radio – Binary (yes/no) plus comments

Table 65. Have you had difficulties finding a mentor? (No category filters)

Value	Count	Percent
Yes	174	37.4%
No	291	62.6%
Statistics		
Total responses	465	
Unanswered	19	
Binomial probability of trial result: 1.31949E-08*		

Interpretation: This question was also partially inspired by the pilot study. Most of the pilot study participants mentioned having mentors throughout various stages of their careers, indicating success in having mentors in general, but some (particularly those in later career stages) mentioned that they experienced difficulties in finding a mentor. Additionally, the literature review suggests the same, that finding mentors, especially for senior level women, is difficult (Ahuja 2002; Orser, Riding, and Stanley 2012).

However, 63% of the participants reported that they have not had difficulties finding a mentor. The p-value is extremely small, indicating that the observed values were not observed by chance, and gives strong evidence that the hypothesis for this question is not true.

Variability by sector might be hard to truly gauge since women might have changed sectors over time. Nonetheless, if the reported numbers are a true indication of finding a mentor in that particular sector, it does seem like women in certain sectors have fared better in finding mentors than others. For example, participants in non-profits are those who most report (56%) having

difficulties finding a mentor. Participants in federal government and higher education are those who least report (31%) having difficulties finding a mentor.

Table 66. Have you had difficulties finding a mentor? (By sector)

Sector	# Responses	# Yes	# No	% Yes	% No	P-value
Federal Gov.	42	13	29	31%	69%	0.005802288*
State Gov.	74	29	45	39.2%	60.8%	0.016556941*
Regional Gov.[1]	5	2	3	40%	60%	n/a
Local Gov.	103	34	69	33%	67%	0.000193286*
Non-Profit	34	19	15	55.9%	44.1%	0.108031528
Private	140	54	86	38.6%	61.4%	0.001726996*
Start-Up	11	4	7	36.4%	63.6%	0.161132813
Higher education	39	12	27	30.8%	69.2%	0.007113699*

Interestingly, the percentage of participants who have had difficulties finding a mentor does not increase with more years in GIS. The group reporting difficulties the most is the group with 3-10 years of GIS experience (43%). Unexpectedly, only 26% of those with 20-30 years of GIS experience report difficulties. The pattern is extremely similar among the different age groups.

Table 67. Have you had difficulties finding a mentor? (By number of years in GIS)

Number of Years in GIS	# Responses	# Yes	# No	% Yes	% No	P-value
0-3 yrs.	101	35	66	34.7%	65.3%	0.00066098*
>3 and <=10 yrs.	178	76	102	42.7%	57.3%	0.008977515*
>10 and <=20 yrs.	139	50	89	36%	64%	0.000274818*
>20 and <=30 yrs.	42	11	31	26.2%	73.8%	0.000973287*
>30 yrs.[2]	2	1	1	50%	50%	n/a

Of the race/ethnicity groups, black/African American and Asian participants are those who most reported having difficulties finding a mentor. Fifty percent of both these groups responded "yes" to this question. However, it is possible that these numbers were observed by chance. But if these numbers are an accurate representation of a larger population, what makes it more difficult for these women to find mentors (in addition to the 42% of Hispanic participants who also responded yes to this question) than it is for white participants, of whom only 38% say that they have had difficulties finding a mentor?

Table 68. Have you had difficulties finding a mentor? (By race/ethnicity)

Race/Ethnicity	# Responses	# Yes	# No	% Yes	% No	P-value
Hispanic	24	10	14	41.7%	58.3%	0.116899967
Black/African American	8	4	4	50%	50%	0.2734375
White	363	136	227	37.5%	62.5%	4.25413E-07*
Asian	24	12	12	50%	50%	0.161180258
Am. Indian/Alas. Nat.[3]	4	1	3	25%	75%	n/a
Nat. Haw./Pac. Is.[3]	3	1	3	0%	100%	n/a

Open text analysis for comments: (172 comments)

The comments reveal a few additional insights. Some participants (24% of the 172 who submitted a comment) said that they have never looked for a mentor. Nineteen percent say that no one else in their organizations does GIS, which adds another dimension to the challenges of finding mentors. The next highest category of comments (9%) indicated that for some participants time barriers are an issue. While both small categories, "I am too senior in my work" and "No senior female GIS people" (both 2%) convey the message that for some, as was originally expected, finding senior level women is challenging.

Table 69. Have you had difficulties finding a mentor? (Open text analysis)

Comment Category	Raw #	Percent (of 172)
I have never looked for a mentor	41	23.8%
No one else in my organization who does GIS	33	19.2%
Hard to find time for mentoring	15	8.7%
More interested in peer to peer than mentoring	6	3.5%
Boys club makes a mentor difficult	4	2.3%
I am too senior in my work	3	1.7%
No senior female GIS people	3	1.7%
Difficulty is finding a *good* mentor	3	1.7%
My organization has a culture of mentoring	2	1.6%
Lack of follow up	2	1.2%
I have never been approached	1	0.6%

SUMMARY OF RESEARCH QUESTION C

To gather information that might help in forming and influencing thought on mentoring relationships and networking groups.

This section of the survey was formulated to gather more information about women's preferences and experiences in mentoring and networking. To summarize the findings, participants are very neutral when it comes to the gender of a potential mentor, with 77% reporting that they do not have a preference. Similarly, most participants are neutral to gender with regard to networking (37% indicating no gender preference and 55% indicating an interest in networking with males and females). Despite the neutrality in response to these two questions, participants are overwhelmingly in favor of female professional groups – 90% say female professional groups are good, and 73% indicate a desire to participate. However, even though female professional groups are well regarded, only 29% of participants participate, suggesting that among those who are in favor of these types of groups there is still a need to increase participation and participation opportunities.

"Is your supervisor male or female?" was also asked. Seventy percent of participants reported having male supervisors. This question was asked in this section because the responses might shed light on whether those women with male supervisors might be more interested in receiving mentoring from, networking with, or meeting women in GIS than those women with female supervisors. A comparative analysis of those who have male supervisors with those who have female supervisors in relation to the other questions is not part of the current analysis – however, this variable could be utilized in future analyses of the survey results. The answers to the question "Is your supervisor male or female," can also be brought into the discussion of other questions in the survey, such as, "Do you think there is an underrepresentation of women in GIS," which is asked in Survey Question 3 of Research Question F. Additionally, the answers to this question can also

help to contribute to further understanding of whether the vertical segregation of women is an issue in GIS.

There are also questions presented in this section that target women's feelings about being women in GIS, or their perceptions around female participation in the field. These include: "Do you feel that you would like to meet other women who work in GIS?" and "Have you ever been the only woman in the room (at meetings, events, etc.)?" Recall that the previous section includes the question "Do you feel that there are enough women in your department?" These and other questions in later sections of this thesis chapter seek to obtain important information regarding women's perceptions of their representation in GIS. The two questions in this section showed that, by and large, women in GIS want to meet other women in the field and that many women have had the experience of being "the only woman in the room." These feelings and experiences further highlight that while there might not be a gross underrepresentation of women in GIS, women's participation still calls for serious attention.

The question "Have you ever obtained a job through a personal connection," helps to highlight the importance of having connections (e.g., mentoring and networking aid women in growing their GIS connections). Fifty-three percent of the women who answered this question found at least one job through a personal connection, which supports this notion.

Lastly, finding out about women's successes in finding mentors in GIS can help inform the development of mentoring strategies within the field. Sixty-three percent of participants have not had difficulties finding a mentor. Women's successes in finding mentors (in addition to obtaining jobs through connections) suggest that GIS is a field in which women have good experiences and opportunities for success.

D. Research Question: Does GIS fit the "hybrid" solution model?

Later articles about IT talk about "hybrid" roles in which not only technical skills are needed but also "soft" skills like communication, etc. (Guerrier et al. 2009; Roan and Whitehouse 2007). It was hoped that these positions would increase the number of women in IT; however these hybrid jobs only served to reinforce and continue traditional workplace gender norms (Guerrier et al. 2009; Roan and Whitehouse 2007). Potential problems with the hybrid concept aside, is there a great prevalence of GIS jobs that are hybrid? GIS seems like a unique field that is inherently hybrid (without the motivation being gender inclusion). It requires multiple skillsets and is interdisciplinary. What does that mean for the inclusion of women? Does it follow the pattern of other so-called hybrid IT jobs that are in reality non-technical and that recirculate traditional gender norms? Or are hybrid GIS jobs the real and good version of hybrid?

Survey Page Header *(page 6 on survey): GIS's "Hybrid" Nature*

Context for survey participants: *Do positions that fall under the GIS umbrella involve multiple categories of skills? What are the skills that survey participants draw upon to complete their work? The questions posed below are being asked, in part, to get a sense of the myriad talents that women bring to their work. Additionally, it is claimed by some that "hybrid" IT positions that combine "hard" technical skills with "soft" communication skills might represent a way to enhance diversity in IT. Is GIS inherently "hybrid"?*

SURVEY QUESTIONS:

1. **Do you consider your position to combine multiple skills? That is, do the tasks that you perform require diverse skills and affinities? On a scale from 1 to 5 indicate which skills are required in your daily activities: ('Zero' would equal not at all, 'one' very little, 'five' a lot, 'two' - 'four' somewhere in between).**

The categories of skills presented in this section include:

- Technical skills – data acquisition
- Technical skills – analysis and modeling
- Technical skills – software and application development
- Knowledge base – core geospatial and abilities and knowledge
- Communication and Workplace skills - teamwork
- Communication and Workplace skills - creative thinking
- Communication and Workplace skills - planning and organizing
- Communication and Workplace skills - problem solving/decision making
- Management competencies

The skills that are included in the bullets above are selections from tiers 3, 4, 5, and 6 of the Geospatial Technology Competency Model (GTCM, shown below). The selected competencies are those that the thesis author believed would best be able to capture GIS-centric technical and "soft" aptitudes to best compare usage of those two broader categories, and to then compare GIS with other hybrid jobs.

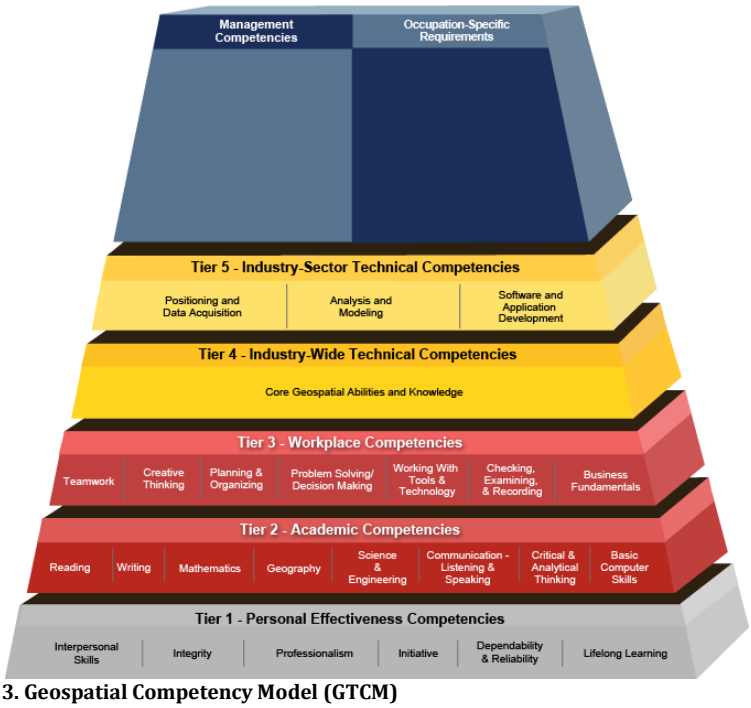


Figure 3. Geospatial Competency Model (GTCM)
Source: GeoTech Center; available from: http://www.careeronestop.org/competencymodel/competency-models/geospatial-technology.aspx (accessed April 1, 2015).

Hypotheses: Yes, GIS jobs are hybrid in nature and they require a mix of technical and "soft" skills. However, in line with what the literature suggests about the balance of skills in hybrid jobs leaning towards the "soft" (Guerrier et al. 2009; Roan and Whitehouse 2007), it is also hypothesized that there will be higher average rank scores in the use of "Communication and Workplace Skills" (tier 3) categories and lower average rank scores in the use of "Technical Skills" categories (tier 5). "Management Competencies" as well will have lower average rank scores (yet will increase with more years in GIS).

Question format: Slider plus textbox

Average ranks are a number between 1 and 5.

Table 70. Technical skills – Data acquisition

Scale	Count	Percent
0	6	1.3%
1	26	5.5%
2	35	7.4%
3	77	16.4%
4	119	25.3%
5	207	44.0%
Statistics		
Total responses	470	
Unanswered	14	
Average rank	**3.910638**	

Table 71. Technical skills – Analysis and modeling

Scale	Count	Percent
0	9	2.0%
1	39	8.5%
2	49	10.6%
3	88	19.1%
4	125	27.1%
5	151	32.8%
Statistics		
Total responses	461	
Unanswered	23	
Average rank	**3.592191**	

Table 72. Technical skills – Software and application development

Scale	Count	Percent
0	88	19.8%
1	89	20.0%
2	88	19.8%
3	77	17.3%
4	50	11.2%
5	53	11.9%
Statistics		
Total responses	445	
Unanswered	39	
Average rank	**2.159551**	

Table 73. Knowledge base – Core geospatial abilities and knowledge

Scale	Count	Percent
0	2	0.4%
1	8	1.7%
2	29	6.1%
3	57	12.1%
4	113	23.9%
5	264	55.8%
Statistics		
Total responses	473	
Unanswered	11	
Average rank	**4.247357**	

Table 74. Communication and workplace skills - Teamwork

Scale	Count	Percent
0	0	0.0%
1	15	3.2%
2	24	5.1%
3	47	9.9%
4	123	26.0%
5	264	55.8%
Statistics		
Total responses	473	
Unanswered	11	
Average rank	**4.262156**	

Table 75. Communication and workplace skills – Creative thinking

Scale	Count	Percent
0	2	0.4%
1	11	2.3%
2	25	5.3%
3	66	14.0%
4	141	29.8%
5	228	48.2%
Statistics		
Total Responses	473	
Unanswered	11	
Average rank	**4.150106**	

Table 76. Communication and workplace skills – Planning and organizing

Scale	Count	Percent
0	1	0.2%
1	18	3.8%
2	23	4.9%
3	67	14.2%
4	111	23.5%
5	252	53.4%
Statistics		
Total Responses	472	
Unanswered	12	
Average rank	**4.17161**	

Table 77. Communication and workplace skills – Problem solving/Decision making

Scale	Count	Percent
0	4	0.8%
1	9	1.9%
2	26	5.5%
3	47	9.9%
4	129	27.2%
5	259	54.6%
Statistics		
Total Responses	474	
Unanswered	10	
Average rank	**4.246835**	

Table 78. Management competencies

Scale	Count	Percent
0	29	6.4%
1	55	12.1%
2	67	14.7%
3	105	23.1%
4	88	19.3%
5	111	24.4%
Statistics		
Total Responses	455	
Unanswered	29	
Average rank	**3.101099**	

Table 79. Competencies averaged

Category	Average Competencies (All)	Average "Soft"† Competencies	Average Technical† Competencies	Management Competencies
All (no category filters)	3.76	4.21	2.88	3.1

†Average "soft" competencies computed by averaging all of the Communication and Workplace skills competencies; average technical competencies computed by averaging Analysis and Modeling and Software and Application development competencies; Positioning and Data Acquisition category is not included in this particular calculation of average technical skills.

Interpretation: In the following discussion, the intention is not to claim what skills women inherently do or do not possess. Nor are the self-ranking or categories used to support any notions that women are better at certain things than others. The self-ranking of this question measures *how often* women use the skills, or "competencies," listed, not their skill level. By measuring to what degree certain skills are used the thesis author hopes to gain insights into what skills and competencies women are being given the opportunity to use in their jobs. Furthermore, tasks at which some women might excel, and which they themselves might consider among their best skills (Question 2 below), might not be those tasks that they actually get to do.

There are three hypotheses associated with this question, all of which have been confirmed. The first is that GIS jobs are hybrid in nature and that diverse skills must be drawn upon, regardless of any imbalances in the proportion in which those skills are leveraged. However, just as the literature that critiques hybrid jobs suggests, the balance between the use of technical and non-technical aspects of these jobs is skewed. Rather than equally drawing from both skillsets, communication skills are more heavily used. Supporting that point, the second hypothesis, that women would use technical skills less frequently than they use "soft" skills in their jobs, is also confirmed, with an overall average rank score of 2.88 versus an average rank score of 4.21 for "soft," or communication related, competencies. Furthermore, the participants have an average rank of 3.1 in regards to their use of management competencies, which supports the hypothesis

that women would score relatively low in their opportunities to use that skill category. However, as was expected and as will be seen below, participants with more years in GIS report using more management competencies. While the difference between technical and management scores is marginal, it is interesting to note the possibility that there might be more opportunity to carry out management related duties than technical duties.

Drilling down into different sectors of the population provides useful insights. First is a consideration of the results by work sector. Those who work in the non-profit sector show the greatest disparity between use of communication and technical skills, with a difference of 1.65 between the average rank scores; they also score the lowest in terms of the use of management competencies (2.54). In start-ups, on the other hand, participants score the best in use of management competencies (3.91). What are the conditions in these two work environments that would cause these differences?

Table 80. Competencies averaged (By sector)

Sector	Average Competencies	Average "Soft" Competencies	Average Technical Competencies	Management Competencies
Federal Gov.	3.64	4.12	2.80	3
State Gov.	3.88	4.22	3.09	3.19
Regional Gov.[1]	4.2	4.65	3.4	3.8
Local Gov.	3.88	4.34	3	3.3
Non-profit	3.67	4.18	2.53	2.54
Private	3.7	4.2	2.75	3.07
Start-up	4.05	4.45	3.3	3.91
Higher education	3.56	3.88	2.91	2.62

Next is an examination of the use of competencies by the number of years in GIS group. Table 81 shows how the use of average "soft," technical, and management competencies increases with more years in GIS experience. It is not surprising to see that with more years in GIS, the more all competencies are drawn upon, particularly the technical and management competencies

(management scores are higher than technical scores for participants with more than three years of GIS experience). Even though this upward trend is not surprising, could some non-gender-specific deduction be made about GIS as a whole with regards to the use of technical competencies (especially software and application development) *diminishing* in the newer generations? A future line of inquiry can investigate whether women are using skills that they have less frequently, or if they are acquiring the skills to a lesser extent.

Table 81. Competencies averaged (By number of years in GIS)

Number of Years in GIS	Average Competencies	Average "Soft" Competencies	Average Technical Competencies	Management Competencies
0-3 yrs.	3.44	4.01	2.42	2.3
>3 and <=10 yrs.	3.72	4.11	2.93	2.95
>10 and <=20 yrs.	3.93	4.39	2.99	3.5
>20 and <=30 yrs.	4.15	4.52	3.32	4.17
>30 yrs.[2]	4.22	4.83	3.17	4.33

When looking at race/ethnicity categories, there is also variability. One of the unique things that can be observed is that for most groups the ranking for management competencies is higher than for average technical skills, yet for Asian participants technical skills trump management skills (3.11 versus 2.68 respectively). Also, the difference between Hispanic participants with the highest average score of 3.54 of technical skills versus black/African American participants with a score of 2.31 is fairly significant. There were only eight participants who identified themselves as black/African American, so the small number of this group may be skewing the results that were captured for them. However, if the numbers of these two groups is an accurate representation, these results are puzzling. If the suspected race/ethnic underrepresentation that might be happening in the field is an issue (perhaps even more of an issue that female underrepresentation), then it poses the question of whether Hispanic and black/African American women share similar experiences on the job.

Table 82. Competencies averaged (By race/ethnicity)

Race/Ethnicity	Average Competencies	Average "Soft" Competencies	Average Technical Competencies	Management Competencies
Hispanic	4.19	4.55	3.54	3.58
Black/African American	3.86	4.56	2.31	3.38
White	3.75	4.22	2.81	3.09
Asian	3.61	3.92	3.11	2.68
Am. Indian/Alas. Nat.[3]	3.44	3.63	2.63	4
Nat. Haw./Pac. Is.[3]	4.33	4.67	3.67	4

Again, please note that this thesis question aims to measure to what degree women use certain skills and does not ask about their skill level. The responses to this question suggest further questions: Does the measurement of use correlate with a measurement of opportunity? Are women are given fewer opportunities to take on technical and managerial work?

Measuring to what degree women utilize certain skills is done to get a sense of whether or not women are trending towards certain types of GIS work. The findings derived from the survey, however, are just a starting point from which to investigate this. For example, would men in GIS score similarly? One might suspect that they would in terms of the communication and other workplace related skills as it seems everyone would have to draw upon these to be successful in any work environment. But would they score similarly in the technical skills categories? It would be helpful to compare the scores of women to those of men in order to fully explore whether women's scores in technical versus "soft" competencies have something to do with gender-related bias, or if that is the nature of GIS jobs in general, for men and women alike.

The findings of this survey section (in addition to the questions posed in the paragraph above) are important additions to the discussion under Research Question B that asks whether there is vertical and/or horizontal segregation of women in GIS. Through this section it has been found that women utilize their technical and management skills to a lesser degree than they use their communication

and workplace skills. This suggests *possible* vertical/horizontal segregation. However, without knowing to what extent men leverage these same skills, it is hard to determine if vertical/horizontal segregation is truly present. Further research that includes men in GIS would help to clarify the results of this survey to that end.

Additionally, the findings of this survey section supplement the findings of another survey question, "Do you *think* that there is an underrepresentation of women in GIS?" Based on the data collected in the survey, there is no evidence of a gross underrepresentation of women in GIS. However, there might be an underrepresentation of women in management and highly technical roles within GIS, which could shape the perception that there in an overall underrepresentation. Even if there is not a general underrepresentation, there might be an underrepresentation in certain positions.

List skills, if desired (Textbox)

In addition to responding to the skills listed above, participants could mention other skills that they use in their jobs. The responses show just how diverse GIS jobs are[5].

Technical skills:
Geospatial software
Database management)
Software installation
Troubleshooting
Programming/scripting
Modeling
Business analyst

Workplace skills:
Conflict resolution
Strategic planning
Project management

Communication skills
Training/teaching/mentoring
Working with GIS interns
Communicating with non-technical staff
Communication skills - writing and presenting
Customer service
Partnership building

Design skills:
Cartographic skills
Graphic arts/design

Other skills:
Event planning
Social media
Researching
Budget/purchasing
Marketing of GIS

Specific knowledge:
Core earth science
Oceanography
Geology
State law
Local news and history

[5] The skills listed here are a combination of what could be considered "Occupation-Specific Requirements" or more specific versions of the general GTCM competency categories.

2. What are your greatest skills?

Hypothesis: None. This question was asked to see what women consider to be their greatest skills. How will this compare with how much they use certain skills at work (Question 1 of this section) – will women have the opportunity to use the skills that they think are their strongest?

Question format: Textbox

Open text analysis for comments: (435 comments)

The open text analysis for this question involved formulating categories from the 435 comments that were submitted. Originally, 27 strength categories were created and were then consolidated into the 9 categories listed in Tables 83 and 84 below. Table 83 provides a "Summarized View" and only shows the nine condensed categories, and Table 84 provides a "Detailed View" and shows the 27 categories that the nine condensed categories are built from.

As participants could identify unlimited number of their greatest strengths, their comments might have been assigned to multiple categories, thereby yielding 793 total strengths reported by 435 women. Percent tabulations are based on the number of women (435) who provided comments. For example, 16% of 435 women who commented said that "organizing/planning/time management" was one of their greatest skills. That category falls into a broader category called "workplace skills," which includes other related strength sub-categories (and 32% of women have some of their strengths in "workplace skills").

The strengths in the Summarized View table directly below are listed in descending order of the percentage of women assigned to that category. The top three strength categories women fall into are first, communication (42%); second, technical – GIS/Analysis (40%); and third, workplace skills (32%).

Table 83. Strengths – Summarized view

Overarching Strength Category	Raw #	Percent (of 435)
Communication	181	41.61%
Technical - GIS/Analysis	176	40.46%
Workplace skills	141	32.41%
Mind skills - Logic/Creativity	140	32.18%
Technical - Design-oriented	64	14.71%
Management	50	11.49%
Technical - Database	16	3.68%
Technical - Programming	14	3.22%
Technical - Software related	11	2.53%
All technical combined	**281**	**64.60%**

The top three skills from the more specific strength categories are "listening/customer service/communications/teamwork" (26%), "GIS analysis/GIS skills/technical skills" (22%), and "critical thinking/problem-solving" (19%).

Table 84. Strengths – Detailed view

Specific Strength Category	Overarching Strength Category	Raw #	Percent (of 435)	Category Sums	Percent (of 435)
Listening/customer service/ communications/teamwork	Communication	112	25.75%		
Training/team development/ teaching	Communication	31	7.13%		
Translating technical knowledge to non-experts	Communication	20	4.60%		
Writing/editing	Communication	18	4.14%	**181**	**41.61%**
Project management	Management	24	5.52%		
Leadership/management	Management	26	5.98%	**50**	**11.49%**
Creativity	Mind Skills - Logic/Creativity	41	9.43%		
Critical thinking/ Problem-solving	Mind Skills - Logic/Creativity	84	19.31%		
Reasoning/logical/analytical	Mind Skills - Logic/Creativity	15	3.45%	**140**	**32.18%**
Database administration	Technical - Database	16	3.68%	**16**	**3.68%**
Cartography/mapping	Technical - Design-oriented	54	12.41%		
Design/graphic skills	Technical - Design-oriented	10	2.30%	**64**	**14.71%**
Data representation/ analysis	Technical - GIS/Analysis	37	8.51%		
GIS analysis/GIS skills/ Technical skills	Technical - GIS/Analysis	96	22.07%		

Specific Strength Category	Overarching Strength Category	Raw #	Percent (of 435)	Category Sums	Percent (of 435)
Geomatics	Technical - GIS/Analysis	1	0.23%		
Spatial analysis	Technical - GIS/Analysis	26	5.98%		
Geodatabases	Technical - GIS/Analysis	5	1.15%		
Remote sensing	Technical - GIS/Analysis	6	1.38%		
QC/QA	Technical - GIS/Analysis	5	1.15%	**176**	**40.46%**
Programming	Technical - Programming	14	3.22%	**14**	**3.22%**
Figuring out new software	Technical - Software Related	11	2.53%	**11**	**2.53%**
Organizing/planning/ time management	Workplace skills	69	15.86%		
Strategic thinking	Workplace skills	3	0.69%		
Multi-tasking	Workplace skills	11	2.53%		
Work ethic	Workplace skills	14	3.22%		
Attention to detail	Workplace skills	29	6.67%		
Networking/office politics	Workplace skills	15	3.45%	**141**	**32.41%**

Table 83 shows that the technical skills associated with GIS and GIS analysis are valued in almost equal measure to communication skills (both categories have 40% of participants). Twelve percent listed management related skills as being amongst their greatest strengths.

The following figures, originally discussed in Question 1 above, are shown again in order to be able to start drawing comparisons between what women say are their strengths and what skills they use most at work. It was found that "soft" competencies are used at an average rate of 4.21, technical competencies at 2.88, and management competencies at 3.1. Also recall, from Survey Question 3 of Research Question B, 23% of participants categorize their work as programming, 71% as analysis, and 58% as cartography.

Comparing greatest skills mentioned to use of skills (as well as how women categorize their work) might be somewhat of a rough exercise as different measurement techniques are used and the open text analysis involved subjective analysis. However, this could help provide insights as to whether the participants have opportunities to do what they think they are good at. (However, what they are good at might be what they get to do). Tables 85 and 86 are an amalgamation of the preceding

greatest skills tables, the GTCM competencies information, and how women categorize their work. Participants report that their "soft" skills are amongst their greatest strengths, and the rank of use is 4 (out of 5). Sixty-five percent indicate technical skills and the rank of use is 2.8. Only 12% cite management related things as their strength, and the rank of use is 3.1.

Table 85. Strengths – Comparison of selected strengths to GTCM Competencies Rank of Use – Summarized view

Overarching Strength Category ("dissolved")	Raw #	Percent (of 435)	GTCM Competency	Rank of Use (scale 1-5)
"Soft" skills (includes: Communication Workplace skills Logic/Creativity)	462	106.21%	Average "Soft"* Competencies	4.17
Technical (includes: GIS/Analysis Design-oriented Database Programming Software Related)	281	64.6%	Average Technical* Competencies	2.88
Management	50	11.49%	Management Competencies	3.1

Table 86. Strengths – Comparison of selected strengths to GTCM Competencies Rank of Use – Detailed view

Specific Strength Category	Raw #	Percent (of 435)	GTCM Competency	Rank of Use
Listening/customer service/ communications/teamwork	112	25.75%	Communication and Workplace skills - creative thinking	4.15
Leadership/management	26	5.98%	Management competencies	3.1
Critical thinking/ problem solving	84	19.31%	Communication and Workplace skills - problem solving/decision making	4.25
Cartography/mapping	54	12.41%	Cartography (from "How would you categorize your work?")	(56%)
Data representation/ analysis	37	8.51%	Technical skills - Analysis and modeling	3.59
			Analysis (from "How would you categorize your work?")	(71%)
GIS analysis/GIS skills/ Technical skills	96	22.07%	Technical skills - Analysis and modeling	3.59
			Analysis (from "How would you categorize your work?")	(71%)
Spatial analysis	26	5.98%	Technical skills - Analysis and modeling	3.59
			Analysis (from "How would you categorize your work?")	(71%)
Programming	14	3.22%	Programming (from "How would you categorize your work?")	(23%)
Organizing/planning/ time management	69	15.86%	Communication and Workplace skills - planning and organizing	4.17

3. What are your areas of weakness?

Hypothesis: None. This question was asked to compare weaknesses to strengths mentioned. It is hoped that reviewing information about skills used at work in combination with what women are listing as greatest skills and weaknesses will yield helpful insights. As mentioned above, women might not have the opportunity to use what they consider to be their greatest skills in their current positions. However, the flip side of that is that perhaps if individuals are not given the opportunity to do certain types of work, they might not have the opportunity to develop more diverse skills.

Question format: Textbox

Open text analysis for comments: (431comments)

The open text analysis for this question involved the same procedure as the question above (percentages based on total number of women who provided comments on this question).

Table 87. Weaknesses – Summarized view

Overarching Weakness Category	Raw #	Percent (of 431)
Technical - Programming	180	41.76%
Workplace skills	83	19.26%
Communication	62	14.39%
Technical - Software Related	41	9.51%
Personal Effectiveness	30	6.96%
Technical - General	23	5.34%
Technical - GIS/Analysis	12	2.78%
Specific Knowledge	10	2.32%
Technical - Design-oriented	9	2.09%
Technical - Other	7	1.62%
Technical - Database	3	0.70%
All technical combined	**275**	**63.81%**

Table 88. Weaknesses – Detailed view

Specific Weakness Category	Overarching Weakness Category	Raw #	Percent (of 431)	Category Sums	Percent of (431)
Communications/speaking/ self-confidence	Communication	62	14.39%	62	14.39%
Particular science (i.e., biology)	Specific Knowledge	1	0.23%		
Statistics/math	Specific Knowledge	9	2.09%	10	2.32%
SQL	Technical - Database	3	0.70%	3	0.70%
Cartographic design	Technical - Design-oriented	9	2.09%	9	2.09%
Technical skills	Technical - General	23	5.34%	23	5.34%
Modeling	Technical - GIS/Analysis	12	2.78%	12	2.78%
Written reports	Technical - Other	7	1.62%	7	1.62%
Programming	Technical - Programming	150	35%		
Software application development	Technical - Programming	30	7%	180	41.76%
Staying current with GIS updates/new software	Technical - Software Related	34	8%		
Open source GIS	Technical - Software Related	2	0.46%		
Servers	Technical - Software Related	5	1.16%	41	9.51%
Management skills/ networking/office politics	Workplace skills	44	10.21%		
Organizing/planning/ time management	Workplace skills	39	9%	83	19.26%
Focus/distractions/ motivation	Personal Effectiveness	18	4.18%		
Bored if not busy/ impatience	Personal Effectiveness	12	2.78%	30	6.96%

4. What skills would you recommend that female newcomers to GIS focus on?

Hypothesis: Women already working in GIS will recommend that newcomers focus on technical skills, especially programming.

Question format: Textbox

Table 89 shows all of the skills that the participants recommend that newcomers focus on. A newcomer might even be able to review this list in order to formulate a strategy on what she might like to seek training on to become a more competitive candidate when seeking a GIS job. See Table 90 for a more generalized view that supports discussion around the hypothesis.

Table 89. Recommended skills – Detailed view

Specific skills listed	**Raw #**	**Percent (of 416)**
Programming and scripting : python; html; Javascript; C++; Cuda; SQL **(Python mentioned 33 times)**	169	40.63%
Communication	40	9.62%
Data science, analysis and management	39	9.38%
Application development	34	8.17%
Technical skills (GIS)	32	7.69%
Core geography, spatial and GIS knowledge	29	6.97%
Familiarity with software and tools	23	5.53%
Database design and management	20	4.81%
Web development and APIs	19	4.57%
Confidence / assertiveness	18	4.33%
Troubleshooting and problem solving	16	3.85%
Analytics	14	3.37%
Ability to communicate work to non-GIS people/management	14	3.37%
Project management	12	2.88%
Modeling	10	2.40%
Presenting results and writing	10	2.40%
Spatial analysis and proper display of spatial data	8	1.92%
Keeping up with technologies and trends	8	1.92%
Creativity	8	1.92%
ArcGIS toolkit and ESRI technologies	7	1.68%
Leadership skills	7	1.68%
Stats, R, SAS	6	1.44%
IT related skills	6	1.44%
Business needs analysis	6	1.44%
Understanding the organization, its needs/workplace and business skills	6	1.44%
Teamwork and Interpersonal skills	6	1.44%
Back-end technologies (SQL)	5	1.20%
Emotional intelligence	5	1.20%
Management skills	5	1.20%
Open source technologies	4	0.96%
Knowing data sources/data acquisition	4	0.96%
Web GIS/ Online tools for mapping	4	0.96%
Cartography	4	0.96%
Cloud technologies	4	0.96%
Specific industry knowledge	4	0.96%
Networking in the GIS community	4	0.96%
Time management	4	0.96%
Mobile	3	0.72%

Specific skills listed	Raw #	Percent (of 416)
ArcGIS Server or other map server technologies	3	0.72%
Map making and design skills	3	0.72%
System/server administration	3	0.72%
User requirements	3	0.72%
Ability to coordinate data between systems	2	0.48%
Remote sensing	2	0.48%
IT Infrastructures	2	0.48%
Understanding and streamlining processes	2	0.48%
Research and development	2	0.48%
Understand why and when to use tools	2	0.48%
Depends on the GIS specialty	2	0.48%
Geoprocessing	1	0.24%
Image analysis	1	0.24%
CAD	1	0.24%
Thinking spatially	1	0.24%
GPS	1	0.24%
Graphic design	1	0.24%
Understanding how enterprise systems are structured	1	0.24%
Humility	1	0.24%
Working	1	0.24%

The specific recommendations listed above are presented in Table 90 summarized into categories. Among all the women who made recommendations, there were 652 recommendations in total, from which this percentage is derived.

Table 90. Recommended skills – Summarized view

Summarized Categories	Raw #	Percent (of 652)
Technical	447	68.56%
Communication	77	11.81%
Workplace	46	7.06%
Personal Effectiveness	33	5.06%
Core Knowledge - GIS	29	4.45%
Management	12	1.84%
Knowledge - Industry Specific	8	1.23%

Sixty-nine percent of the recommendations relate to technical skills, with 40% of participants specifically mentioning programming, which supports the hypothesis. The thesis author believes that because the survey participants view not having solid programming skills as a weakness, and it is also viewed as skill that is in demand and well-compensated, they therefore recommend that newcomers focus on it.

SUMMARY OF RESEARCH QUESTION D

GIS's "Hybrid" Nature

The primary goal of this survey section was to find out more about what skills women use in their current GIS positions. The first survey question asked participants to rank how often they use different skill categories. Would participants report using both technical and "soft" skills and, if so, would they use one of those skill categories more so than the other? There is a body of literature about "hybrid" jobs in IT that require technical and "soft" skills (Guerrier et al. 2009; Roan and Whitehouse 2007). It was hoped that through these types of jobs female participation in IT would increase (Guerrier et al. 2009; Roan and Whitehouse 2007). However, given the emphasis of use of "soft" skills in these positions, their occupation by women did not serve to increase women's equal participation in technical roles (Guerrier et al. 2009; Roan and Whitehouse 2007). Would GIS be the same?

The results of this survey section revealed that GIS jobs require a diverse skillset. Participants reported the use of both technical and "soft" skills. However, rather than equally drawing from both skillsets, communication skills are more heavily used. The average rank score for the use of all skills is 3.76 (out of 5). The average rank score for technical competencies is 2.88 versus an average rank score of 4.21 for "soft," or communication related, competencies. Additionally, the participants have an average rank of 3.1 in regards to their use of management competencies. The

expectation that women would score relatively lower on the use of technical and management competencies was confirmed.

One of the particularly insightful comments made in reaction to the first question in this section is, "I am the GIS manager so my job inherently requires more of the "soft" skills you list. If I were technical staff, those values would be less but still important. I feel that we work in a customer oriented field - we don't have work unless someone needs what we do so it is important to have good people and communication skills." This points to the notion mentioned above that communication skills in GIS are important in general, regardless of how technical a position might be.

As mentioned, the aim of the first question in this survey section was to measure to what degree women *use* certain skills. The question was not about their skill level. Collecting this data is an important first step in an effort to find out if women are given opportunities to use all of the skills that GIS jobs require, or if gender bias is pushing them towards certain types of work as opposed to others. Are women given equal opportunities to take on technical and managerial work? As is also mentioned in this section, further research that includes men in GIS would be essential to see if there is a difference between the types of work that different people in GIS are doing.

The findings of this survey section (in addition to the questions posed in the paragraph above) are important additions to the discussion under Research Question B that asks whether there is vertical and/or horizontal segregation of women in GIS. Through this section it has been found that women utilize their technical and management skills to a lesser degree than they use their communication and workplace skills. This suggests *possible* vertical/horizontal segregation. However, without knowing to what extent men leverage these same skills, it is hard to determine if vertical/horizontal

segregation is truly present. Further research that includes men in GIS would help to clarify the results of this survey to that end.

E. Research Question: What role does the discipline of geography play in the Women in GIS topic?

Does geography temper some of the non-female friendly aspects of GIS that might come from the computer science roots/nature of GIS? Are geography departments a source of women in GIS?

Survey Page Header *(page 8 on survey): Pipelines to GIS*

Context for survey participants: *How do women who work in GIS come to GIS? Do many hear about GIS and receive GIS training via geography degrees? Do some hear and learn about it through other academic disciplines or other means (such as on the job, etc.)? Could there potentially be a more significant presence of women in GIS due to its ties to geography?*

SURVEY QUESTIONS:

1. **What is your highest degree in? If multiple degrees, what are they and in what discipline?**

Hypothesis: A vast majority of women in GIS have come to the GIS professional field via geography and earth sciences (such as environmental studies/sciences or geology) degrees, and fewer women will come to the field through computer science or similar degrees. Aside from what is mentioned in the hypothesis, what are the other degree types that women have?

Question format: Multiple choice - up to three combinations of drop-down menus of attainment levels and disciplines

Table 91. Bachelor's degrees

Degree†/††	**Raw #**	**Percent (of 450 women reporting education)**
Bachelor's degree (B.A. and B.S.)	450 (15 of 450 women have 2 bachelor's)	100% (not counting more than 1 bachelor's)
Master's degree	289 (9 women have 2 master's)	64% (not counting more than 1 master's)
PhD's	57	13%
Certificates	139 (11 women have 2 and 2 women have 3 certificates)	31%

† Includes completed and in-process degrees.
†† There was not a field in survey for Associate's degrees. Three women indicated Associate's under the Certificates value (those three not reflected in in this table).

Table 92. Bachelor's degrees by type (Primary degree only)

Primary† Degree Type	**Raw #**	**Percent (of 450 women)**
Geography††	**120**	**26.67%**
Environmental Science/Studies	61	13.56%
Geology	20	4.44%
Biology	19	4.22%
Engineering	19	4.22%
GIS†††	**18**	**4%**
Computer Science	**15**	**3.33%**
Math	11	2.44%
Planning/Architecture	10	2.22%
Science - Other	10	2.22%
Anthropology	9	2%
International/Public Affairs/Studies	8	1.78%
Business Related	7	1.56%
Political Science	6	1.33%
Physics	5	1.11%
Archaeology	4	0.89%
Landscape Architecture	4	0.89%
Other[6]	39	8.67%
Unknown	65	14.44%
TOTAL	**450**	**100%**

† Primary degree: In order to calculate percent of type of degree per 450 women, it was necessary to resolve those women who obtained two degrees (to select only one of their bachelor's degrees). To do this, the degree that was more relevant to a woman's highest degree was selected. In cases where this was not possible, the first degree listed by the survey respondent was selected.
†† Geography includes anyone who mentioned geography and geography plus anything else.
††† Four women call their bachelor's degree "GIS" – since it is unclear if this was within a geography department, these are listed separately.

[6] **"OTHER"** includes (these are either only mentioned once or 3 or less times (ones that had 4 or more get listed in main table)): Accounting; Agronomy; Art's English; Art History; Art; Journalism/Photojournalism; BFA; Studio Art; Communications; Criminal Justice; Dentistry; Economics; Elem Ed; English Lit; English Writing; English; Environmental Studies; Women, Gender and Sexuality Studies; Finance; Fine Arts; General Agriculture; Health; History; Humanities; Journalism; Nursing; Psychology; Secondary Educ PE & Math [Assigned this as other since not sure which one was predominant]; Social Science; Sociology; Technical Theatre; Telecommunications; Urban Studies; Wildlife.

Unknown: Those that put a numerical value for how many degrees obtained, but did not specify in what.

Table 93. Bachelor's degrees by type (All degrees)

Degree Type	Primary Degree	Secondary Degree	Total	Percent (of 465 total degrees)
Geography	**120**	**1**	**121**	**26.02%**
Environmental Science/Studies	61	2	63	13.55%
Geology	20	0	20	4.3%
Biology	19	0	19	4.09%
Engineering	19	0	19	4.09%
GIS	**18**	**0**	**18**	**3.87%**
Computer Science	15	1	16	3.44%
Math	11	0	11	2.37%
Planning/Architecture	10	0	10	2.15%
Science - Other	10	0	10	2.15%
Anthropology	9	0	9	1.94%
International/Public Affairs/Studies	8	1	9	1.94%
Business Related	7	1	8	1.72%
Political Science	6	0	6	1.29%
Physics	5	0	5	1.08%
Archaeology	4	1	5	1.08%
Landscape Architecture	4	0	4	0.86%
Other	39	5	44	9.46%
Unknown	65	3	68	14.62%
TOTAL	**450**	**15**	**465**	**100%**

Discussions of bachelor's degrees: The hypothesis that geography or earth sciences degrees would be the most common degrees among the women who participated in the survey is confirmed. Twenty-six percent of the participants who responded to the question have geography bachelor's degrees (or 30% if you consider the GIS degrees as being within a geography department or a geography bachelor's specialization). When combining the number of participants who have geography, GIS, environmental science/studies, and geology degrees (those that were part of the hypothesis) that accounts for 49% of participants possessing a total of those 222 degrees. The p-value is extremely small (p-value=5.0507E-125*), indicating that the observed values were not observed by chance, giving strong evidence that the hypothesis for this question is true.

The other part of the hypothesis is that not many women would come to GIS careers via computer science type degrees. This is also confirmed – only 16 participants (3% of all the 465 degrees reported) have computer science degrees.

Table 94. Master's degrees by type

Degree Type†	**#**	**# (if 2)**	**Total**	**Percent (of 289 Women with Masters)**	**Percent (of 450 Women with B.A.)** ††
Geography	70	0	70	24.22%	15.56%
Geography - GIS	10	0	10	3.46%	2.22%
(Total Geography) †††	**(80)** †††	**(0)** †††	**(80)** †††	**(27.68%)**†††	**(17.78%)**†††
GIS	57	1	58	20.07%	12.89%
GIS – Geoinformatics	3	0	3	1.04%	0.67%
GIS – Geomatics	2	0	2	0.69%	0.44%
GIS - Remote Sensing	6	0	6	2.08%	1.33%
(Total GIS) †††	**(108)** †††	**(1)** †††	**(69)** †††	**(23.88%)**†††	**(15.33%)**†††
Environmental Science/Studies	40	1	41	14.19%	9.11%
Environmental Science/Studies - GIS	4	0	4	1.38%	0.89%
(Total Environmental Science/Studies) †††	**(44)** †††	**(1)** †††	**(45)** †††	**(15.57%)**†††	**(10%)**†††
Planning	20	0	20	6.92%	4.44%
Geology	13	0	13	4.50%	2.89%
Geology – GIS	1	0	1	0.35%	0.22%
(Total Geology) †††	(14)†††	(0) †††	(14) †††	(4.85%)†††	(3.11%)†††
Business Related or MBA	10	2	12	4.15%	2.67%
Engineering	12	0	12	4.15%	2.67%
Public Health/Public Administration	6	0	6	2.08%	1.33%
Science - Other	5	1	6	2.08%	1.33%
Computer Science	**2**	**0**	**2**	**0.69%**	**0.44%**
Other	22	4	26	9.00%	5.78%
Unknown	6	0	6	2.08%	1.33%
TOTAL	**289**	**9**	**298**		

† If respondent mentioned something like Discipline + specialty or two things, those things are listed as new rows in this table. For example, if someone said "geology and GIS", this is listed as separate as someone who just did geology.
†† This number means, of the 450 women who have education (bachelor's being the baseline), 15.6% went on to get geography master's, while 24.2% of women that have masters have it in geography.
††† Aggregates of "specializations" within disciplines – these do not impact grand TOTAL number, as the things they are aggregates of are already in grand TOTAL.

Discussion of master's degrees: Sixty-four percent of participants who have bachelor's degrees went on to attain master's degrees. The degree category with the largest percentage of participants

is geography – 18% who have bachelor's degrees decided to pursue a master's in geography, and 28% of the 289 participants with a master's have it in geography. The next highest occurrence of a master's is in GIS (24% of the 289 participants with master's degrees), with 15% in bachelor's going on to pursue graduate GIS education. The pattern of becoming more specialized with the higher level of education starts to become apparent, especially in the specialization of GIS degrees. In addition to listing a GIS master's, some participants also indicated some area of specialty (such as remote sensing). It is possible that those who just indicated GIS also had an area of specialization but did not specify that in their responses.

Environmental science/studies continues to be a widely pursued degree at the master's level, with 16% of the women with a master's having it in environmental science/studies. Ten percent of participants who have bachelor's degrees went ahead to pursue master's degrees in environmental science/studies. On the other hand, computer science continues to be rarely pursued with less than 1% of women with master's degrees possessing that type of degree.

Table 95. PhD degrees by type

Degree Type	**Raw #**	**Percent (of 57 PhD's)**
Geography	**17**	**29.82%**
GIS and Specialties (Remote Sensing; Cartography; Spatial Statistics; Geomatics; GIScience)	**9**	**15.79%**
Geological Sciences	4	7.02%
Medical Geography	2	3.51%
Natural Resource Studies	2	3.51%
Agriculture	1	1.75%
Anthropology	1	1.75%
Biology	1	1.75%
City and Regional Planning	1	1.75%
Civil and Environmental Engineering	1	1.75%
Computational Social Science	1	1.75%
Computer Science	1	1.75%
Education with Focus on Instructional Technology Specifically GIS	**1**	**1.75%**
Environmental Science	1	1.75%
Forest Ecology, Remote Sensing and GIS	**1**	**1.75%**
Geography and Project Engineering	1	1.75%

Degree Type	Raw #	Percent (of 57 PhD's)
Horticulture and Forestry	1	1.75%
Hydrogeology	1	1.75%
Hydrology	1	1.75%
Law	1	1.75%
Leisure Behavior	1	1.75%
Marine Geomatics	**1**	**1.75%**
MD In Medicine	1	1.75%
Urban And Regional Science	1	1.75%
Veterinary Pathobiology Spatial Epidemiology Focus	**1**	**1.75%**
Unknown	3	5.26%
Total	**57**	100%

Discussion of PhD's: Table 95 above is intentionally left less generalized to show the increased level of specialization that was observed in looking at the survey results as women obtain higher levels of education. Of the 57 participants who report PhD's, seven specified that they are currently PhD candidates. Geography and GIS continue to be areas of study that women pursue at the PhD level. Of the 57 participants who have PhDs, 30% have PhDs in geography and 16% have PhDs in GIS and other GIS related specialties (not including those who reported very specific GIS studies such as marine geomatics, which are listed separately).

Table 96. Certificates by type

Certificate Type	Raw #	Percent (of 152 Certificates)
GIS	**93**	**61.18%**
GIS and Remote Sensing	**4**	**2.63%**
GISP	15	9.87%
Project Management	3	1.97%
Biology	2	1.32%
Education	2	1.32%
Business	1	0.66%
CAD	1	0.66%
CAE in English	1	0.66%
Cartography	**1**	**0.66%**
CBE	1	0.66%
CCD	1	0.66%
CCIM	1	0.66%
CEM	1	0.66%
Certified Floodplain Manager	1	0.66%
Computational Science	1	0.66%

Certificate Type	Raw #	Percent (of 152 Certificates)
Computer Science	1	0.66%
Conservation and Land Management	1	0.66%
Conservation Biology and Environmental Policy	1	0.66%
Environmental Regulations and Permits	1	0.66%
ESRI Enterprise Administration Associate	1	0.66%
ESRI Enterprise Geodatabase Management Professional	1	0.66%
Geology	1	0.66%
Hazwoper	1	0.66%
Integrated Coastal and Ocean Management	1	0.66%
IT	1	0.66%
MAI	1	0.66%
Organizational Leadership	1	0.66%
P.G.	1	0.66%
Photogrammetry	**1**	**0.66%**
PMP	1	0.66%
Post-Graduate Certificate in Geomatics	**1**	**0.66%**
Rural Sociology and Economic Development	1	0.66%
Urban Planning	1	0.66%
Writing	1	0.66%
Unknown	4	2.63%
Total	**152**	100%

Discussion of certificates: One hundred and thirty-nine participants have certificates. Eleven participants have two certificates and two have three certificates. Sixty-six percent of the 152 total certificates are in GIS and related areas of study (GIS; GIS and remote sensing; cartography; photogrammetry; post-graduate certificate in geomatics combined). Fifteen participants mentioned that they are Certified GIS Professionals (GISP). Even more might be GISPs but this was not explicitly asked in the survey.

Of those with certificates, 18 have a geography or GIS master's but do not have a geography or GIS bachelor's degree. Sixty participants with GIS certificates (13% of the 450 who reported on their education achievements) have neither a geography nor a GIS bachelor's or master's degree. This suggests that their GIS training was through a certificate alone and possibly through other non-

geography or GIS-related bachelor's or master's degrees.

2. How did you hear about GIS?

Hypothesis: None. This question was posed from a neutral standpoint to learn more about how women hear about GIS.

Question format: Textbox

Table 97. How did you hear about GIS?

Comment Category	Raw #	Percent (of 457)
In college, a required, general curricula, or core course, advisor or course catalog (undergrad or graduate)	131	28.70%
On the job	69	15.10%
Working in a related field	16	3.50%
Via an entry level job	15	3.30%
From a colleague, family member or friend	13	2.80%
Already in related field as GIS technology developed	11	2.40%
Love of maps	6	1.30%
From a GIS professional	5	1.10%
Tools needed for another job	4	0.90%
Conference or seminar	3	0.70%
ESRI	3	0.70%
Geography or other scientific literature	3	0.70%
Media or Internet research	1	0.20%

Interpretation: While there is not necessarily a gender-related aspect to this question, the results, when tied to the first question of this section about what discipline participants have their degrees in, might provide insights into identifying the common pathways into the GIS field. It was expected for the survey question above that many participants would come to the professional sphere of GIS specifically via geography educations. In regards to the current question about how they heard about GIS, 29% of the participants fell into the category of, "In college, a required, general curricula, or core course, advisor or course catalog (undergrad or graduate)." This further supports the notion that many women discover GIS first in primarily geography educational settings. Twenty-two percent of the participants who responded to this question heard about GIS in a work related

situation ("On the job," "Working in a related field," and "Via an entry level job" combined). It would be interesting to learn if the women who found out about GIS first through work then pursued formalized GIS training in a university setting. As is mentioned above, it appears that the GIS-related education of 60 of the participants (13% of the 450 women who reported on their education achievements) was through a GIS certificate alone (and not a bachelor's and/or a master's degree in geography or GIS). Learning about the most basic level of education that is required to enter the field (and succeed) might prove helpful even beyond the "women in GIS" topic. If many women (or men) who are already in the professional sphere, and who are already highly educated in other disciplines, hear about GIS at work and are interested in becoming GIS professionals, they might consider that obtaining a GIS certificate might allow for successful entry into the field.

3. Did you ever have a GIS internship?

Hypothesis: GIS internships are fairly common. However, the aim of the question is not to prove or disprove the hypothesis. Rather, it is asked to gather more information about pathways into GIS careers.

Question format: Radio – yes/no/not applicable

Table 98. Did you ever have a GIS internship? (No category filters)

Value	Count	Percent
Yes	224	47.5%
No	236	50.0%
Not applicable	12	2.5%
Statistics		
Total responses	472	
Unanswered	12	
Chi-squared test: 1.48957E-44*		

Interpretation: Nearly half (48%) of survey participants have had GIS internships, which supports the hypothesis that GIS internships are fairly common (additionally, the p-value is extremely small indicating that these numbers were not observed by chance). The only sector in which having had internships was not prevalent is the start-up filter, in which only 10% of participants in that category say that they have had an internship (p-value = 0.007*).

As can be seen in the Table 99, internships are far more prevalent among newcomers to GIS. Whether this is a pattern that is specific to GIS or whether it is the case that internships in general are becoming increasingly more typical, these numbers suggest that for newcomers to GIS, having an internship is important (in order to compete with other entry-level candidates who have GIS internships on their resumes). Further supporting this statement is the fact that 65% of those in the 21-30 years old category (typical college graduates in this category) have had GIS internships.

Table 99. Did you ever have a GIS internship? (By number of years in GIS)

Number of Years in GIS	# Responses†	# Yes	# No	% Yes	% No	P-value
0-3 yrs.	102	56	45	54.9%	44.1%	1.5169E-11*
>3 and <=10 yrs.	180	98	78	54.4%	43.3%	1.7858E-18*
>10 and <=20 yrs.	141	59	77	41.8%	54.6%	1.06318E-13*
>20 and <=30 yrs.	41	8	32	19.5%	78%	3.98207E-09*
>30 yrs.[2]	3	0	2	0%	66.7%	n/a

† Number of responses includes total number of participants that answered this question and includes not applicable. However, only responses of 'yes' and 'no' reflected in the other columns of this table.

4. If so, did that internship lead to a full-time position?

Hypothesis: None. This question was asked to gather more information about pathways into GIS careers. However, it is suspected that GIS internships are excellent gateways to positions in GIS – either through the internships directly leading to full-time positions or by providing necessary skills that cannot be gained in educational programs alone.

Question format: Radio – yes/no/not applicable

Table 100. If so, did that internship lead to a full-time position? (No category filters)

Value	Count	Percent
Yes	92	22.5%
No	124	30.4%
Not applicable	192	47.1%
Statistics		
Total responses	408	
Unanswered	76	
Chi-squared test: 4.6964E-09*		

Table 101. If so, did that internship lead to a full-time position? (Filtered)

If yes internship, not led to job	109	54.77%
If yes internship, yes led to job	**90**	**45.23%**
Filter total	199	

Results filtered by those who responded "yes" to previous question ("Did you ever have a GIS internship?").

Interpretation: The results for this question have been filtered by those who responded that yes, they had a GIS internship, in order to better see how many of those who had GIS internships went on to obtain a full-time position. With this filter, it has been discovered that for 45% of the 199 participants who reported having GIS internships, these internships led to a full-time position. This strongly supports the idea that GIS internships are invaluable. If nearly half of participants had internships and there is a 45% success rate of obtaining jobs through an internship, it can be deduced that internships are an excellent way to begin a career in GIS. Additionally, if women (or people, in general) who have not had GIS internships are competing for jobs with people who have had GIS internships, which is a large percentage of the population as the survey results suggest, it can be further inferred that having a GIS internship could be advantageous.

5. Feel free to add comments about any other way(s) internship may have been beneficial.

Hypothesis: None. However, it is expected that women who have had internships will make helpful comments about the benefits of internships.

Question format: Textbox

Open text analysis: (131 comments)

Table 102. Feel free to add comments about any other way(s) internship may have been beneficial.

Comment Category	Raw #	Percent (of 131)
Led to a job or job offer	41	31.30%
Provide real world and hands-on experience	28	21.40%
Means to develop skills	16	12.20%
Provide professional references/build resume	13	10%
Networking	11	8.40%
Learn if GIS is right for me	8	6.10%
Let intern learn how to work and demonstrate professional abilities	7	5.30%
Learn about GIS careers	6	4.60%
Way to practice and hone skills learned in school	6	4.60%
Led to research work, continuing studies or publication	3	2.30%
Let me showcase the power of GIS to the organization	2	1.50%
Broaden horizons	2	1.50%
Was not a positive experience	1	0.70%

Interpretation: Of those who made comments, 31% said that the benefit of an internship was that it led to a job. Even for those participants for whom an internship did not lead to a full-time position, many commented on the other benefits of an internship. Twenty one percent said that internships helped to provide hands-on experience and 12% said internships helped them to develop skills – internships can be seen as great ways to supplement formal education. Only one comment reflected a negative internship experience.

On the benefits of GIS internships, two women in mentor roles made these comments:

> "I have mentored several students, and all of them landed great GIS jobs. This is an important step to get good experience, learn more, and it is nearly mandatory for getting a job. Most GIS jobs are asking for a 4 year degree plus experience and recommendations."

> "I have been the internship coordinator for GIS and geography and find this is THE best way students to learn a) real world skills b) work ethic c) networking toward job obtainment."

While these two comments, or this sub-section in general, do not necessarily have a gender-related aspect to them, they are presented here because, even if internships are invaluable to males and females alike, and even though the benefits of internships would be the same for both men and

women, if female representation is an issue in GIS then it is of the utmost importance for women to pursue and obtain GIS internships. It could ensure for women a higher success rate in moving from the educational to the professional sphere.

SUMMARY OF RESEARCH QUESTION E

Pipelines to GIS

The questions in this survey section seek to explore the areas of study that bring women to careers in the professional GIS sphere, and how they find out about GIS. Do most women learn about GIS in school or do some hear about it in other ways? Would most women who work in GIS come to their GIS careers via geography educations (or through earth/environmental science/studies type degrees)? Would this be true for men as well? Is the GIS professional world is made up of a lot of geographers, or people with geography and/or earth/environmental science/studies backgrounds? The point of this line of reasoning is to further explore how and why the technical GIS realm is different from other technical realms such as IT. Is it partially because the educational background of GIS professionals has shaped the GIS field differently?

It was found that the survey participants are highly educated. Four hundred and fifty participants reported on their educational achievements, indicating whether they attained bachelor's, master's, or PhD degrees, or certificates, and, if so, in what disciplines. The largest degree category for all levels of education is geography. As mentioned, geography and earth/environmental science/studies are much more common pathways to working in GIS than are such degrees as computer science. A high percentage of participants found out about GIS in school – and if the highest percentage of participants have geography educations, it can be deduced that a significant amount of women learned about GIS through their geography studies.

This thesis section also explored the incidence of internships among the participants and whether GIS internships tended to lead to full-time GIS positions. Almost half of the participants surveyed have had GIS internships, and for almost half of them this led to full-time work. While it could be argued that internships are important for both men and women, if it is a goal to increase diversity in GIS, then women and other underrepresented groups should be further encouraged to pursue internships.

F. Research Question: Does the number of years in the GIS field have any bearing on the results of the survey questions?

Specifically, do women with more years in GIS have different perceptions of the status of women in GIS? Will they respond differently to questions such as "Do you think there in underrepresentation of women in GIS" or "Do women face bias as GIS professionals?" Additionally, will women with more years in GIS have different experiences than newcomers (thereby altering their perceptions)? Do the observations derived from these questions point to a change in the GIS field over time (to a field that is becoming increasingly better for women)?

Survey Page Header *(page 9 on survey)****:*** *Optimism?*

Context for survey participants: *Is there an underrepresentation of women in GIS (See Research Question B, Survey Question 6 for numerical representation of women in GIS)? Do women face gender bias in their career paths that might hinder their success? What are the different perceptions of women? Do perceptions about the status of women in GIS vary based on a woman's length of time in the field and other career stage details?*

SURVEY QUESTIONS:

1. How many years have you been working in a professional setting?

Hypothesis: None. This question was asked to gather work history information about the women who participated in this survey.

Question format: Integer

Table 103. Years working in a professional setting (No category filters)

	Years in a professional setting
Average	14.03
Min	0.5
Max	48
Median	12
Statistics	
Total responses	477
Unanswered	7

Table 104. Years working in a professional setting (Categorical view)

Value	Count	Percent
0-3 yrs.	57	11.95%
>3 and <=10 yrs.	153	32.08%
>10 and <=20 yrs.	165	34.59%
>20 and <=30 yrs.	73	15.3%
>30 yrs.[2]	29	6.08%
Statistics		
Total responses	477	
Unanswered	7	

Interpretation: On average, survey participants have been working in the professional sphere for 14 years, with a minimum of 0.5 years to a maximum of 48 years. The number of years in a professional setting can also be broken down into categories to help group participants into similar years of work experience. Only 12% of participants are new to working in the professional sphere (three or fewer years), while 56% have more than ten years of experience. Overall, the numbers suggest that women in GIS have a significant amount of professional experience, and only a small percentage have little to no work experience. The number of women in the GIS field with a high level of professional experience could be helpful to their female counterparts. Women with a lot of experience could have a higher level of workplace intelligence and agility in navigating the professional sphere – knowledge which they could impart through formal and informal mentoring to the women that they work with or whom they know through networking. Not only is having GIS

know-how important, but more general professional experience among women in GIS could lead to not only a stronger female GIS workforce, but also a better GIS workforce in general.

The overall numbers reflect a somewhat balanced workforce (in terms of the number of years that women have worked in the professional sphere) if you split up the population into two groups – one group of participants with up to ten years of work experience (44%) and one group with more than ten years of experience (56%). These numbers suggest that women with up to ten years work experience will find a fair number of women with more experience than they have to look up to. However, women who have between 10 and 20 years of experience and higher have progressively fewer women with more experience to look up to. Specifically, women with 10-20 years of professional experience, have 22% of women to look up to (meaning that only 22% of the survey population has over 20 years of experience), and women with 20-30 years of experience only have 7% of the women above them to look up to.

Do the number of years in a professional setting vary greatly by sector? Table 105 helps to answer this question. Participants with little to no work experience (0-3 years) only account for 2% of federal and local government workers. Accordingly, these two sectors have the largest proportion of participants with over 20 years of experience (federal government = 42% and local government = 30%). Meanwhile, the non-profit and higher education sectors have about 18% of participants with only 0-3 years of experience, and start-ups have a significant 36%. As there are only ten participants who are part of the start-up sector, it is possible that these numbers were observed by chance (p-value is 0.54). However, if the numbers derived from the survey results are an accurate representation of the larger population, it can be seen that the different sectors are comprised of women with greatly varying amounts of work experience. The numbers also suggest that some sectors, such as start-ups, have many fewer women with increasing amounts of general workforce

experience – this lopsidedness could possibly cause or be representative of other vertical career advancement issues (such as encountering a glass ceiling).

Table 105. Years working in a professional setting (By sector)

Sector	# Responses	0-3 yrs.	>3 and <=10 yrs.	>10 and <=20 yrs.	>20 and <=30 yrs.	>30 yrs.
Federal Gov.	43	1 2.33%	13 30.23%	11 25.58%	12 27.91%	6 13.95%
State Gov.	74	11 14.86%	22 29.73%	28 37.84%	12 16.22%	1 1.35%
Regional Gov.[1]	5	0 0%	3 60%	2 40%	0 0%	0 0%
Local Gov.	107	2 1.87%	26 24.3%	47 43.93%	21 19.63%	11 10.28%
Non-profit	37	7 18.92%	16 43.24%	11 29.73%	2 5.41%	1 2.70%
Private	144	22 15.28%	52 36.11%	47 32.64%	16 11.11%	7 4.86%
Start-up	11	4 36.36%	2 18.18%	3 27.27%	1 9.09%	1 9.09%
Higher education	38	7 18.42%	12 31.58%	11 28.95%	6 15.79%	2 5.26%

Please note that the percentages in this table pertain to each sector row. For example, of all the women who work in federal government, 2% have 0-3 years of GIS experience, 30% have 3-10 years of experience, and so on.

(More statistics for this question are presented in the tables under Question 2 below.)

2. Of those years, how many have been in GIS?

Hypothesis: None. This question was asked to gather GIS-related work history information for the women who participated in this survey. Additionally, the variable of number of years in GIS has been utilized to filter overall survey responses for all questions in the survey.

Question format: Integer

Table 106. Years working in a professional GIS setting (No category filters)

	Years in prof. setting†	Of those, years in GIS
Average	14.03	10.06
Min	0.5	0
Max	48	39
Median	12	8
Statistics		
Total responses	477	476
Unanswered	7	8

† Number of years in professional setting presented again here in order to more easily compare with number of years in GIS.

Table 107. Years working in a professional GIS setting (Categorical view)

Value	Count	Percent
0-3 yrs.	104	21.85%
>3 and <=10 yrs.	183	38.45%
>10 and <=20 yrs.	144	30.25%
>20 and <=30 yrs.	42	8.82%
>30 yrs.[2]	3	0.63%
Statistics		
Total Responses	476	
Unanswered	8	

Interpretation: On average, participants have been working in the professional GIS sphere for 10 years, with a minimum of 0 years to a maximum of 39 years. Similar to the question above, the survey population can be broken down into five categories to combine participants with similar amounts of GIS experience.

As is noted above, only 12% of the participants have only 0-3 years of overall professional experience. However, 22% of the participants have 0-3 years *GIS-specific* work experience, indicating that among the entry-level GIS group (0-3 years GIS professional experience) some have had other work experience. Additionally, there is an indication of a career change into GIS, not only among the entry-level group, but throughout the other groups with higher levels of general professional experience. Although this is not within the scope of this thesis study, it would be interesting to learn what these career changers did prior to working in GIS. Were they in fields with different types and levels of female participation? How do their prior experiences shape their views on the topic of women in GIS and the GIS field in general? Furthermore, do they bring with them skills from their prior jobs, either technical or "soft," that enhance their GIS capabilities? Similarly, it would also be interesting to find out if any women have left the GIS field and, if so, what their motivations to do so were.

Beyond what is discussed in the question above (years of general professional experience), there is an even greater drop off among the groups of participants with progressively higher numbers of years in the GIS field. There are even more entry level female GIS professionals and fewer and fewer participants with more GIS experience. Only 40% of participants have more than 10 years of GIS experience, as compared to 56% with ten or more years of general professional experience. Furthermore, only 9% of the participants have more than 20 years of GIS experience, suggesting that there are fewer senior women for the group below them (with less than 20 years of GIS experience) to look up to.

Table 108 below provides a view of the numbers of participants in different sectors with different amounts of GIS experience. Federal and local government have the highest percentage of participants with more than 20 years of GIS experience, with 21% and 17% respectively. Meanwhile state government has a poor representation of participants with this amount of GIS experience (3%). When it comes to the other end of the spectrum, non-profits and start-ups have the highest amount of entry level GIS participants, 32% and 45% respectively. What the numbers in Table 108 suggest is that while certain sectors can better provide entry-level opportunities to those seeking GIS employment, those who enter those sectors might have fewer women in their organizations with more GIS experience to mentor them. Also, do these numbers mean that it might be even more difficult to get higher level positions in those same sectors in which women find entry-level employment, as is suggested by the dwindling number in certain sectors of women with more GIS experience? Or, could it simply mean that these sectors are later adopters of GIS, and that is why the number of women with more GIS experience dwindles?

Table 108. Years working in a professional GIS setting (By sector)

Sector	# Responses	0-3 yrs. GIS	>3 and <=10 yrs.	>10 and <=20 yrs.	>20 and <=30 yrs.	>30 yrs.	(More than 20 yrs.)
Federal Gov.	74	5 11.63%	17 39.53%	12 27.91%	9 20.93%	0 0%	20.93%
State Gov.	43	15 20.27%	31 41.89%	26 35.14%	2 2.70%	0 0%	2.7%
Regional Gov.[1]	5	0 0%	3 60%	2 40%	0 0%	0 0%	0%
Local Gov.	106	15 14.15%	37 34.91%	36 33.96%	17 16.04%	1 0.94%	16.98%
Non-profit	37	12 32.43%	14 37.84%	11 29.73%	0 0%	0 0%	0%
Private	144	38 26.39%	60 41.67%	38 26.39%	7 4.86%	1 0.69%	5.56%
Start-up	11	5 45.45%	4 36.36%	1 9.09%	0 0%	1 9.09%	9.09%
Higher education	38	9 23.68%	10 26.32%	16 42.11%	3 7.89%	0 0%	7.89%

The responses to this question (how many years in GIS) have been utilized to filter the responses for all questions in the survey. The interest in the different years of GIS experience groups was derived from the pilot study. One important use of the creation of this particular filter is to see if women with more years in GIS (or those that have been referred to as the "first generation" of women in GIS in this thesis) have different perceptions of the status of women in GIS. Have they had different experiences than newcomers, thereby altering their perceptions? Do women in different GIS generations have significantly different responses to the questions that were posed in the survey? Also, could differences in responses possibly point to a change in time of the GIS field? Variations in survey question responses by number of years in GIS is discussed throughout this thesis chapter.

There were six survey questions that yielded interesting results for this first generation (not always one of variation). These results are discussed in the survey analysis sections that they are part of, but are consolidated here to more easily see how this group of survey participants is unique:

- **Do you feel that there are enough women in your department?**

  With more years in GIS, those saying "definitely yes" drop off. Seventeen percent of those with 0-3 years of GIS experience say "definitely yes," falling to only 8% of those with 20-30 years in GIS.

- **Do you feel that you would like to meet other women who work in GIS?**

  93% of participants with more than 20 years of GIS experience would like to meet other women who work in GIS (responses to this question steadily increased from 86% of women with 0-3 years of GIS experience).

- **Skills:**

  The use of average "soft," technical, and management competencies increases with more years in GIS experience.

- **Do you think there is an underrepresentation of women in GIS?**

  Contrary to what was expected, the number of years in GIS does not seem to have an impact on the responses to this question. Sixty-nine percent of participants who have more than 20 years of GIS experience think that there is an underrepresentation of women in GIS – this number is slightly higher than those with less years in GIS, but not significantly so (61%-64% of those with less years of experience said yes).

- **Do women face bias as GIS professionals?**

  There is a diminishing trend of the survey participants perceiving that women face bias as GIS professionals. Fifty percent of those with 0-10 years of GIS experience, 48% of women between 10 and 20 years, and 40% of those with more than 20 years say that women face bias.

- **Does your gender play a role in what you view those challenges to be? (In response to "Do you view attaining the next step in your career as having challenges?")**

Roughly 40% of participants with up to 20 years of GIS experience think that their gender plays a role in the challenges of attaining the next step in their careers. This is compared with 29% of those with more than 20 years of GIS experience.

- **Do you feel that gearing work-family policies with women in mind alienates women?** Participants with 0-20 years of GIS experience responded to this question similarly (63-65% said "yes"), however 85% of those with 20-30 years of GIS experience think that gearing work-family policies with women in mind alienates women.

3. Do you think there is an underrepresentation of women in GIS?

Hypothesis: Yes, women will believe that there is an underrepresentation of women in GIS. Whether or not there is a statistically evidenced overall underrepresentation of women in GIS, women who work in GIS will feel that they are underrepresented in the field. This is hypothesized for two reasons. First, it is based on informal observations (for example, of conversations at conferences such as the 2013 Association of American Geographers Annual Conference and other recent local conferences). Second, even if women were to account for half of the GIS workforce, it is possible that women are either not proportionally represented in high-level positions and/or in more highly technical roles. This will lead women to perceiving a general underrepresentation.

Question format: Radio – Binary (yes/no)

Table 109. Do you think there is an underrepresentation of women in GIS? (No category filters)

Value	Count	Percent
Yes	300	63.6%
No	172	36.4%
Statistics		
Total responses	472	
Unanswered	12	
Binomial probability of trial result: 8.88174E-10*		

Interpretation: Sixty-four percent of the participants said that they think there in an underrepresentation of women in GIS. The p-value is extremely small, indicating that the observed values were not observed by chance and that the number of participants who think there is underrepresentation is significant, giving strong evidence that the hypothesis for this question is true.

Do women in certain sectors, or with different numbers of years in GIS, or different groups of women, have different perceptions when it comes to this question? Across sectors, the responses were consistent, except in higher education. Here, 72% of participants indicated that they perceived an underrepresentation, versus other sectors like local government where only 59% thought so.

79% of Hispanic participants feel that there is an underrepresentation, while only 54% of Asian participants think so. What would be the factors that would make these two groups perceive the representation of women so differently?

Table 110. Do you think there is an underrepresentation of women in GIS? (By race/ethnicity)

Race/Ethnicity	# Responses	# Yes	# No	% Yes	% No	P-value
Hispanic	24	19	5	79.2%	20.8%	0.002533436*
Black/African American	8	5	3	62.5%	37.5%	0.21875
White	233	233	137	63%	37%	1.45059E-07*
Asian	26	14	12	53.8%	46.2%	0.143910944
Am. Indian/Alas. Nat.[3]	3	2	1	66.7%	33.3%	n/a
Nat. Haw./Pac. Is.[3]	3	1	2	33.3%	66.7%	n/a

Contrary to what was expected, the number of years in GIS does not seem to have an impact on the responses to this question. Sixty-nine percent of participants who have more than 20 years of GIS experience think that there is an underrepresentation of women in GIS – this number is slightly higher than those with fewer years in GIS, but not significantly so (61%-64% of those with fewer

years of experience said yes). As there are relatively fewer participants with more years of experience in GIS, it could have been expected that with more years in GIS, the greater the perception of an underrepresentation of women in GIS. Perhaps other factors come into play at this point in women's careers that make gender seem relatively less of an important issue. Even if gender-related issues do occur with more years in GIS, or with more years of work experience in general, other factors, such as age-bias, might be more prominent (this in fact was cited by a number of the women with more years in GIS). Or perhaps over time this first generation group of women in GIS has observed more women entering the field, thereby creating the view that women are now comparatively better represented.

Regardless of variations in survey participant categories on the results of the question, the hypothesis for this question is confirmed – a significant amount of participants do perceive an underrepresentation of women in the field. As is mentioned above, whether or not there is an actual representation, a *perceived* underrepresentation could still exist as well as color women's experiences of their GIS careers. If narratives of underrepresentation persist, will this have a positive or negative effect on women's participation in the field?

4. Do women face bias as GIS professionals?

Hypothesis: Yes, women will think that women face bias as GIS professionals.

Question format: Radio – Binary (yes/no)

Table 111. Do women face bias as GIS professionals? (No category filters)

Value	Count	Percent
Yes	229	48.4%
No	244	51.6%
Statistics		
Total responses	473	
Unanswered	11	
Binomial probability of trial result: 0.028919226*		

Interpretation: Whether or not women are underrepresented in GIS (in addition to the concept of perceived underrepresentation), it is still possible that they face bias as GIS professionals and/or feel that they face bias. This type of bias can include being left out of male networks (Ahuja 2002; Bastalich et al. 2007; Cross and Linehan 2006; Guerrier et al. 2009; Orser, Riding, and Stanley 2012; Wentling and Thomas 2009), receiving lower pay rates than men (Ahuja 2002; Glover 2002; Prescott and Bogg 2011), not having the same opportunities as men for certain types of work, and so on). Do women in the GIS field perceive a bias? Similar to underrepresentation, whether or not there is a bias, if women *think* that there is such a bias, it could potentially shape their view on the topic of women in GIS and their experience of being women in GIS. Participants were divided nearly 50-50 on this question. Forty-eight percent said that, yes, women face bias as GIS professionals. The p-value is less than .05, indicating that the observed values were not observed by chance. While only 48% of participants thinking that women face bias as GIS professionals may not be enough to strongly confirm the hypothesis, a considerable amount of the population thinks that bias exists.

There is a relationship between sector of employment and response to whether women face bias as GIS professionals. Only 36% of participants who work at a start-up said they think women face bias in GIS, compared with 63% of participants who work in higher education. This is really interesting given that start-ups has the highest percent of participants with male supervisors compared to higher education which has the lowest. The results for the start-up group are also surprising given that the start-up group is the one with the smallest amount of female participation (28% female representation in the field). In terms of the different government sectors, 51% of the participants in the federal sector say that women face bias as GIS professionals, whereas only 38% in local government think so.

Table 112. Do women face bias as GIS professionals? (By sector)

Sector	# Responses	# Yes	# No	% Yes	% No	P-value
Federal Gov.	43	22	21	51.2%	48.8%	0.119604179
State Gov.	74	32	42	43.2%	56.8%	0.047367539*
Regional Gov.[1]	5	1	4	20%	80%	n/a
Local Gov.	106	40	66	37.7%	62.3%	0.003181208*
Non-Profit	36	16	20	44.4%	55.6%	0.106343535
Private	142	79	63	55.6%	44.4%	0.027257336*
Start-Up	11	4	7	36.4%	63.6%	0.161132813
Higher education	38	24	14	63.2%	36.8%	0.035177633*

In terms of race/ethnicity, black/African American participants also responded to this question differently than the larger population – 75% answered "yes." However the p-value of this population is 0.109375, so it is possible that these numbers were observed by chance.

While there is only marginal variation in responses when comparing the different age categories, there is variation when comparing by number of years in GIS. If we treat the number of years in GIS categories as three separate GIS generations – one of less than ten years in GIS, the next as having between 10 and 20 years in GIS, and the first generation as having more than 20 years in GIS – we see a diminishing trend among survey participants' perceptions that women face bias as GIS professionals. Fifty percent of participants with 0-10 years of GIS experience, 47.6% of participants between 10 and 20 years, and 40% of those with more than 20 years say that women face bias (Table 113 shows the non-collapsed number of years in GIS categories).

Table 113. Do women face bias as GIS professionals? (By number of years in GIS)

Number of Years in GIS	# Responses	# Yes	# No	% Yes	% No	P-value
0-3 yrs.	101	46	55	45.5%	54.5%	0.053216347
>3 and <=10 yrs.	181	95	86	52.5%	47.5%	0.047404549*
>10 and <=20 yrs.	143	68	75	47.6%	52.4%	0.056181648
>20 and <=30 yrs.	42	17	25	40.5%	59.5%	0.057903418
>30 yrs.[2]	3	1	2	33.3%	66.7%	n/a

Similar to the question of "Do you think there is an underrepresentation of women in GIS," it is surprising that fewer participants with more years in GIS think that women in GIS face bias. Is it because they recall a time when there might have been more gender-based bias present? That is, they possibly perceive an improved situation for women in the field and therefore are less likely to respond yes to this question? Or, is it that new challenges are faced at the point at which they are in in their careers, and so gender is less of a prominent issue? Or, on a more positive note, is it because they have had successful careers and have "gone far" in GIS – thereby diminishing the view that women face bias as GIS professionals?

5. Is this bias unique to GIS (Yes) or is it more general (No)?

Hypothesis: Women will think this bias is more general.

Question format: Radio

Table 114. Is this bias unique to GIS (Yes) or is it more general (No)? (No category filters)

Value	Count	Percent
Yes (bias is unique to GIS)	26	5.6%
No (bias is more general)	320	69.0%
I don't think women face gender-based bias (n/a)	118	25.4%
Statistics		
Total responses	464	
Unanswered	20	
Chi-squared test: 3.10399E-64*		

Interpretation: Because GIS is largely a field and/or a tool that is often part of other disciplines, and because GIS positions are also located in a variety of industries, and because gender bias in the workplace is a broader issue, it was hypothesized that participants would think that the bias they face (if they do think there is a bias) is not unique to GIS and that it is more general. In fact, only 6% believe that the bias is unique to GIS while 69% think that it is more general (the other 25% answered they don't think there is bias). The p-value is extremely small, indicating that the

observed values were not observed by chance and that the number of participants who think that the bias women face is not unique to GIS is significant, giving strong evidence that the hypothesis for this question is true.

(Tables for survey population groups are not presented for this question as the responses were fairly consistent across groups.)

The answers to a question like this might prove useful on a few levels. First, if the issue is not with the GIS field itself, but is more of a generalized issue, it might be more productive to tackle gender issues from a broader perspective. Second, if women do not think that the gender-related issues they might face are GIS field-related, then that might reflect well upon the GIS professional sphere – perhaps it is a good technical field for women to pursue. In that vein, how does GIS compare to other male-dominated fields? If it is found that gender-bias in other male dominated, technical fields is specific to those fields, how is GIS different? What conditions exist in GIS that might make it a better environment for female participants? The findings of Research Question A might be a particularly good starting point for addressing these questions, in addition to the findings of Research Question E that explores the pipelines of women into GIS.

6. Was getting to where you are in your career easy (Yes) or difficult (No)?

Hypothesis: None. The responses to this question, plus comments, are to assess if there is an overall narrative, or lack thereof, of struggle.

Question format: Radio – Binary (yes/no) plus comments

Table 115. Was getting to where you are in your career easy (Yes) or difficult (No)? (No category filters)

Value	Count	Percent
Yes	190	46.1%
No	222	53.9%
Statistics		
Total responses	412	
Unanswered	72	
Binomial probability of trial result: 0.01135769*		

Interpretation: Just about half of the participants said that getting to where they are in their careers has been difficult (or put differently, half said it was *not* difficult).

Have different numbers of participants in different sectors experienced difficulty in getting to where they are in their careers? Sixty percent of participants in start-ups said yes, they have had difficulties, as opposed to 34% in higher education. Again, we can compare these figures to the prominence of male versus female supervisors. Eighty-two percent of participants in start-ups reported having male supervisors – does this factor into their view that getting to where they are in their careers has been challenging? Conversely, has the lower number of women in higher education with male supervisors, led to the opposite? Also of note regarding the start-up group is that 66% of participants in this sector do not feel that women face bias as GIS professionals – this suggests that they do not view the difficulties that they have had as relating to their gender.

Table 116. Was getting to where you are in your career easy (Yes) or difficult (No)? (By sector)

Sector	# Responses	# Yes	# No	% Yes	% No	P-value
Federal Gov.	39	19	20	48.7%	51.3%	0.125370688
State Gov.	60	23	37	38.3%	61.7%	0.020283543*
Regional Gov.[1]	3	2	1	66.7%	33.3%	n/a
Local Gov.	92	51	41	55.4%	44.6%	0.048409593*
Non-Profit	35	14	21	40%	60%	0.067519705
Private	125	58	67	46.4%	53.6%	0.051630439
Start-Up	10	6	4	60%	40%	0.205078125
Higher education	32	11	21	34.4%	65.6%	0.030040853*

In terms of other variation in reaction to the question, 55% of Hispanic participants said "yes" compared with 42% of Asian participants. If these numbers were not observed by chance, what could be the cause of this difference?

When it comes to age groups, participants who are in between 41 and 50 years old are the ones who most report having difficulties – are women in that age bracket at similarly challenging junctures in their careers?

Table 117. Was getting to where you are in your career easy (Yes) or difficult (No)? (By age bracket)

Age Bracket	# Responses	# Yes	# No	% Yes	% No	P-value
21-30	121	48	61	44%	56%	0.035305467*
31-40	160	70	90	43.8%	56.3%	0.01812659*
41-50	81	44	37	54.3%	45.7%	0.065531012
51-60	56	21	23	47.7%	52.3%	0.114403997
61-70	8	3	5	37.5%	62.5%	0.21875

Open text analysis for comments: (231 comments)

The nature of this question is not "scientific" – how someone perceives whether or not their career path has been difficult is highly subjective and personal. Additionally, difficulty in getting to where one is in his or her career is not unique to females. However, this question attempted to assess if there is an overarching narrative of "struggle" among women in GIS, or if there are other more positive attitudes. Survey participants were asked to provide comments in order to give more meaning to this question.

The top comment category (shown in Table 118 below) of "Required hard work and perseverance, not necessarily difficult," addresses the idea that viewing women's participation in male dominated fields as an experience that is categorized as one of "struggle" may not be entirely appropriate. That is to say, just because perseverance is required this does not mean it has been a "difficult" or negative experience.

Most of the comments that participants provided about the ease or difficulty in getting to where they are in their careers fell into non-gender related categories. For example, the second most popular comment category with 12% of comments falling into that category is that "It is key to get skills and credentials and keep them current" – something that could be an issue for men and women alike. These comments relate to the earlier findings of the survey (Research Question A, Survey Question 3) that there is a strong and constant need to update GIS skills regularly.

Only a small percentage of comments fell into categories dealing with obstacles outside of the workplace. For example, 4% of participants commented on issues relating to "Hard to return after having kids; childcare and family-life balance are challenges."

Table 118. Was getting to where you are in your career easy (Yes) or difficult (No)? (Open text analysis)

Comment Category	Raw #	Percent (of 231)
Required hard work and perseverance, not necessarily difficult	82	35.5%
It is key to get skills and credentials and keep them current	30	13%
Times of both	28	12.1%
Easy, because of good luck or being at the right place at the right time	18	7.8%
Difficult due to market, poor job prospects; more GIS people now	17	7.4%
Networking and connections are essential	16	6.9%
Easy to start, hard to get promotions or find higher level jobs	13	5.6%
It makes it easier if you have a supportive management that invests in you	11	4.8%
Discrimination has been a factor	9	3.9%
Hard to return after having kids; childcare and family-life balance are challenges	9	3.9%
Easy in early stages	6	2.6%
Women can feel a need to promote themselves and work harder more than their male counterparts	6	2.6%
Hard to get the right job	4	1.7%
Similar challenges to women working in other tech fields	3	1.3%
Age bias, vs gender	3	1.3%
It helped being a woman (not enough in dept. or office)	3	1.3%
Hard to get an entry level job without experience	3	1.3%
Depends on the specific area. Ex.: data collection and programming	2	0.9%
It makes it harder in a workplace with weak management or being only GIS person	2	0.9%
Better in GIS than other tech fields	1	0.4%

A comment made in response to this question that addresses many of the questions posed in this thesis, particularly those relating to how GIS and IT might be different is the following:

> "I faced some challenges getting to my current career, like anyone else, but none of them specific to my gender. My experiences in IT before I went into GIS were much more challenging. I faced direct and obvious gender discrimination as well as challenges related to the economy. I do not know if the improved situation is because of IT vs. GIS, or because I moved to the non-profit sector which has more women, or because I am in a more senior position."

7. Do you view attaining the next step in your career as having challenges?

Hypothesis: The women who participate in the survey will view attaining the next step in their careers as having challenges.

Question format: Radio – Binary (yes/no)

Table 119. Do you view attaining the next step in your career as having challenges? (No category filters)

Value	Count	Percent
Yes	385	82.3%
No	83	17.7%
Statistics		
Total responses	468	
Unanswered	16	
Binomial probability of trial result: 6.17262E-48*		

Interpretation: Eighty-two percent of the participants say that they view attaining the next step in their career as having challenges. The p-value is extremely small, indicating that the observed values were not observed by chance, and giving strong evidence that the hypothesis for this question is true. It is interesting that 54% participants say that getting to where they are in their careers has not been difficult, yet 82% view the next steps as having challenges.

Due to what the literature suggests about women's increasing level of obstacles as their careers progress (Ahuja 2002), it was expected that with more years in GIS, more women would say that they view attaining the next step in their careers as having challenges. This is not the case, 90% of

participants with 0-3 years in GIS responded to this question with yes, progressively declining to 76% of participants with more than 20 years (bottom two lines of Table 120 collapsed). There is a similar pattern with the age categories.

Table 120. Do you view attaining the next step in your career as having challenges? (By number of years in GIS)

Number of Years in GIS	# Responses	# Yes	# No	% Yes	% No	P-value
0-3 yrs.	103	93	10	**90.3%**	9.7%	2.32628E-18*
>3 and <=10 yrs.	181	150	31	**82.9%**	17.1%	2.52526E-20*
>10 and <=20 yrs.	139	108	31	**77.7%**	22.3%	1.26675E-11*
>20 and <=30 yrs.	40	31	9	**77.5%**	22.5%	0.000248691*
>30 yrs.[2]	2	1	1	**50%**	50%	n/a

8. Does your gender play a role in what you view those challenges to be?

Hypothesis: Yes, women will believe their gender plays a role in the challenges of attaining the next career step.

Question format: Radio – Binary (yes/no) plus comments

Table 121. Does your gender play a role in what you view those challenges to be? (No category filters)

Value	Count	Percent
Yes	184	39.7%
No	279	60.3%
Statistics		
Total responses	463	
Unanswered	21	
Binomial probability of trial result: 2.06681E-06*		

Interpretation: Sixty percent of participants do not think their gender plays a role in the challenges of attaining the next step in their careers. The p-value is extremely small, indicating that the observed values were not observed by chance, giving strong evidence that the hypothesis for this question is not true. Despite that a greater proportion of participants do not view their gender as playing a role in the challenges of attaining the next step in their careers, that 40% do think so could be considered significant.

When examining the results of this question by different sectors, again the higher education and start-up sectors were those with the greatest variation, with 53% and 27% respectively saying "yes" to this question (although the p-values for both of these sectors indicate that these numbers might have been observed by chance). Again, the differences between these two sectors are interesting based on what is brought up in the discussions above.

Table 122. Does your gender play a role in what you view those challenges to be? (By sector)

Sector	# Responses	# Yes	# No	% Yes	% No	P-value
Federal Gov.	41	15	26	36.6%	63.4%	0.028845659*
State Gov.	75	27	48	36%	64%	0.004858145*
Regional Gov.[1]	5	1	4	20%	80%	n/a
Local Gov.	100	33	67	33%	67%	0.000232471*
Non-Profit	36	14	22	38.9%	61.1%	0.055243395
Private	139	63	76	45.3%	54.7%	0.036910533*
Start-Up	11	3	8	27.3%	72.7%	0.080566406
Higher education	38	20	18	52.6%	47.4%	0.122156055

There is also variation in the responses to this question when examining the results by number of years in GIS categories. Roughly 40% of participants with up to 20 years of GIS experience think that their gender plays a role in the challenges of attaining the next step in their careers. This is compared with 29% of those with more than 20 years of GIS experience (bottom two rows of Table 123 collapsed).

Table 123. Does your gender play a role in what you view those challenges to be? (By number of years in GIS)

Number of Years in GIS	# Responses	# Yes	# No	% Yes	% No	P-value
0-3 yrs.	101	40	61	39.6%	60.4%	0.008977299*
>3 and <=10 yrs.	180	72	108	40%	60%	0.001616136*
>10 and <=20 yrs.	138	58	80	42%	58%	0.011801262*
>20 and <=30 yrs.	39	11	28	28.2%	71.8%	0.003048728*
>30 yrs.[2]	2	1	1	50%	50%	n/a

There is a similar trend of diminishing yes responses among the older age brackets. Forty-two percent of 21-30 year olds think that their gender plays a role in the challenges of attaining the next steps in their careers, compared to 34% of 51-60 year olds and 11% of 61-70 year olds.

Table 124. Does your gender play a role in what you view those challenges to be? (By age bracket)

Age Bracket	# Responses	# Yes	# No	% Yes	% No	P-value
21-30	120	50	70	41.7%	58.3%	0.013813841*
31-40	181	76	105	42%	58%	0.005818492*
41-50	88	30	58	34.1%	65.9%	0.00096124*
51-60	52	18	34	34.6%	65.4%	0.009475082*
61-70	9	1	8	11.1%	88.9%	0.017578125*

Open text analysis for comments: (225 comments)

The open text analysis for this question was done by breaking down the comments by how participants responded to the question ("yes" or "no" to "Does your gender play a role in what you view those challenges to be?"). This was done in order to come up with two broad categories – first, gender-related challenges and second, non-gender related challenges.

The top comment category for gender-related challenges is "Family and relationship responsibilities" with 27% of the 121 comments falling into that category (see discussion below under Research Question G on categorizing family responsibilities as a woman's challenge). The next most popular gender-related challenges category is "Men are selected more for management and promotions" with 21% of comments falling into that category.

The top two comment categories for non-gender related challenges are "Limited opportunities for advancement in current job" (27%) and "Acquiring and developing skills" (22%). The second comment category is another item discovered through the survey that further supports the notion that updating skills, while rewarding, could also pose a challenge (see Research Question A, Survey

Question 3, "Is there a need to update your GIS skills regularly (i.e. learn new software/methods)?").

Table 125. Does your gender play a role in what you view those challenges to be? (Open text analysis 1) Comment categories of those who responded "yes" to the question (40%; "Does your gender play a role in what you view those challenges to be?"; 121 comments)

Types of gender-related challenges	Raw #	Percent (of 121)
Family and relationship responsibilities	33	27.3%
Men are selected more for management and promotions	25	20.7%
"Old Boys club" and male dominated work place attitudes prevail; female boss stigma	21	17.4%
Gender - female associated behaviors and attitudes towards them	13	10.7%
"Presumed incompetent"[7]	10	8.3%
Age bias	8	6.6%
Higher salaries for men	4	3.3%
Expect women to do things not asked of men or generally work harder	4	3.3%
Men candidates are favored over women	2	1.7%
Race bias	1	0.8%

Table 126. Does your gender play a role in what you view those challenges to be? (Open text analysis 2) Comment categories of those who responded "no" to the question (60%; "Does your gender play a role in what you view those challenges to be?"; 104 comments)

Types of non-gender related challenges	Raw #	Percent (of 104)
Limited opportunities for advancement in current job	28	26.9%
Acquiring and developing skills	22	21.2%
Finding a job/finding the right job/job competition	17	16.3%
Keeping up with technology	11	10.6%
Acquiring a higher degree	7	6.7%
GIS and GIS jobs not too well understood by management	6	5.8%
Life-work balance	5	4.8%
Age concerns	3	2.9%
Transitioning from a tech to management role	3	2.9%
Networking	2	1.9%

[7] One of the women who made a comment in response to this question mentioned the book *Presumed Incompetent: The Intersections of Race and Class for Women in Academia.* The term "presumed incompetent" captured so well the sentiments of other women who provided comments that the thesis author utilized it as a comment category to code other comments.

SUMMARY OF RESEARCH QUESTION F

Does the number of years in the GIS field have any bearing on the results of the survey questions? Specifically, do women with more years in GIS have different perceptions of the status of women in GIS – will they respond differently to questions such as "Do you think there is underrepresentation of women in GIS" or "Do women face bias as GIS professionals?" Additionally, will women with more years in GIS have different experiences than newcomers (thereby altering their perceptions)? Do the observations derived from these questions point to a change in the GIS field over time (to a field that is becoming increasingly better for women)?

The first two questions of this survey section collected information about the number of years that participants have been in a professional setting and then the number of years specifically in a GIS setting. The results for the number of years in a GIS professional setting have been used to create categories with which to filter the rest of the survey questions. The intention of this was to see if participants with differing years of GIS experience have had distinct experiences and if their perceptions vary, particularly in regard to views on the status of women in GIS. This categorization has been used throughout the survey. The questions in which interesting variations occur based on the number of years in GIS include discussions of this finding. An end goal to such an examination was to see if and how the GIS professional sphere has changed over time, and if it might be becoming increasingly a more gender-balanced field and one that is better in regards to the status of female participation.

On average, participants have worked in a professional setting for 14 years, and specifically in a GIS setting for 10 years. While most of the participants have up to 20 years of GIS experience (91% of the survey population) those with over 20 years of experience drop off markedly (they make up only 9% of the survey population, as compared to the group with 10-20 years, which is 30% of the

survey population). Their small numbers and the fact that they were among the first people to join the GIS workforce give them a unique viewpoint. This is also supported by the statistics presented in this thesis.

After collecting the number of years of work and GIS experience, this survey section included a suite of questions regarding participants' perceptions of women's status, or representation, in professional GIS as well as their views on their experiences working in GIS. First, participants were asked "do you think there is an underrepresentation of women in GIS?" Then, "do women face bias as GIS professionals?" Next, "Is this bias unique to GIS or is it more general?" Sixty-four percent of the participants reported that they think that there is an underrepresentation of women in GIS. This confirms the hypothesis that women in GIS would perceive an underrepresentation (this was the hypothesis even if an underrepresentation was not found). Of the places of employment represented in the survey results, women make up 40% of the GIS workforce, so while their representation is not completely equal, they are not grossly underrepresented. Nonetheless, a large percentage of participants perceive an underrepresentation. Unexpectedly, there was no variation in responses to this question according to the amount of experience in GIS variable. It was expected that, with more years in GIS, the perception of underrepresentation might increase, due to that group's smaller size (or, conversely, that the perception could decrease, if those women with more experience in GIS observed the field becoming more gender diverse over time). In regard to the other two questions, 48% of participants think women face bias as GIS professionals, and only 6% of women think this bias is unique to GIS, while 69% think that the bias is more general.

The participants were then asked about ease or difficulty in their careers. Forty-six percent of participants said that getting to where they are in their careers has been difficult. Eighty-two

percent view attaining the next step in their careers as having challenges and 40% view their gender playing a role in those challenges.

G. Research Question/Purpose: Exploration of factors relating to work-life balance.

Is this important to women in GIS? Do GIS jobs allow for flexible arrangements that might enhance work-life? What are women's opinions about work-life/family?

Survey Page Header *(page 10 on survey): Work-Life Balance*

Context for survey participants: *There is a debate in literature regarding women and technology careers and the work-life/family issue. Some claim that lack of flexibility and other factors that hinder work-life balance are a barrier specifically for women, and that removing these hindrances would afford greater work-life balance and allow more women to participate in technology careers (Ahuja 2002; Cross and Linehan 2006). Others claim that calling this a woman's issue is a mistake that only serves to cast women outside of the realm of technology careers* (*Bastalich et al. 2007). The questions in this section are to add information to the already established dialogue as well as to explore GIS-specific accounts of work-life balance issues (or lack thereof).*

SURVEY QUESTIONS:

1. Is work-life balance an important characteristic of a job? How important is it to you? Why or why not?

Hypothesis: Work-life balance will be a very important characteristic of a job.

Question format: Likert plus textbox

Table 127. Is work-life balance an important characteristic of a job? How important is it to you? (No category filters)

Value	Count	Percent
Not important	3	0.6%
Neutral	24	5.1%
Important	142	30.0%
Very important	305	64.4%
Statistics		
Total responses	474	
Unanswered	10	
Chi-squared test: 4.8639E-105*		

Interpretation: It could be assumed that work-life balance would be an important characteristic of a job for anybody, either male or female. However, as the literature suggests, work-life balance might be even more important to women, especially if they shoulder more responsibilities for taking care of children and elderly family members than men do (Ahuja 2002; Bastalich et al. 2007; Cross and Linehan 2006). The hypothesis that participants would deem work-life balance to be an important part of a job is confirmed, with 94% of participants saying that it is important (important and very important combined, 64% of those saying it is very important). The p-value is extremely small, indicating that the observed values were not observed by chance.

(Comparative tables of the different survey population categories and open text analysis are not presented here as the overall results for this question overwhelmingly confirm the rather "obvious" hypothesis. Additionally, there is no significant variation to report.)

2. Would you say that in your current job you have a good level of work-life balance?

Hypothesis: Women will be dissatisfied with their level of work-life balance in their current jobs.

Question format: Likert

Table 128. Would you say that in your current job you have a good level of work-life balance? (No category filters)

Value	Count	Percent
Definitely!	186	39.2%
Yes, but could be better	187	39.4%
A little	62	13.1%
Not at all	38	8.0%
I don't know/care	2	0.4%
Statistics		
Total responses	475	
Unanswered	9	
Chi-squared test: 1.72587E-66		

Interpretation: Literature about working in IT suggests that IT work environments do not provide the needed flexible arrangements that would support a high level of work-life balance (Ahuja 2002; Castaño and Webster 2011; Cross and Linehan 2006; Guerrier et al. 2009; Prescott and Bogg 2011; Orser, Riding, and Stanley 2012). As such, the hypothesis for this question is that GIS environments might also be similarly inflexible, or at least not conducive to work-life balance satisfaction. However, the hypothesis is not supported by the results of the survey. Most participants (79%) say that they have a good level of work life balance – only 39% of which say "yes, but could be better." Only 21% of participants report "a little" to "not at all."

Under Research Question A there are a suite of questions asking if the survey participants have to work long hours and if they have flexible work arrangements (this question also repeated below). The results show that 67% of the participants do not have to work long hours and 76% have flexible work arrangements (for example, teleworking, alternative work schedules, etc.). The results for the current question regarding if the participants have a good level of work-life balance in their current positions is in line with the results of those two other questions. Similar to many of the results from Research Question A, comparing GIS to the field of IT, the results here also suggest that the GIS professional sphere is different from IT – the work conditions for women in GIS seem better. Regardless, due to these discovered differences, it is further proved that GIS is its own unique technical field requiring its own body of diversity literature.

A closer look can be taken to see if there is any variation among any of the categories of participants. Participants working in the non-profit sector are those that are most satisfied with their level of work-life balance – 87% say that they have a good level. Conversely, those in the start-up and higher education sectors are the ones where participants are less satisfied with work-life

balance. Approximately 72% of participants in these two sectors say they have a good level of work-life balance – still a very high level, but less than in the other sectors.

Table 129. Would you say that in your current job you have a good level of work-life balance? (By sector)

Sector	# Responses	Good level†	Not good level†
Federal Gov.	42	78.6%	19%
State Gov.	74	75.7%	24.3%
Regional Gov.[1]	5	80%	20%
Local Gov.	107	83.2%	16.8%
Non-Profit	**37**	**86.5%**	**13.5%**
Private	142	76.8%	22.5%
Start-Up	**11**	**72.7%**	**27.3%**
Higher education	**39**	**71.8%**	**28.1%**

† "Good level" is "Definitely!" and "Yes, but could be better" combined, and "Not good level" is "A little" and "Not at all" combined. "I don't know/care" not included in the table.

Again, reviewing the results discussed in Research Question A can show what conditions might lead to satisfaction in work-life balance among different sectors: the higher-education sector has the most flexible work arrangements at 92% of participants saying "yes" and the non-profit sector the second highest at 84% of participants saying "yes." In regards to the higher education sector, this group had the largest percentage of participants reporting that they have to work long hours yet they are the ones with the best rate of flexible work arrangements – perhaps these two conditions balance to yield the 72% of participants in this group who say that they have a good level of work-life balance (but perhaps their need to work long hours is the thing that makes them less satisfied with their level of work-life balance as compared to the other groups).

Table 130 below suggests that the number of years in GIS does not impact levels of work-life balance. Eighty-two percent of participants with more than 20 years of GIS experience report a good level of work experience, almost the same as those with 0-3 years of GIS experience, and only slightly more than those with 3-20 years (76-77%). It might have been expected that with more years in GIS, the more work-life balance satisfaction would be impacted. For example, more years in GIS might lead to more work responsibility and a higher level of difficulty, and therefore require

more hours on the job. Or vying for higher-level jobs might create a competitive situation in which longer hours or a higher level of commitment are necessary. Table 131 does show that the participants with more years in GIS have to work longer hours, however, this does not seem to have an effect on participants' views on their overall level of work-life balance. As is also mentioned in Research Question A, even though more participants with more years in GIS report having to work longer hours, more of them also report having flexible work arrangements.

Table 130. Would you say that in your current job you have a good level of work-life balance? (By number of years in GIS)

Years in GIS	# Responses	Good level†	Not good level†
0-3 yrs.	103	83.5%	16.5%
>3 and <=10 yrs.	181	77.3%	22.1%
>10 and <=20 yrs.	143	76.2%	23.1%
>20 yrs.	45	82.2%	17.7%

† "Good level" is "Definitely!" and "Yes, but could be better" combined, and "Not good level" is "A little" and "Not at all" combined. "I don't know/care" not included in the table.

Table 131. Are you required to work long hours? (By number of years in GIS)

Number of Years in GIS	# Responses	# Yes	# No	% Yes	% No	P-value
0-3 yrs.	104	26	78	25%	75%	1.11185E-07*
>3 and <=10 yrs.	182	60	122	33.0%	67.0%	1.31386E-06*
>10 and <=20 yrs.	144	50	94	34.7%	65.3%	7.52568E-05*
>20 and <=30 yrs.	42	19	23	45.2%	54.8%	0.101584945
>30 yrs.[2]	3	1	2	33.3%	66.7%	n/a

In comparing the need to work long hours with the availability of flexible work arrangements providing a good level of work-life balance to employees, could any conclusions be derived to aid organizations in creating policies and workplace conditions that would be more satisfactory for women, and for men for that matter, who have home/family responsibilities (or who just want the balance in general)? Which is more important – the need to work schedules that do not require long work hours or flexible work arrangements? If organizations cannot guarantee both, could further research be conducted to see which is more beneficial so that organizations can provide one of these to their employees?

3. Are work-family issues more relevant to women than to men?

Hypothesis: Due to the assumption that women probably shoulder more responsibility for the caring of children and elderly family members, it is hypothesized that women will think that work-family issues are more relevant to women.

Question format: Radio – Binary (yes/no)

Table 132. Are work-family issues more relevant to women than to men? (No category filters)

Value	Count	Percent
Yes	317	67.3%
No	154	32.7%
Statistics		
Total responses	471	
Unanswered	13	
Chi-squared test: 5.88374E-14*		

Interpretation: Sixty-seven percent of participants believe that work-family issues are more relevant to women than they are to men. The p-value is extremely small, indicating that the observed values were not observed by chance, giving strong evidence that the hypothesis for this question is true.

Unexpectedly, there is a significant difference between the sector of employment reported and the response to whether work-family issues are more relevant to women than men. Fifty-four percent of participants in local government, 61% of participants in federal government, and 68% of participants in non-profit think work-family issues are more relevant to women than to men, compared with 82% of participants at start-ups and 95% of participants in higher education. Why would sector have such a marked bearing on this question? Do different sectors place different demands on or have different expectations of their employees, or attract people with different values, beliefs, and lifestyles?

Table 133. Are work-family issues more relevant to women than to men? (By sector)

Sector	# Responses	# Yes	# No	% Yes	% No	P-value
Federal Gov.	43	26	17	60.5%	39.5%	0.047881673*
State Gov.	73	53	20	72.6%	27.4%	4.55072E-05*
Regional Gov.[1]	5	5	0	100%	0%	n/a
Local Gov.	103	56	47	54.4%	45.6%	0.053105143
Non-Profit	36	24	12	66.7%	33.3%	0.018214308*
Private	143	96	47	67.1%	32.9%	1.3478E-05*
Start-Up	11	9	2	81.8%	18.2%	0.0703125
Higher education	39	37	2	94.9%	5.1%	1.34787E-09*

This question and the ones following were asked to try to gain some insights into the complex conceptualization that frames work-life/family as an issue that is more relevant to women. The literature poses two contradictory, or at least counter-productive, ideas. One is that creating work-life/family policies specifically geared toward women only serves to further separate women from men, thereby undermining women's participation in male dominated fields and in workplaces in general (Bastalich et al. 2007). The other idea is that it is difficult for women to participate equally due to the fact that they shoulder more responsibilities for caring for children and elderly family members (Cross and Linehan 2006) thereby creating their greater need for work-life/family balance. How does one deal with the possibility that work-family issues are more important to women, but that by saying so it might only create a further divide? Furthermore, if women themselves view work-family issues as being more relevant to them does that contradict what theorists say about the dangers of creating work-life/family policies geared towards women? The responses to the questions below might help to further understand the complexities of work-life balance.

4. Do you think that women are more responsible (than men) for caring for children and elderly family members?

Hypothesis: Women will think that women shoulder more responsibilities for caring for children and elderly family members than men do.

Question format: Radio – Binary (yes/no)

Table 134. Do you think that women are more responsible (than men) for caring for children and elderly family members? (No category filters)

Value	Count	Percent
Yes	369	78.0%
No	104	22.0%
Statistics		
Total responses	473	
Unanswered	11	
Binomial probability of trial result: 2.90989E-36*		

Interpretation: Seventy-eight percent of participants believe that women are more responsible (than men) for caring for children and elderly family members. The p-value is extremely small, indicating that the observed values were not observed by chance, giving strong evidence that the hypothesis for this question is true.

It is noteworthy that while 78% of the participants think that women are more responsible (than men) for caring for children and elderly family members, only 67% think that work-family issues are more relevant to women than to men.

There is again a significant difference among sector of employment and response to whether women shoulder more responsibilities than men in caring for children and elderly family members. Sixty percent of participants in federal government responded yes to this question compared with 89% of participants in the non-profit group. According to the results of this survey, the non-profit sector is much younger in composition – 69% of the participants in the non-profit sector are between 21 and 40 years old, compared to the federal government in which only 39% of the participants are under 40 (more figures on sector age composition are provided in the section below). One might expect that there would be differences in views on family care responsibilities

across different age groups. However, please note that there is no relation between age group and response to this question. So it seems that it is something specifically about the participants in different sectors that is shifting the response to this question.

Table 135. Do you think that women are more responsible (than men) for caring for children and elderly family members? (By sector)

Sector	# Responses	# Yes	# No	% Yes	% No	P-value
Federal Gov.	43	26	17	60.5%	39.5%	0.047881673*
State Gov.	73	55	18	75.3%	24.7%	5.82247E-06*
Regional Gov.[1]	5	3	2	60%	40%	n/a
Local Gov.	105	78	27	74.3%	25.7%	2.16193E-07*
Non-Profit	37	33	4	89.2%	10.8%	4.80541E-07*
Private	142	118	24	83.1%	16.9%	1.66336E-16*
Start-Up	11	9	2	81.8%	18.2%	0.0703125
Higher education	39	33	6	84.6%	15.4%	5.93468E-06*

Similar to the overall results, the disparities between the responses to this question and the question preceding it ("Are work-family issues more relevant to women than to men?") are apparent when viewing the results by sector. Fifty-four percent of participants in local government think that work-family issues are more relevant to women than to men, yet 74% of them think that women shoulder more responsibilities than men in caring for children and elderly family members. Sixty-seven percent of participants in non-profits think that work-family issues are more relevant to women than to men, yet 89% of them think that women shoulder more responsibilities than men in caring for children and elderly family members. In most cases, a higher percentage of participants think that women are more responsible in family care and a smaller percentage of participants think that work-family issues are more relevant to women than they are to men. The only case for which this is not so is among participants in higher education. Ninety-five percent of participants in this sector think that work-family issues are more relevant to women than to men, yet 85% of them think that women shoulder more responsibilities than men in caring for children and elderly family members

Similar to the question above, this question was also posed to understand if and why work-life/family balance is more relevant to women than it is for men. The results of this question further support and compound what is mentioned above about the conflicting greater need for women to have a good level of work-life balance and the danger of creating and enacting policies based on that same idea. If 78% of participants think that women are more responsible for caring for children and elderly family members (and the reality matches what they think), this strongly supports the notion that certain accommodations ought to be made for them so that they can take care of their home responsibilities and at the same time be able to freely participate in the GIS field. However, would these accommodations have unintended consequences?

One example of a comment from another survey question that speaks to the issues brought up in this and other discussions in this thesis is:

> "The challenge is more from the demands of a woman and gender biases from society, toward the responsibilities of a woman within the family, than specifically from being discriminated by men at work. Society seems to have placed the responsibility of child rearing on the woman… Thus, we are challenged by having home duties while trying to be equally functional at work (keeping up with knowledgebase) with well rested men."

5. Do you think more policies should be implemented geared specifically towards women that would allow for better work-family balance? If you disagreed with the above, why?

Hypothesis: None. Due to the complexity of the two thoughts mentioned above, that women probably do shoulder more family care responsibilities than men, yet that targeting work-family policies specifically towards women might alienate them, the thesis author wanted to gauge how women in GIS feel about this topic. Are they aware of this complexity?

Question format: Radio – Binary (yes/no) plus textbox

Table 136. Do you think more policies should be implemented geared specifically towards women that would allow for better work-family balance? (No category filters)

Value	Count	Percent
Yes	239	51.4%
No	226	48.6%
Statistics		
Total responses	465	
Unanswered	19	
Binomial probability of trial result: 0.030847443*		

Interpretation: Participants are divided on this issue. Nearly half say that, yes, more policies should be implemented geared specifically towards women that would allow for better work-family balance, while the other half say no.

There is a significant difference among race/ethnicity and response to whether policies should be geared towards women. Just 46% of white participants said "yes," compared to 75% of Hispanic and black/African American participants (p-value=0.109375), and 81% of Asian participants.

The mixed results to this question support the idea that gearing work-family policies specifically towards women is a complicated and possibly contentious issue. It is an issue on which a lot of people are torn, from the women themselves to the researchers on this topic.

Open text analysis for comments: (229 comments)

The top comment category for this question reveals more nuances to the work-life/family issue. Fifty-eight percent of the comments were not about the policies themselves but more about men and women equally shouldering responsibilities for family members (including that they already do, or that men should be expected to). Just like the comment highlighted above about the societal expectation for women to take care of their families, this comment category shows that a major

societal shift would need to occur in relation to work-family – it is not just about policies being implemented. Regarding another societal shift, 14% of the comments expressed that "Society and workplace should be more family focused regardless of gender." Two comment categories support the argument that enacting work-family policies specifically towards women might undermine women's participation in GIS (which is relevant to Question 7 below): "These policies reinforce women's role as principle childcare giver" (9%) and "Earning true equality means there can't be different treatment for women" (8%).

Table 137. Do you think more policies should be implemented geared specifically towards women that would allow for better work-family balance? (Open text analysis)
If you disagreed with the above, why?

Comment Category	Raw #	Percent (of 229)
Men and women should have equal family opportunities/responsibilities/men should step up/many men already do provide childcare/non-traditional families i.e. not just about women	132	57.6%
Society and workplace should be more family focused regardless of gender	32	14%
These policies reinforce women's role as principle childcare giver	21	9.2%
Earning true equality means there can't be different treatment for women	19	8.3%
Impossible to implement such policies/policies won't affect things very much	10	4.3%
Work/non-work balance is important for everyone independent of family/childcare	5	2.2%
Employers should provide more childcare services	4	1.7%
These policies not fair for those w/o children	2	0.8%
Prioritizing family will have career implications	1	0.4%

6. Is work-life and work-family an issue for men and women alike?

Hypothesis: None. This is a rephrasing of the previous survey question, "Are work-family issues more relevant to women than to men?" This version of the question is a bit broader because "work-life" and "work-family" are both mentioned, as opposed to just "work-family." However, it is probable that more women will respond "yes" to this question than for the other question that is

just about work-family. This question also could help to test the consistency in responses between these two questions, especially following the previous two questions.

Question format: Radio – Binary (yes/no)

Table 138. Is work-life and work-family an issue for men and women alike? (No category filters)

Value	Count	Percent
Yes	359	75.9%
No	114	24.1%
Statistics		
Total responses	473	
Unanswered	11	
Binomial probability of trial result: 4.87608E-31*		

Interpretation: Seventy-six percent of participants view work-life and work-balance as being an issue for men and women alike. The p-value is extremely small, indicating that the observed values were not observed by chance.

In response to the other similar survey question "Are work-family issues more relevant to women than to men," 67% of participants responded yes. As was expected, a slightly higher percentage of participants think that work-life/work-family is an issue for men and women alike. However, despite this, the responses for both of these questions are consistent with one another.

7. Do you feel that gearing work-family policies with women in mind alienates women?

Hypothesis: Women will feel that gearing work-family policies with women in mind alienates women.

Question format: Radio – Binary (yes/no)

Table 139. Do you feel that gearing work-family policies with women in mind alienates women? (No category filters)

Value	Count	Percent
Yes	306	66.0%
No	158	34.1%
Statistics		
Total responses	464	
Unanswered	20	
Binomial probability of trial result: 1.44397E-12*		

Interpretation: Sixty-six percent of participants feel that gearing work-family policies with women in mind alienates women. The p-value is extremely small, indicating that the observed values were not observed by chance, and giving strong evidence that the hypothesis for this question is true.

Participants in higher education are those who least think so (60%), while participants in start-ups are those who most think so (80%). Could the previous discussion about the difference in prevalence of male supervisors in these two sectors be a factor (82% of participants in the start-up sector and 54% of participants in higher-education have male supervisors)?

Table 140. Do you feel that gearing work-family policies with women in mind alienates women? (By sector)

Sector	# Responses	# Yes	# No	% Yes	% No	P-value
Federal Gov.	43	29	14	67.4%	32.6%	0.008910656*
State Gov.	74	46	28	62.2%	37.8%	0.010438071*
Regional Gov.[1]	5	2	3	40%	60%	n/a
Local Gov.	100	70	30	70%	30%	2.31707E-05*
Non-Profit	36	22	14	61.1%	38.9%	0.055243395
Private	141	94	47	66.7%	33.3%	2.42134E-05*
Start-Up	10	8	2	80%	20%	0.043945313*
Higher education	37	22	15	59.5%	40.5%	0.068133521

Participants with 0-20 years of GIS experience responded to this question similarly (63-65% said "yes"), however 85% of those with 20-30 years of GIS experience think that gearing work-family

policies with women in mind alienates women. This further shows that this first generation of females in GIS have a different viewpoint than newcomers.

Table 141. Do you feel that gearing work-family policies with women in mind alienates women? (By number of years in GIS)

Number of Years in GIS	# Responses	# Yes	# No	% Yes	% No	P-value
0-3 yrs.	102	65	37	63.7%	36.3%	0.001670316*
>3 and <=10 yrs.	177	112	65	63.3%	36.7%	0.000112287*
>10 and <=20 yrs.	141	92	49	65.2%	34.8%	8.99974E-05*
>20 and <=30 yrs.	39	33	6	84.6%	15.4%	5.93468E-06*
>30 yrs.[2]	2	2	0	100%	0%	n/a

In response to the question "Do you think more policies should be implemented geared specifically towards women that would allow for better work-family balance," 49% of the participants responded "no" – and 84% of those participants who said "no" to that question think that gearing work-family policies with women in mind alienates women.

Table 142. Do you feel that gearing work-family policies with women in mind alienates women? (Filtered)

Gearing work-family policies with women in mind does *not* alienate women	35	15.6%
Gearing work-family policies with women in mind does alienate women	190	84.4%
Filter total	225	

Results filtered by those who responded "no" to previous question ("Do you think more policies should be implemented geared specifically towards women that would allow for better work-family balance?").

8. If your company does have flexible work arrangements available, do you avail yourself of them? Do you feel comfortable doing so? Why or why not?

Hypothesis: Women will avail themselves of flexible work arrangements if they are available, but will not feel comfortable doing so.

Question format: Radio – Binary (yes/no) plus textbox

Table 143. If your company does have flexible work arrangements available, do you avail yourself of them? (No category filters)

Value	Count	Percent
Yes	339	76.9%
No	102	23.1%
Statistics		
Total responses	441	
Unanswered	43	
Binomial probability of trial result: 3.03127E-31*		

Table 144. Do you feel comfortable doing so? (No category filters)

Value	Count	Percent
Feels comfortable	286	84.6%
Does not feel comfortable	52	15.4%
Statistics		
Filter total	338	
Unanswered	n/a	
Binomial probability of trial result: 1.12542E-40 *		

Results filtered by those who responded "yes" to previous question ("If your company does have flexible work arrangements available, do you avail yourself of them?").

Interpretation: Seventy-seven percent of participants take advantage of the flexible work arrangements that are available to them at their companies, and 85% of them feel comfortable doing so. The p-values for both of these questions are extremely small, indicating that the observed values were not observed by chance, giving strong evidence that the first hypothesis for this question is true and the second is false.

The literature suggests that even if workplaces have flexible work arrangements available, women will either not take advantage of them or will feel uncomfortable doing so because it will have negative repercussions (Cross and Linehan 2006; Guthrie, Soe, and Yakura 2009; also see Prescott and Bogg 2011). However, this does not seem to be the case for the participants of the survey – they both take advantage of flexible work arrangements and feel comfortable doing so.

There is some variation amongst the survey groups. For example, participants at non-profits are the ones who most report taking advantage of flexible work arrangement 86% (although only 74% say that they feel comfortable doing so). Participants in state government are the ones that least take advantage (73%; but 86% feel comfortable). Federal government is the group in which participants feel the most comfortable (94%) and higher education is the group in which participants feel least comfortable (68%).

Table 145. If your company does have flexible work arrangements available, do you avail yourself of them? (By sector)

Sector	# Responses	# Yes	# No	% Yes	% No	P-value
Federal Gov.	42	32	10	76.2%	23.8%	0.000334567*
State Gov.	70	51	19	72.9%	27.1%	5.37732E-05*
Regional Gov.[1]	5	5	0	100%	0%	n/a
Local Gov.	90	67	23	74.4%	25.6%	1.2729E-06*
Non-Profit	36	31	5	86.1%	13.9%	5.48596E-06*
Private	135	103	32	76.3%	23.7%	2.37053E-10*
Start-Up	11	9	2	81.8%	18.2%	0.026855469*
Higher education	36	28	8	77.8%	22.2%	0.000440346*

Table 146. Do you feel comfortable doing so? (By sector)

Sector	# Responses	# Yes	# No	% Yes	% No	P-value
Federal Gov.	32	30	2	93.8%	6.3%	1.15484E-07*
State Gov.	51	44	7	86.3%	13.7%	5.14145E-08*
Regional Gov.[1]	5	4	1	80%	20%	n/a
Local Gov.	66	59	7	89.4%	10.6%	1.05546E-11*
Non-Profit	31	23	8	74.2%	25.8%	0.003673474*
Private	103	87	16	84.5%	15.5%	2.21428E-13*
Start-Up	9	9	0	100%	0%	0.001953125*
Higher education	28	19	9	67.9%	32.1%	0.025730208*

Results filtered by those who responded "yes" to previous question ("If your company does have flexible work arrangements available, do you avail yourself of them?").

Participants with more years in GIS increasingly avail themselves of flexible work arrangements. Seventy percent of participants with 0-3 years of GIS experience do so, while 97% of participants with 20-30 years do so. Number of years in GIS, however, does not have a great impact on the level

of comfort with taking advantage of flexible work arrangements – 79-86% of all participants feel comfortable (no discernible pattern of increase or decrease as years in GIS go up).

Table 147. If your company does have flexible work arrangements available, do you avail yourself of them? (By number of years in GIS)

Number of Years in GIS	# Responses	# Yes	# No	% Yes	% No	P-value
0-3 yrs.	97	68	29	70.1%	29.9%	2.76845E-05*
>3 and <=10 yrs.	165	119	46	72.1%	27.9%	3.78078E-09*
>10 and <=20 yrs.	138	113	25	81.9%	18.1%	5.73647E-15*
>20 and <=30 yrs.	38	37	1	97.4%	2.6%	1.38243E-10*
>30 yrs.[2]	3	2	1	66.7%	33.3%	n/a

Table 148. Do you feel comfortable doing so? (By number of years in GIS)

Number of Years in GIS	# Responses	# Yes	# No	% Yes	% No	P-value
0-3 yrs.	68	54	14	79.4%	20.6%	4.17534E-07*
>3 and <=10 yrs.	119	103	16	83.6%	13.4%	4.04819E-17*
>10 and <=20 yrs.	112	96	16	85.7%	14.3%	1.83277E-15*
>20 and <=30 yrs.	37	31	6	83.8%	16.2%	1.6915E-05*
>30 yrs.[2]	2	2	0	100%	0%	n/a

Results filtered by those who responded "yes" to previous question ("If your company does have flexible work arrangements available, do you avail yourself of them?").

Participants of different age categories also avail themselves of flexible work arrangements. Participants who are 21-30 and 61-70 years old are those who least do so (74% and 70% respectively). Participants who are 51-60 years old are the ones who most do so (86%) and 83% of them feel comfortable.

Table 149. If your company does have flexible work arrangements available, do you avail yourself of them? (By age bracket)

Age Bracket	# Responses	# Yes	# No	% Yes	% No	P-value
21-30	111	82	29	73.9%	26.1%	1.61564E-07*
31-40	170	122	48	71.8%	28.2%	3.95581E-09*
41-50	85	71	14	83.5%	16.5%	9.82158E-11*
51-60	52	46	6	88.5%	11.5%	4.5205E-09*
61-70	10	7	3	70%	30%	0.1171875

Table 150. Do you feel comfortable doing so? (By age bracket)

Age Bracket	# Responses	# Yes	# No	% Yes	% No	P-value
21-30	82	64	18	78%	22%	1.21007E-07*
31-40	121	105	15	86.8%	12.4%	2.03123E-18*
41-50	71	63	8	88.7%	11.3%	4.50584E-12*
51-60	46	38	8	82.6%	17.4%	3.70808E-06*
61-70	7	7	0	100%	0%	0.0078125*

Results filtered by those who responded "yes" to previous question ("If your company does have flexible work arrangements available, do you avail yourself of them?").

Open text analysis for comments (Why or why not?): (242 comments)

Most of the comments that participants provided fell into categories that reflected comfort with taking advantage of flexible work arrangements. For example, 12% of participants said, "My company/boss is supportive of using the flexible arrangements," 7% said, "Others do it (use flexible arrangements), so it feels OK," and 6% said, "Common practice for both men and women to use flexible arrangements." In terms of commentary that reflected discomfort, small percentages fell into categories that expressed feelings of guilt arising when using flexible work arrangements, that other coworkers were critical, or that there is a pressure to always be available and present at work.

Table 151. If your company does have flexible work arrangements available, do you avail yourself of them? Do you feel comfortable doing so? Why or why not?

Comment Category	Raw #	Percent (of 242)
My company/boss is supportive of using the flexible arrangements	30	12.4%
Others do it (use flexible arrangements), so it feels OK	16	6.6%
Common practice for both men and women to use flexible arrangements	15	6.2%
Feel guilty for using flexible arrangements	13	5.4%
People snoop behind your back if you use flexible arrangements	11	4.5%
There is a particular stigma for women using flexible arrangements	7	2.9%
Other parents in the workplace makes it feel OK to use flexible arrangements	6	2.5%
Health is more important than work (which is why I use flexible arrangements)	5	2.1%
Pressure to always be available (i.e. prevents using flexible arrangements)	4	1.6%
I'm less comfortable doing it since I'm newer/younger	3	1.2%
I use flexible arrangements because I am not ambitious (i.e. if I were ambitious I could not take advantage)	2	0.8%
Daycare prevents using flexible arrangements	1	0.4%
Flexible arrangements made daycare unnecessary	1	0.4%

SUMMARY OF RESEARCH QUESTION G

Exploration of factors relating to work-life balance. Is this important to women in GIS? Do GIS jobs allow for flexible arrangements that might enhance work-life? What are women's opinions about work-life/family?

Please see the literature review for a discussion of how work-life/family balance is possibly a bigger issue for women than it is for men. However, the literature review also mentions that it is possible that framing work-family as a woman's issue might simply reinforce current gender norms (Bastalich et al. 2007). In order to address these issues, this survey section was included, both to see if GIS jobs boast good levels of work-life/family balance and to see where women in GIS stand on the issues presented in the literature review.

94% of participants reported that work-life balance is an important characteristic of a job (important and very important combined, 64% of those saying it is very important). Most participants (79%) say that they have a good level of work life balance in their current jobs – only 39% of whom say "yes, but could be better." Only 21% of participants reported "a little" to "not at all."

67% of participants believe that work-family issues are more relevant to women than they are to men. Seventy-eight percent of participants believe that women are more responsible (than men) for caring for children and elderly family members. When asked if they think more policies should be implemented geared specifically towards women that would allow for better work-family balance, nearly half say that, yes, more policies should be implemented geared specifically towards women that would allow for better work-family balance, while the other half say no.

Even though 67% of the participants think that work-family issues are more relevant to women than they are to men, 76% of participants view work-life and work-balance as being an issue for men and women alike. Even though about half of the participants said more policies should be implemented geared towards women, 66% of participants feel that gearing work-family policies with women in mind alienates women. The nature of the results of these questions further supports the idea that the issue work-life/family balance is complicated.

Regardless of how complicated this issue may be, 77% of participants take advantage of the flexible work arrangements that are available to them at their companies, and 85% of them feel comfortable doing so. This is different from what was suggested by the literature review, that is, that women would feel uncomfortable taking advantage of family friendly policies (Cross and Linehan 2006; Guthrie, Soe, and Yakura 2009; also see Prescott and Bogg 2011).

Similar to what is mentioned in other areas of the survey analysis, it would be interesting to circulate the survey questions of this section to men in GIS. Would work-life balance be as important to them? Would they share the same views with regard to the other questions?

H. Research Question/Purpose: The collection of demographic information.

Survey Page Header *(page 11 on survey): Woman, and….*

Context for survey participants: *Being a woman is just one aspect of a person's identity. How do other demographic factors interplay with gender and with an individual's experience in the field of GIS?*

NOTE: The data contained in the tables presented in this section provide background information on the survey participants, and can perhaps be used for further investigations. They are used as a basis for categorizing responses to the other survey questions, and as such only the quantitative data is presented here, without discussion. Throughout this thesis chapter, variations in responses to survey questions based on the demographic groups presented below are presented and discussed (please see other sections for these discussions).

SURVEY QUESTIONS:

1. Race/ethnicity

Hypothesis: Women in GIS will be predominantly white. Other races/ethnicities such as black/African American and Hispanic will be less represented. Although female underrepresentation is the focus of this thesis, there might be other, more pronounced areas of underrepresentation requiring attention.

Question format: Multiple choice

Table 152. Race/ethnicity of survey participants

Value	Count	Percent
Black or African American	8	1.7%
White	394	84.9%
Asian	27	5.8%
American Indian or Alaska Native	6	1.3%
Native Hawaiian or Other Pacific Islander	4	0.9%
Hispanic/Latino	24	5.2%
Other:	25	5.4%
Total race/ethnicities marked	488	---
Statistics		
Total Responses	464	
Unanswered	20	

Note about responses: Participants could mark off more than one race/ethnicity, therefore total race/ethnicities claimed equals more than the total number of participants who answered this question. When dividing the overall survey population into race/ethnic groups to filter survey questions, the thesis author only allowed for one race/ethnicity identification per survey participant as not to have duplicate survey participants in different filters. In cases where participants indicated both white and some other race/ethnicity, the other race/ethnicity was assigned to that participant. If the participant claimed three or more ethnicities, these participants were not included in any filter groups. Those that marked only "other" were also not included in filter groups.

Table 153. Only one race/ethnicity per participant (for survey filter purposes)

Value	Count	Percent
Hispanic/Latino	24	5.5%
Black or African American	8	1.8%
White	374	85.2%
Asian	26	5.9%
American Indian or Alaska Native	4	0.9%
Native Hawaiian or Other Pacific Islander	3	0.7%
Statistics		
Total responses	479	
Unanswered	5	

Table 154. Sectors (By race/ethnicity)

	State Gov.	Federal Gov.	Regional Gov.	Local Gov.	Non-profit	Start-up	Private	Higher-education	Other
Hispanic	3 4.29%	1 2.44%	0 0%	10 10%	1 3.03%	1 10%	5 3.73%	2 6.45%	1 7.14%
Black/ African American	1 1.43%	0 0%	0 0%	0 0%	0 0%	0 0%	4 2.99%	1 3.23%	2 14.29%
White	55 78.57%	37 90.24%	5 100%	85 85%	29 87.88%	7 70%	119 88.81%	26 83.87%	10 71.43%
Asian	8 11.43%	2 4.88%	0 0%	3 3%	3 9.09%	2 20%	5 3.73%	2 6.45%	1 7.14%
Am. Indian/Alas. Nat.[3]	1 1.43%	1 2.44%	0 0%	1 1%	0 0%	0 0%	1 0.75%	0 0%	0 0%
Nat. Haw./Pac. Is.[3]	2 2.86%	0 0%	0 0%	1 1%	0 0%	0 0%	0 0%	0 0%	0 0%
TOTAL	70	41	5	100	33	10	134	31	14

Percentages are of sector – for example, 4.29% of participants in state government are Hispanic.

Table 155. Years in GIS (By race/ethnicity)

	0-3 yrs. GIS	>3 and <=10 yrs. GIS	>10 and <=20 yrs. GIS	>20 and <=30 yrs. GIS	>30 yrs. GIS
Hispanic	5 5.26%	10 5.99%	4 3.01%	5 12.82%	0 0%
Black/African American	1 1.05%	3 1.80%	4 3.01%	0 0%	0 0%
White	78 82.11%	142 85.03%	117 87.97%	32 82.05%	2 100%
Asian	10 10.53%	12 7.19%	4 3.01%	0 0%	0 0%
Am. Indian/Alas. Nat.[3]	0 0%	0 0%	3 2.26%	1 2.56%	0 0%
Nat. Haw./Pac. Is.[3]	1 1.05%	0 0%	1 0.75%	1 2.56%	0 0%
TOTAL	95	167	133	39	2

Percentages are of years in GIS grouping – for example, 5.26% of participants with 0-3 years of experience in GIS are Hispanic.

Table 156. Race (By number of years in GIS)

	Hispanic	Black/ African American	White	Asian	Am. Indian/ Alas. Nat.	Nat. Haw./ Pac. Is.
0-3 yrs. GIS	5 20.83%	1 12.50%	78 21.02%	10 38.46%	0 0%	1 33.33%
>3 and <=10 yrs. GIS	10 41.67%	3 37.50%	142 38.27%	12 46.15%	0 0%	0
>10 and <=20 yrs. GIS	4 16.67%	4 50%	117 31.54%	4 15.38%	3 75%	1 33.33%
>20 and <=30 yrs. GIS	5 20.83%	0 0%	32 8.63%	0 0%	1 25%	1 33.33%
>30 yrs. GIS[2]	0 0%	0 0%	2 0.54%	0 0%	0 0%	0
Total	24	8	371	26	4	3

Percentages are of race – for example, 20.83% of Hispanic participants have 0-3 years of experience in GIS.

Table 157. Average years in a professional setting and average years in GIS:

	Average Years in a Professional Setting	Average Years in GIS
Hispanic	14	11
Black/African American	18	11
White	14	10
Asian	9	7
Am. Indian/Alas. Nat.[3]	27	17
Nat. Haw./Pac. Is.[3]	17	13

2. Age

Hypothesis: None.

Question format: Integer

Table 158. Age of participants

	Age
Average	38.24
Min	21
Max	69
Median	37
Statistics	
Total responses	465
Unanswered	19

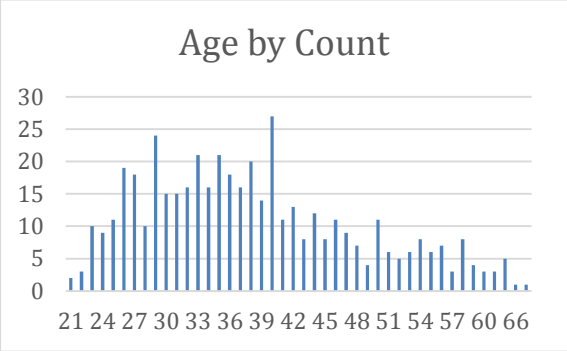


Table 159. Age of participants (Categorical view)

Value	Count	Percent
21-30	121	26.02%
31-40	184	39.57%
41-50	94	20.22%
51-60	56	12.04%
61-70	10	2.15%
Statistics		
Total responses	465	
Unanswered	19	
Chi-squared test: 3.34E-39*		

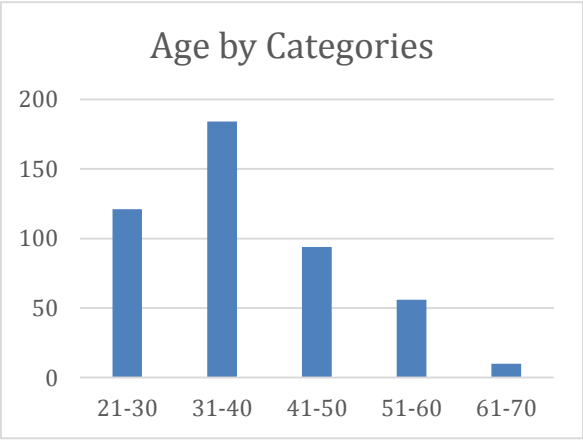


Table 160. Sectors (By age brackets)

Age	State Gov.	Federal Gov.	Regional Gov.	Local Gov.	Non-profit	Start-up	Private	Higher-education	Other
21-30	21 27.27%	5 10.20%	0 0%	15 12.71%	11 28.21%	6 60%	45 29.22%	12 29.27%	5 31.25%
31-40	28 36.36%	14 28.57%	3 50%	41 34.75%	16 41.03%	3 30%	62 40.26%	10 24.39%	7 43.75%
41-50	14 18.18%	12 24.49%	1 16.67%	30 25.42%	8 20.51%	1 10%	17 11.04%	7 17.07%	4 25%
51-60	7 9.09%	9 18.37%	1 16.67%	16 13.56%	2 5.13%	0 0%	15 9.74%	6 14.63%	0 0%
61-70	2 2.78%	0 0%	0 0%	5 4.67%	0 0%	1 9.09%	1 0.71%	1 2.78%	0 0%
TOTAL	72	40	5	107	37	11	140	36	16

Percentages are of sector – for example, 27.27% of participants in state government are 21-30 years old.

Table 161. Age (By sector)

Sector	21-30	31-40	41-50	51-60	61-70
State Gov.	21 17.50%	28 15.22%	14 14.89%	7 12.50%	2 20%
Federal Gov.	5 4.17%	14 7.61%	12 12.77%	9 16.07%	0 0%
Regional Gov.	0 0%	3 1.63%	1 1.06%	1 1.79%	0 0%
Local Gov.	15 12.50%	41 22.28%	30 31.91%	16 28.57%	5 50%
Non-profit	11 9.17%	16 8.70%	8 8.51%	2 3.57%	0 0%
Start-up	6 5%	3 1.63%	1 1.06%	0 0%	1 10%
Private	45 37.50%	62 33.70%	17 18.09%	15 26.79%	1 10%
education	12 10%	10 5.43%	7 7.45%	6 10.71%	1 10%
Higher-education	5 4.17%	7 3.80%	4 4.26%	0 0%	0 0%
Total	120	184	94	56	10

Percentages are of age – for example, 17.5% of 21-30 year old participants work in state government.

OTHER DEMOGRAPHIC VARIABLES COLLECTED IN SURVEY:

Education – See Research Question E, Survey Question 1

Years in a Professional Setting – See Research Question F, Survey Question 1

Years in GIS – See Research Question F, Survey Question 2

SUMMARY OF RESEARCH QUESTION H

None, see note above.

I. Research Question: Is continuing education an important aspect of enhancing GIS careers that is both encouraged by employers and that is taken advantage of by women? Are women GIS professionals being given opportunities to get the knowledge and training that they need?

Survey Page Header *(page 12 on survey): Are you supported in updating skills?*

Context for survey participants: *Is continuing education an important aspect of enhancing GIS careers that is both encouraged by employers and that is taken advantage of by women? Are women GIS professionals being given opportunities to get the knowledge and training that they need?*

Are learning resources and training available to women at work, or must they take continuing education outside of work to perform their current jobs? Also, are women very motivated to seek out additional training to augment their knowledge and expand their skills?

SURVEY QUESTIONS:

1. Do you feel that taking continuing education classes is necessary to your current work?

Hypothesis: Yes, taking continuing education classes is necessary for women (and men, too) to perform their current work successfully. This question is similar to Research Question A, Survey Question 4, which asks "Do you need to take continuing education courses and/or other trainings to update knowledge?" However, the survey question in the current section is slightly altered to refocus the question towards finding out if taking continuing education classes is necessary for *women to perform their current work*.

Question format: Radio – Binary (yes/no)

Table 162. Do you feel that taking continuing education classes is necessary to your current work? (No category filters)

Value	Count	Percent
Yes	386	82.0%
No	85	18.1%
Statistics		
Total responses	471	
Unanswered	13	
Binomial probability of trial result: 2.9066E-47*		

Interpretation: Eighty-two percent of participants feel that taking continuing education classes is necessary to their current work. The p-value is extremely small, indicating that the observed values were not observed by chance, and giving strong evidence that the hypothesis for this question is true. In response to the other question regarding continuing education, 70% of participants reported that they need to take continuing education courses to update their knowledge. More participants report needing to take continuing education to perform their current work as opposed to generally update their knowledge.

Please see Research Question A, Survey Question 4 for an in-depth discussion about the need to take continuing education. Tables are presented here for responses to this question by sector and race/ethnicity. However, the discussion is relatively short due to the overlap with the other section.

Variation by sector includes 73% of participants in the start-up sector versus 88% of participants in state government responding "yes" to this question.

Table 163. Do you feel that taking continuing education classes is necessary to your current work? (By sector)

Sector	# Responses	# Yes	# No	% Yes	% No	P-value
Federal Gov.	40	34	6	85%	15%	3.49099E-06*
State Gov.	75	66	9	88%	12%	3.32449E-12*
Regional Gov.[1]	5	5	0	100%	0%	n/a
Local Gov.	106	91	15	85.8%	14.2%	7.99162E-15*
Non-Profit	37	31	6	83.8%	16.2%	1.6915E-05*
Private	141	106	35	75.2%	24.7%	5.74879E-10*
Start-Up	11	8	3	72.7%	27.3%	0.080566406
Higher education	38	28	10	73.7%	26.3%	0.001719795*

There is also some variation by race/ethnicity. White participants feel less required (80% of them) to take continuing education classes to perform their current work, compared to 88% of Asian participants , and then compared to 100% of black and Hispanic participants.

Table 164. Do you feel that taking continuing education classes is necessary to your current work? (By race/ethnicity)

Race/Ethnicity	# Responses	# Yes	# No	% Yes	% No	P-value
Hispanic	24	24	0	100%	0%	5.96046E-08*
Black/African American	8	8	0	100%	0%	0.00390625*
White	369	290	79	78.6%	21.4%	7.05711E-30*
Asian	25	22	3	88%	12%	6.85453E-05*
Am. Indian/Alas. Nat.[3]	4	4	0	100%	0%	n/a
Nat. Haw./Pac. Is.[3]	3	3	0	100%	0%	n/a

2. Do you feel that taking continuing education classes would be necessary to obtaining a different position?

Hypothesis: Yes, taking continuing education classes would be necessary to obtaining a different position.

Question format: Radio – Binary (yes/no)

Table 165. Do you feel that taking continuing education classes would be necessary to obtaining a different position? (No category filters)

Value	Count	Percent
Yes	371	79.1%
No	98	20.9%
Statistics		
Total responses	469	
Unanswered	15	
Binomial probability of trial result: 7.49767E-39*		

Interpretation: Anyone seeking to change her (or his) position might need to take continuing education to enhance skills. Additionally, based on the hypothesis that women might be given fewer opportunities to be in more highly technical roles, it is possible that women who desire such highly technical roles will be required to take continuing education classes in order to add new skills to their toolset that they don't have the chance to add in their current positions.

Seventy-nine percent of participants feel that taking continuing education classes would be necessary to obtaining a different position. The p-value is extremely small, indicating that the observed values were not observed by chance, giving strong evidence that the hypothesis for this question is true. Why do so many participants feel that taking continuing education classes would be necessary to obtain a different position? Is it because they need more technical skills to which they are not exposed at work? Would men answer this question similarly?

Eighty-five percent of participants in federal government feel that taking continuing education classes would be necessary to obtain a different position, whereas 64% of participants in start-ups think so (p-value indicates results may have been observed by chance for this group).

Table 166. Do you feel that taking continuing education classes would be necessary to obtaining a different position? (By sector)

Sector	# Responses	# Yes	# No	% Yes	% No	P-value
Federal Gov.	41	35	6	85.4%	14.6%	2.04472E-06*
State Gov.	74	53	21	71.6%	28.4%	8.01794E-05*
Regional Gov.[1]	5	5	0	100%	0	n/a
Local Gov.	105	85	20	81%	19%	3.88963E-11*
Non-Profit	37	31	6	83.8%	16.2%	1.6915E-05*
Private	141	113	28	80.1%	19.9%	1.00097E-13*
Start-Up	11	7	4	63.6%	36.4%	0.161132813
Higher education	38	26	12	68.4%	31.6%	0.009849737*

Ninety-six percent of Asian participants feel that taking continuing education classes would be necessary to obtain a different position, whereas 77% of white participants think so.

Table 167. Do you feel that taking continuing education classes would be necessary to obtaining a different position? (By race/ethnicity)

Race/Ethnicity	# Responses	# Yes	# No	% Yes	% No	P-value
Hispanic	24	22	2	91.7%	8.3%	1.64509E-05*
Black/African American	8	7	1	87.5%	12.5%	0.03125*
White	368	282	86	76.6%	23.4%	6.40992E-26*
Asian	24	23	1	95.8%	4.2%	1.43051E-06*
Am. Indian/Alas. Nat.[3]	4	4	0	100%	0%	n/a
Nat. Haw./Pac. Is.[3]	3	3	0	100%	0%	n/a

The feeling that continuing education classes would be necessary to obtaining another position diminishes by the number of years in GIS – 84% of participants with 0-3 years think so, versus 76% of participants with 20-30 years.

Table 168. Do you feel that taking continuing education classes would be necessary to obtaining a different position? (By number of years in GIS)

Number of Years in GIS	# Responses	# Yes	# No	% Yes	% No	P-value
0-3 yrs.	103	86	17	83.5%	16.5%	1.13319E-12*
>3 and <=10 yrs.	180	145	35	80.6%	19.4%	1.57636E-17*
>10 and <=20 yrs.	140	105	35	75%	25%	8.64356E-10*
>20 and <=30 yrs.	41	31	10	75.6%	24.4%	0.000509817*
>30 yrs.[2]	2	2	0	100%	0%	n/a

3. On-the-job learning related questions

Question format (for all): Radio – Binary (yes/no)

a. Does your position have many learning opportunities?

Hypothesis: None. This question was asked to assess if GIS jobs have many learning opportunities and, if not, if this has any bearing on the need to take continuing education classes. Additionally, what does the lack of learning opportunities in a position say about the nature of the position as a whole?

Table 169. Do you feel that taking continuing education classes would be necessary to obtaining a different position? (No category filters)

Value	Count	Percent
Yes	358	75.8%
No	114	24.2%
Statistics		
Total responses	472	
Unanswered	12	
Binomial probability of trial result: 7.40174E-31*		

Interpretation: In order to be able to perform current work successfully and to achieve career growth and upward mobility, being able to learn new things at work is essential. A healthy proportion of participants, 76%, report that their positions have many learning opportunities.

There is variation by sector, however, ranging from 62% of participants in federal government to 92% of participants in higher education reporting that their positions have many learning opportunities. The results of the previous question revealed that 85% of participants in federal government feel that taking continuing education classes would be necessary to obtain a different position (this was the highest percentage for that question). Here it is revealed that the federal government group is the one that least reports on-the-job learning opportunities. A result such as this suggests that there is a connection between how much opportunities for learning there are on the job and the need to take continuing education.

Table 170. Do you feel that taking continuing education classes would be necessary to obtaining a different position? (By sector)

Sector	# Responses	# Yes	# No	% Yes	% No	P-value
Federal Gov.	42	26	16	61.9%	38.1%	0.037859927*
State Gov.	73	62	11	84.9%	15.1%	3.76771E-10*
Regional Gov.[1]	5	3	2	60%	40%	n/a
Local Gov.	107	80	27	74.8%	25.2%	9.69962E-08*
Non-Profit	37	28	9	75.7%	24.3%	0.000905155*
Private	141	104	37	73.8%	26.2%	4.8036E-09*
Start-Up	11	8	3	72.7%	27.3%	0.080566406
Higher education	38	35	3	92.1%	7.9%	3.069E-08*

Seventy-seven percent of white participants report on the job learning opportunities, as compared to 63% of black/African American participants (p-value=0.2 – not statistically significant). The comparison above regarding federal government applies here as well. White participants were the ones who least reported needing to take continuing education classes to obtain a new job, and here they are the ones who most report on-the-job learning opportunities.

Table 171. Do you feel that taking continuing education classes would be necessary to obtaining a different position? (By race/ethnicity)

Race/Ethnicity	# Responses	# Yes	# No	% Yes	% No	P-value
Hispanic	24	16	8	66.7%	33.3%	0.043837488*
Black/African American	8	5	3	62.5%	37.5%	0.21875
White	370	285	85	77%	23%	8.21429E-27*
Asian	25	18	7	72%	28%	0.014325976*
Am. Indian/Alas. Nat.[3]	4	3	1	75%	25%	n/a
Nat. Haw./Pac. Is.[3]	3	3	0	100%	0%	n/a

Women in positions that do not provide a good level of learning opportunities might feel an additional burden if they have to seek out continuing education courses on their personal time. As is discussed in the sections above, while the requirement to constantly update skills and knowledge might be rewarding, it could also be a hardship if it tampers with work-life balance. Figures such as the ones presented in this section might be examined by GIS or HR departments within these sectors to see how they can improve in providing learning opportunities to their employees. Job seekers might also consider such figures when looking for work – perhaps sectors with better learning opportunities are better sectors in which to work.

b. Are you required to accomplish tasks that push you to learn new things?

Hypothesis: None. Similar to question above, this question was asked to assess how many learning opportunities GIS positions have and if they present opportunities for skill growth.

Table 172. Are you required to accomplish tasks that push you to learn new things? (No category filters)

Value	Count	Percent
Yes	401	84.8%
No	72	15.2%
Statistics		
Total responses	473	
Unanswered	11	
Binomial probability of trial result: 8.72739E-57*		

Interpretation: Discussion for question above applies here.

Table 173. Are you required to accomplish tasks that push you to learn new things? (By sector)

Sector	# Responses	# Yes	# No	% Yes	% No	P-value
Federal Gov.	42	34	8	81%	19%	2.6837E-05*
State Gov.	74	63	11	85.1%	14.9%	2.21278E-10*
Regional Gov.[1]	5	5	0	100%	0%	n/a
Local Gov.	107	86	21	80.4%	19.6%	6.10689E-11*
Non-Profit	37	34	3	91.9%	8.1%	5.65342E-08*
Private	141	118	23	83.7%	16.3%	5.62263E-17*
Start-Up	11	10	1	90.9%	9.1%	0.005371094*
Higher education	38	37	1	97.4%	2.6%	1.38243E-10*

Table 174. Are you required to accomplish tasks that push you to learn new things? (By race/ethnicity)

Race/Ethnicity	# Responses	# Yes	# No	% Yes	% No	P-value
Hispanic	24	18	6	75%	25%	0.008022547*
Black/African American	8	4	4	50%	50%	0.2734375
White	371	322	49	86.8%	13.2%	9.82225E-51*
Asian	25	21	4	84%	16%	0.000376999*
Am. Indian/Alas. Nat.3	4	4	0	100%	0%	n/a
Nat. Haw./Pac. Is.3	3	3	0	100%	0%	n/a

c. If so, do you enjoy that aspect or is it a hardship?

Hypothesis: Participants will enjoy that aspect.

Table 175. If so, do you enjoy that aspect or is it a hardship? (No category filters)

Value	Count	Percent
Yes	388	91.1%
No	38	8.9%
Statistics		
Total responses	426	
Unanswered	58	
Binomial probability of trial result: 1.6656E-74*		

Interpretation: While the learning necessitated by the ever-evolving nature of technology (and GIS) might pose some challenges, women (and people in general) will enjoy that aspect of their jobs. Being pushed to learn new things will be seen as a rewarding challenge, especially in the promise that it may hold to attain new skills to acquire new jobs. Ninety-one percent of participants enjoy being pushed to learn new things.

SUMMARY OF RESEARCH QUESTION I

Is continuing education an important aspect of enhancing GIS careers that is both encouraged by employers and that is taken advantage of by women? Are female GIS professionals being given opportunities to get the knowledge and training that they need?

The current section aimed to measure to what degree women feel the *need* to take continuing education classes. However, it might be the case that women also *like to* take continuing education classes – as was seen from the survey respondents' responses about their educational achievements (Research Question E, Survey Question 1), women in GIS are a highly educated group. Based on the number of advanced degrees and other certificates attained, it seems that these women are extremely motivated to continue to learn.

However, needing to take continuing education classes (versus merely liking to) could be a useful measurement of the demands of GIS, and if those demands might have any impact on work-life balance. Eighty-two percent of participants report that they feel that taking continuing education classes is necessary to their current work. Seventy-nine percent of participants feel that taking continuing education classes would be necessary to obtain a different position. Are these large percentages of participants that feel that continuing education is necessary an indication that participating in professional GIS requires constant learning and updating of skills (for more on this see Research Question A, Survey Questions 3 and 4)? Moreover, is this requirement in any way a

burden? When the participants were asked if they are required to accomplish tasks at work that push them to learn new things, 91% said that they enjoy this aspect of their work. So it is possible that the learning that occurs through continuing education is also an aspect that women enjoy and that they might not mind having to take such courses (even if they must be taken during personal time).

On-the-job learning was also measured in this section – one, as a starting point from which to measure how challenging (and possibly rewarding) GIS positions are and, two, to get a sense of whether there is a relationship between having opportunities to learn at work and feeling the need to take continuing education. Overall, 76% of participants reported that they have learning opportunities in their current positions, which possibly reflects the fact that GIS positions are dynamic and can provide people with growth opportunities. However, it seems that there is a possible pattern among those who report fewer learning opportunities at work feeling that they need to take continuing education. For example, 85% of participants in federal government feel that taking continuing education classes would be necessary to obtain a different position (this was the sector with the highest percentage of women reporting this for this question). This sector also has the smallest proportion of participants (62%) reporting that they have many on-the-job learning opportunities. Conversely, across race/ethnicity groups, white participants reported least needing to take continuing education classes to obtain a new job and reported the most on-the-job learning opportunities.

J. Research Question: Is putting the word "Women" in front of "GIS" to come up with the phrase "Women in GIS" wrong?

Does the mere saying of this just serve to reinforce women's alienation and their being seen as other?

Survey Page Header *(page 13 on survey): Women? In GIS*

Context for survey participants: *How do you identity yourself – as a "woman in GIS," a "GIS professional," or as both? Some literature suggests that certain ways of talking about gender and career paths only serve to reinforce the current status quo (Bastalich et al. 2007). That is, saying "women in GIS," for example, might reinforce that women are not already a significant part of GIS, or that they are somehow different than others (men) in GIS. However, it might be that women do share a collective experience, and perhaps even approach the world and careers differently (than men), and as such identifying as women is appropriate. How do different women who work in GIS identify themselves? Should the term "women in GIS" be embraced? Finding out how actual women in GIS identify themselves might suggest answers.*

SURVEY QUESTIONS:

1. **The term "women in GIS" is a good way to categorize, or describe, women who work in GIS (Strongly agree, disagree, etc.)**

Hypothesis: None. This question was asked to see how women preliminarily felt about the term "women in GIS." It is possible that assigning the word "woman" before a professional career title might have unintended negative consequences, including making women, themselves, feel set apart (inspired from: Bastalich et al. 2007; Ullman 2013). How do females working in GIS react to this term?

Question format: Likert

Table 176. The term "women in GIS" is a good way to categorize, or describe, women who work in GIS. (No category filters)

Value	Count	Percent
Strongly disagree	40	8.4%
Disagree	87	18.4%
Neutral	194	40.9%
Agree	126	26.6%
Strongly agree	27	5.7%
Statistics		
Total responses	474	
Unanswered	10	
Chi-squared test: 4.73E-41*		

Interpretation: The question results are mixed and balanced somewhat equally between agreement and disagreement, with a lot of neutrality in between. Nearly 27% of participants disagree on some level that the term "women in GIS" is a good way to categorize or describe women who work in GIS. A slightly higher number of participants (32%) think that the term is good, while 41% are neutral about it. What can this spread of numbers definitely say about calling women in GIS "women in GIS"? Basically, the reactions are mixed to the point that it would be difficult to claim that women working in GIS are categorically opposed to being called such. By the number of participants who are either neutral about the term or agree with it, it seems that the term "women in GIS" in okay to use. That being said, there is a not insignificant contingent that does not like the term – about a quarter of the participants reject the term as a good way to categorize women who work in GIS.

In terms of women who *agree* that the term "women in GIS" is a good way to categorize or describe women who work in GIS, the state government sector has the highest percentage of participants (41%) and local government has the lowest percentage (22%). In terms of those who *disagree* with

the statement, the non-profit sector has the highest percentage of participants (33%), and the start-up sector has the lowest percentage (18%).

Table 177. The term "women in GIS" is a good way to categorize, or describe, women who work in GIS. (By sector)

Sector	# Responses	Disagree†	Neutral	Agree†	P-value††
Federal Gov.	43	23.3%	39.5%	37.2%	2.60523E-05*
State Gov.	75	26.7%	32%	41.3%	0.000226462*
Regional Gov.[1]	5	20%	60%	20%	n/a
Local Gov.	107	31.8%	46.7%	21.5%	2.0602E-11*
Non-Profit	36	33.3%	33.3%	33.3%	0.009296474*
Private	140	22.9%	42.1%	35%	1.72707E-12*
Start-Up	11	18.2%	45.5%	36.4%	0.21314426
Higher education	39	28.2%	46.2%	25.6%	0.000335751*

† Disagree is "strongly disagree" and "disagree" combined. Agree is "strongly agree" and "agree" combined.
†† P-values are for non-combined results.

Is there any relationship between the responses to this survey question and female representation in different sectors, as well as a relationship to other information uncovered through the thesis? The information bulleted below is a starting point from which to investigate possible relationships and to create group profiles. The referenced data comes from tables presented above (see *Female Representation in Sectors*; *Male vs. Female Supervisors (by sector)*; *Do Women Face Bias as GIS Professionals (by sector)*?)

- State government is the group that most agreed (41%) that the term "women in GIS" is a good way to categorize, or describe, women who work in GIS; and this sector has 41% female representation. Seventy-one percent of participants in state government have male supervisors and 25% have female supervisors. Forty-three percent think women face bias as GIS professionals, 57% do not think so.

- Participants in local government were the ones who least agreed (22%) with the statement, and this sector has 60% female representation, the highest of all the sectors. Sixty percent have male supervisors and 36% have female supervisors. 38% think women face bias as GIS professionals, 62% do not think so.

- Participants in the non-profit sector were the ones who most disagreed (33%) with the statement and this sector has 45% female representation. Seventy percent have male supervisors and 30% have female supervisors. Forty-four percent think women face bias as GIS professionals, 56% do not think so.

- Participants in the start-up group were the ones who least disagreed with this statement and this is the group with the poorest female representation with only 28% women. Eighty-two percent have male supervisors and 0% have female supervisors (18% don't have supervisors or said "n/a"). Thirty-six percent think women face bias as GIS professionals, 64% do not think so.

Hispanic participants were the ones who least agreed (as well as most disagreed) that the term "Women in GIS" is a good way to categorize, or describe, women who work in GIS (25%). They were also the race/ethnicity group that most thought that there is an underrepresentation of women in GIS (see *Do you think there is an underrepresentation of women on GIS? (by Race/Ethnicity)?* Meanwhile, Asian participants were the ones who most agreed (46%) that the term "Women in GIS" is good and this was the group that least thought (54%) that there was female underrepresentation in GIS. (Note the comparison of other variables that is presented for sectors above and that is not done here because there was no significant variation in those responses for race/ethnicity groups).

Table 178. The term "women in GIS" is a good way to categorize, or describe, women who work in GIS. (By race/ethnicity)

Race/Ethnicity	# Responses	Disagree†	Neutral	Agree†	P-value††
Hispanic	24	45.8%	29.2%	25%	0.417401251
Black/African American	8	25%	25%	50%	0.945022758
White	370	26.2%	43.2%	30.5%	6.10199E-38*
Asian	26	26.9%	26.9%	46.2%	0.177317837
Am. Indian/Alas. Nat.[3]	4	75%	0%	25%	n/a
Nat. Haw./Pac. Is.[3]	3	0%	66.7%	33.3%	n/a

† Disagree is "strongly disagree" and "disagree" combined. Agree is "strongly agree" and "agree" combined.
†† P-values are for non-combined results.

As the number of years in GIS increases, participants agreed less that the term "women in GIS" is a good way to categorize, or describe, women who work in GIS, beginning with 39% of participants with 0-3 years agreeing falling down to 10% of participants with 20-30 years of GIS experience. Participants with more years of GIS experience increasingly sense a male dominated culture (21% of 0-3 rising to 33% of 20-30 years of GIS experience) (see *Do you feel that there is a male-dominated culture? For example, a "boys club" type situation? Do you feel excluded in any way from activities? (by number of years in GIS)*.

Table 179. The term "women in GIS" is a good way to categorize, or describe, women who work in GIS. (By number of years in GIS)

Number of Years in GIS	# Responses	Disagree†	Neutral	Agree†	P-value††
0-3 yrs.	102	20.6%	40.2%	39.2%	8.59002E-10*
>3 and <=10 yrs.	181	26%	39.8%	34.3%	1.38464E-14*
>10 and <=20 yrs.	143	30.8%	36.4%	32.9%	3.53876E-10*
>20 and <=30 yrs.	42	28.6%	61.9%	9.5%	5.32823E-10*
>30 yrs.[2]	3	33.3%	66.7%	**0%**	n/a

† Disagree is "strongly disagree" and "disagree" combined. Agree is "strongly agree" and "agree" combined.
†† P-values are for non-combined results.

2. The term "women in GIS" is not a good thing – it separates and alienates women who work in GIS from men.

Hypothesis: This second question is intentionally more charged than the first, more neutral question of how women feel about the term "women in GIS." By pointing out through the wording of the question that it is possible that the term "women in GIS" might separate and alienate women who work in GIS from men, women are asked to reassess the term in that new light. The thesis author did not intend to lead the survey participants towards a specific response, the only intention was to ask the question again in a slightly different way to see if responses might be altered somehow. Upon the survey participants' follow-up assessment of the term, is it found that women's opinion of the term slightly changes from neutral to more opinionated? The hypothesis is that this question will yield more negative reactions to the term "women in GIS."

Question format: Likert plus comments

Table 180. The term "women in GIS" is not a good thing – it separates and alienates women who work in GIS from men. (No category filters)

Value	Count	Percent
Strongly disagree	23	4.9%
Disagree	90	19.1%
Neutral	185	39.3%
Agree	129	27.4%
Strongly agree	44	9.3%
Statistics		
Total responses	471	
Unanswered	13	
Chi-squared test: 4.26E-38*		

Interpretation: The hypothesis for this question is not strongly supported by the survey results, nor is it entirely disproved. The responses to this question are just as mixed as the results to the first question in this survey section. Thirty-nine percent of the participants feel neutral about the term ("women in GIS" is not a good thing – it separates and alienates women who work in GIS from men), almost the same exact amount as the first question. Thirty-seven percent of participants agree (agree and strongly agree combined) that the term "women in GIS" is not a good thing in that it separates and alienates women who work in GIS from men, while 24% of participants disagree with that statement. The responses are slightly more weighted towards agreeing that the term "women in GIS" is *not* good.

However, in response to the question above, 32% of participants agree that the term "women in GIS" is a good way to categorize, or describe, women who work in GIS. At the same time, 37% of participants agree that the term "women in GIS" is not a good thing in that it separates and alienates women who work in GIS from men. By comparing these two generalized numbers, it could be said that women like and dislike the term "women in GIS" to almost the same degree.

The responses to this question can be filtered in such a way that it is possible to see if how participants answered the first question changed when asked the second question about the term "women in GIS." For example, if women agreed that the term "women in GIS" **is a good way** to categorize, or describe, women who work in GIS, then what were the responses to the other question of the term "women in GIS" **is *not* a good thing** – it separates and alienates women who work in GIS from men?

Table 181. The term "women in GIS" is not a good thing – it separates and alienates women who work in GIS from men. (Filtered)

9% of the 153 women who agreed with the first statement†, agreed with the second statement††.
79% of the 127 women who disagreed with the first statement†, agreed with the second statement††.
25% of the 194 women who were neutral about the first statement†, agreed with the second statement††.

† First statement = The term "women in GIS" is a good way to categorize, or describe, women who work in GIS.
†† Second statement = The term "women in GIS" is not a good thing – it separates and alienates women who work in GIS from men.

There is a significant difference among sector of employment and response to the term "women in GIS" is not a good thing. Participants in start-ups were much more likely to disagree with the statement (63% said either disagree or strongly disagree), compared with 23-34% of participants disagreeing from other sectors. Those in local government were those who least disagreed with the statement (12% said either "disagree" or "strongly disagree").

Table 182. The term "women in GIS" is not a good thing – it separates and alienates women who work in GIS from men. (By sector)

Sector	# Responses	Disagree†	Neutral	Agree†	P-value††
Federal Gov.	41	34.1%	36.6%	29.3%	0.000665961*
State Gov.	75	24%	37.3%	38.7%	7.57736E-06*
Regional Gov.[1]	5	20%	60%	20%	n/a
Local Gov.	104	11.5%	48.1%	40.4%	7.1635E-14*
Non-Profit	37	29.7%	29.7%	40.5%	0.052892906
Private	141	25.5%	39.7%	34.8%	5.12684E-12*
Start-Up	11	63.6%	27.3%	9.1%	0.151021869
Higher education	39	23.1%	33.3%	43.6%	0.038734992*

† Disagree is "strongly disagree" and "disagree" combined. Agree is "strongly agree" and "agree" combined.
†† P-values are for non-combined results.

There is also a significant difference among race/ethnicity and agreement with the term "women in GIS" is not a good thing. Forty-two percent of Asian participants "agreed" or "strongly agreed" with the statement, compared to 37% of white, 33% of Hispanic, and 25% of black/African American participants.

Table 183. The term "women in GIS" is not a good thing – it separates and alienates women who work in GIS from men. (By race/ethnicity)

Race/Ethnicity	# Responses	Disagree†	Neutral	Agree†	P-value††
Hispanic	24	20.8%	45.8%	33.3%	0.026564014*
Black/African American	8	50%	25%	25%	0.735758882
White	367	23.4%	39.5%	37.1%	3.24337E-32*
Asian	26	26.9%	30.8%	42.3%	0.27187303
Am. Indian/Alas. Nat.[3]	3	0%	33.3%	66.7%	n/a
Nat. Haw./Pac. Is.[3]	3	33.3%	66.7%	0%	n/a

† Disagree is "strongly disagree" and "disagree" combined. Agree is "strongly agree" and "agree" combined.
†† P-values are for non-combined results.

Matching the pattern of responses to the question above, participants with more years of GIS experience increasingly agree that the term "women in GIS" is not a good thing – it separates and alienates women who work in GIS from men. Thirty-four percent of participants with 0-3 years of GIS experience, going up to 44% of participants with 20-30 years of experience agree.

Table 184. The term "women in GIS" is not a good thing – it separates and alienates women who work in GIS from men. (By number of years in GIS)

Number of Years in GIS	# Responses	Disagree†	Neutral	Agree†	P-value††
0-3 yrs.	102	29.4%	36.3%	34.3%	1.72841E-06*
>3 and <=10 yrs.	179	27.4%	40.8%	31.8%	1.16988E-14*
>10 and <=20 yrs.	143	21%	37.8%	41.3%	2.48269E-12*
>20 and <=30 yrs.	41	9.8%	46.3%	43.9%	2.89032E-05*
>30 yrs.[2]	3	0%	33.3%	66.7%	n/a

† Disagree is "strongly disagree" and "disagree" combined. Agree is "strongly agree" and "agree" combined.
†† P-values are for non-combined results.

Open text analysis for comments: (107 comments)

Participants were able to submit comments in response to this question. The nature of these comments was such that categorizing and quantifying them was not possible. However, some of the insights garnered from the comments that were repeated several times included:

- "Men in GIS" would not be good term, therefore "women in GIS" is not good.
- Torn – sees self as GIS professional, but "women in GIS" might be useful in certain contexts.
- Unsure – has it helped thus far?
- "Women in GIS" creates solidarity with other women or a good "cohort."
- "Women in GIS" does NOT alienate or hinder.
- "Women in GIS" DOES alienate and hinder or does a disservice to women.
- "Women in GIS" good way to call an event or group but not an individual.
- Gender is not an appropriate filter in professional world.

3. You identify yourself as a (if you had to pick one): (a) "woman in GIS" (b) GIS professional (no gender)

Hypothesis: The term "women in GIS" when applied at a group level is one that can be regarded from a more impersonal, dispassionate stance. However, what an individual woman wants to be called and how she identifies herself, is a different, more personal matter. It is hypothesized that women in GIS, from an individual perspective, will prefer to identify themselves as "GIS professionals," free of gender assignations.

Question format: Radio – Binary

Table 185. You identify yourself as a (if you had to pick one): (a) "woman in GIS" (b) GIS professional (no gender). (No category filters)

Value	Count	Percent
"woman in GIS"	29	6.1%
GIS professional (no gender)	447	93.9%
Statistics		
Total responses	476	
Unanswered	8	
Binomial probability of trial result: 1.08576E-97*		

Interpretation: The hypothesis for this question is overwhelmingly confirmed, and the p-value is extremely small indicating that the results of this question were not observed by chance. A grand majority of the survey participants (94%) would rather drop the word "woman," and simply identify themselves as "GIS professionals."

A higher percentage of participants in federal government (16%) and the start-up sector (18%, p-value=0.03) would prefer to identify themselves as "woman in GIS."

Table 186. You identify yourself as a (if you had to pick one): (a) "woman in GIS" (b) GIS professional (no gender). (By sector)

Sector	# Responses	Woman in GIS	GIS Professional	P-value
Federal Gov.	43	16.3%	83.7%	3.66346E-06*
State Gov.	75	5.3%	94.7%	3.21727E-17*
Regional Gov.[1]	5	0%	100%	n/a
Local Gov.	107	2.8%	96.3%	3.18047E-26*
Non-Profit	37	2.7%	97.3%	2.6921E-10*
Private	142	7%	93%	1.1914E-28*
Start-Up	11	18.2%	81.8%	0.026855469*
Higher education	39	5.1%	94.9%	1.34787E-09*

While there is not a steadily increasing or decreasing pattern for higher numbers of GIS experience, there is some slight variation: 7% of participants with 0-3 years, 8% of 3-10, 4% of 10-20, and 5% of 20-30 would prefer to keep "woman" in their identification.

SUMMARY OF RESEARCH QUESTION J

Is putting the word "women" in front of "GIS" to come up with the phrase "women in GIS" wrong? Does the mere saying of this merely serve to reinforce women's alienation and their being seen as other?

Please see the literature review for a discussion on adding the words "woman" and "women" in front of "in GIS."

Women's take on the word "woman" is very different when it comes to individual identification, as opposed to identification on a group level. Women, for the most part, seem to be okay with the term "women in GIS" but not okay with "*woman* in GIS." Only 32% of women agree that the term "women in GIS" is a good way to categorize, or describe, women who work in GIS, and

simultaneously 37% of women agree that the term "women in GIS" is not a good thing because it separates and alienates women who work in GIS from men. Meanwhile, 94% of the survey participants would rather be called "GIS professional" than "woman in GIS."

Is this difference because, when taken from an individual perspective, being seen as a "GIS professional" is more neutral? Yet on a group level, "women in GIS" affirms a sub-community of GIS professionals that women can, and like to, participate in? A quote that was submitted in response to the term "women in GIS" speaks pointedly to this idea:

> "I think it is okay to identify ourselves as such since we are a minority. I would only use it as part of a group though. As a person I would like to remove the terms woman from describing professional individuals because then the norm of man first is reinforced."

V. Conclusion

This thesis began with one thought in mind: there is an underrepresentation of women in GIS and it is an issue that deserves attention. In the end, it was discovered that the situation is significantly more nuanced than can be captured by a simple black or white question such as whether women are underrepresented. However, the thought still remains that it is an issue that deserves further attention.

A. What are the key takeaways from the thesis?

Findings of the first research question:

The first research question that the thesis set out to answer was, "Is there an underrepresentation of women in the geographic information systems (GIS) professional sphere?" It was hypothesized that, yes, there would be an underrepresentation of women in GIS.

The key takeaway from the research findings is that while there might not be an overall numerical underrepresentation of women in GIS, women might be more underrepresented in certain sectors and in certain types of positions.

By extrapolating the numbers reported by survey participants of their GIS departments to the GIS field at large, it can be concluded women are ***not*** grossly underrepresented in GIS. Based on the sample, it was found that the GIS professional workforce is 42% female. While this is not a completely balanced representation it might be considered a healthy representation.

In the literature review, it is mentioned that one of the arguments for why it is important to increase the numbers of women in STEM careers is that the proportion of women working in STEM

should mirror the larger labor and societal picture. If women account for half of the workforce, then IT (and other STEM fields) should reflect the overall labor statistics (Ahuja 2002; Beede et al. 2011; Cross and Linehan 2006). According to Department of Labor (2014b) statistics listed on their website, women make up 52% of the civilian population and 47% of the overall labor force (both statistics are for women 16 years and over). It appears that the proportion of women in GIS is slightly lower than the proportion reported by the DOL of the general labor force, but not significantly so. The proportion of women in GIS might not mirror the larger societal picture, but it closely reflects the overall labor situation.

There are two other general, recent figures with which the results of this thesis can be compared: according to other DOL figures from 2013 cited on the National Center for Women and Information Technology website, women hold about 26% of computing-related occupations; and according to 2013 National Science Foundation (NSF) statistics, women make up 29% of all science and engineering occupations. In comparing the number of women in GIS to these other generalized figures, the thesis results indicate that women in GIS are better represented than they are in these other STEM-related occupations. However, as is suggested in a few places in this thesis, women in GIS might also be women in computer and information technology or women in science and engineering. If women in GIS are included in the STEM figures of the DOL and the NSF, would then the STEM numbers be even smaller without the GIS women? It would be helpful if GIS were more explicitly categorized and reported in these other DOL and NSF figures to better measure women's representation in GIS, as well as to more actively place them in the larger STEM context.

The figures cited in the above paragraphs (of female representation in GIS discovered through this thesis, in computer and information technology from the DOL, and in science and engineering from the NSF) are *general* figures. There is great variation among the occupations that fall under

computer and information technology, as well as among those that fall under science and engineering. For example, according to NSF figures, 74% of psychologists and only 25% of computer and math scientists are women (National Science Foundation 2013). And according to DOL figures, 40% of web developers and only 8% of computer network architects are women (Department of Labor 2013).

As found in this thesis, the same general patterns are also potentially extant within GIS. Variation in participation within GIS is not only similar to these other STEM fields but it also helps to further clarify the original research question of whether there is an underrepresentation of women in GIS. The survey did not capture information about different specific occupations within GIS (for example, GIS technicians, software developers, or GIS analysts) but it did collect information about which sectors women work in, information about how they categorize their work, as well as to what degree they utilize different skills in their current positions. It was found that more women who participated in the survey work in certain sectors, namely in local government or in private companies, as opposed to non-profits. Even though more participants might be found in these sectors, it still does not guarantee equal representation. For example, while the largest proportion of survey participants (30%) works in the private sector, that sector is made up of 68% men and only 32% women. Meanwhile, only 8% of survey participants work in non-profits, but that sector is made up of 45% women.

So, while an overall underrepresentation of women in GIS was not found, a significant underrepresentation of women in certain sectors was found. In response to another question about how women categorize their work, it was also found that women perform analysis to a much greater degree than programming, suggesting that the possible range of occupations within GIS might not be equally occupied by women as men (research including men would have to be

conducted to definitively answer this). Similarly, regarding the skills that women are called upon to use at work, it was found that, while women reported the use of both technical and "soft" skills, instead of drawing equally from both skillsets, women use soft skills to a greater extent (4.21 out of 5 average rank score) and scored themselves relatively lower on the use of technical (2.88 out of 5) and management competencies (3.1 out 5). These three sets of findings point to a similar variation among job types occupied by women within GIS as occurs within computer and information technology, science, and engineering. The findings also suggest that, again, while overall female representation in GIS is significant, the details of that representation suggest possibly uneven participation.

Tying back to the discussion in the literature review, while the survey indicated that women's numerical participation in GIS might closely reflect the overall participation of women in the labor force, this fact does not mean that GIS is devoid of issues impacting women's participation – a deeper investigation is required to uncover the nuanced experiences of women working in GIS.

Findings of the second research question:

To the end of uncovering the nuanced experiences of female participation in GIS, the second research question asked, "Do women in GIS experience gender-based obstacles to success? What are the experiences of women in GIS?" It was hypothesized that "It is likely that women in GIS have experienced gender-based obstacles to success. However, it might be that GIS has unique characteristics that distinguish it from other male dominated fields, such as information technology (IT), and which might make female participation in GIS distinct from those fields."

First, do women in GIS experience gender-based obstacles? The key takeaways from the research findings are not as easily summarized as they are for the first research question. The answer is both yes and no.

Questions on the obstacles learned about in the literature review, which largely focused on IT, were asked in the survey to find out if women in GIS face similar challenges. It was found that the participants generally did not face the same obstacles, or at least not to the same degree as women might in IT. Of the challenges uncovered in the literature that have gender-related aspects or consequences, it was generally found that women in GIS are not required to work long hours as much as they do in IT, that GIS workplaces allow for more flexible work arrangements, and that a male-dominated culture is not widely perceived (please note that these are the generalized findings and that the Survey Results and Discussions chapter should be consulted for a much more detailed discussion). Women also seem to participate in work-related social gatherings (GIS related or otherwise), which suggests that they participate in the "dominant culture" of their workplaces. However, IT and GIS are very similar in the constant need for updating knowledge, with a vast majority of the survey participants reporting the need to regularly update their skills.

The findings mentioned above about the skills that women use at work and how they categorize their work help answer both whether there is an underrepresentation of women in GIS, as well as contributing to an understanding of whether women face gender based obstacles. Based on the results of the survey, it seems that a gender bias might be present that is pushing women toward certain types of work and that women are given more opportunities for certain types of work as opposed to others. A research study that also includes men in GIS would be necessary for a comparative analysis. Other survey results, such as the fact that 70% of women report having male supervisors, are a possible indication of two things. One, more male supervisors suggests that there

might be obstacles to achieving leadership roles for females. Two, more male supervisors might create a male-dominated culture in the workplace, or at least the perception that men have more opportunities to be in certain roles.

The survey included a number of questions regarding women's perceptions of their representation in GIS. These questions were incorporated since it is believed (by the thesis author) that perception itself might be a possible indicator of either obstacles faced or of the more nuanced status of women in GIS (regardless of actual numerical underrepresentation). Survey participants were asked, "Do you think there is an underrepresentation of women in GIS?" Sixty-four percent of the participants replied yes. They were also asked, "Do women face bias as GIS professionals?" In addition to, "Is this bias unique to GIS or is it more general?" Forty-eight percent of the participants think that women face bias as GIS professionals, and only 6% of the participants think this bias is unique to GIS, while 69% think that the bias is more general. That a majority of participants think that they are underrepresented, and that half think women face bias as GIS professionals, points to the possibility that even though gross underrepresentation is not present, other conditions exist to create these perceptions. However, given that 69% of participants think that the bias is not unique to GIS, it is possible that gender related issues are a larger problem and are not particular to GIS (as mentioned above, if women in GIS are also women in computer and information technology or women in science and engineering, could these other larger fields be the greater source of bias?).

With a similar purpose of attempting to measure gender based obstacles, other survey questions explored whether women in GIS feel isolated. Survey participants were asked, "Do you feel that you would like to meet other women who work in GIS?" and "Have you ever been the only woman in the room (at meetings, events, etc.)?" The two questions in this section showed that, by and large, women in GIS want to meet other women in the field and that many women "have been the only

woman in the room." These feelings and experiences further highlight that while there might not be a gross underrepresentation of women in GIS, attention still needs to be placed on women's participation.

B. Thesis author's reactions to the overall findings and lessons learned about the research process

Thesis author's reactions to the overall findings:

It was surprising to learn that women are well represented in GIS overall. The research presented herein suggests that rather than thinking about "more," we should be asking "how." How are women participating in GIS? How could women's experiences in GIS be improved? How could women make GIS a stronger field? How should researchers and policymakers continue to approach the subject of "women in"?

The biggest takeaway for the thesis author is that the details do matter. As some literature suggests, women are not a monolithic group and they should be approached on a more individualized basis (Trauth 2002). Who are the unique women that work in GIS? To that end, the examination of the survey questions presented in Chapter IV includes presenting, analyzing, and discussing the results of the survey population as a whole, in addition to breaking down the survey population using certain filters. Those filters include sector, race/ethnicity, number of years working in GIS, and age groups. Survey responses were filtered to determine whether there was any variation in the data and it was found that, yes, there were potentially meaningful variations. Filtering by the number of years worked in GIS was one such group that produced meaningful and interesting variation. The information that was discovered in both the literature review and in the pilot study, both that women with increasing amounts of professional experience, in general, and

that the first generation of women in GIS, specifically, would have differing experiences and views than newcomers, was confirmed. Additionally, race and ethnicity categories also showed variation that merits additional research. A grand majority of the survey population was white (85%). The sample sizes of other groups, such as black/African American women (2%), were too small to statistically test the significance of responses, however, the results indicate possible differences in responses along race/ethnicity groups. Furthermore, that the GIS field is predominantly white, as reflected by the survey sample, indicates another important conclusion – race and ethnic underrepresentation is also an issue in GIS, perhaps even more so than female underrepresentation.

While some of the results to specific survey questions were unexpected, particularly those attempting to compare GIS to IT, it was encouraging to find that GIS seems like a good field for female participation, with its good work-life balance, strong sense of community, opportunities for networking and mentoring, and importance placed on continuing development.

Another takeaway, related to the above, that was particularly significant to the thesis author, and hopefully can be to other researchers as well, is that exploring gender based challenges goes beyond asking questions about specific, concrete workplace characteristics. While it is important to ask all of the questions included in this thesis, including such questions as, "Are you required to work long hours," or "Does your workplace offer flexible work arrangements," and so on, the answers to these questions may not lead to conclusive results. For example, it was found that women in GIS seem to enjoy good overall workplace conditions (in relation to the questions asked in the survey). However, the existence of such conditions does not guarantee that there are no gender-based obstacles. That is, gender-based obstacles might be unknowingly faced, due to the fact that the gender coding of occupations seems to be deeply entrenched and largely invisible.

Therefore, questions such as those examining the hybrid nature of GIS (regarding what types of work women have opportunities to do in GIS) deserve further attention as well.

Lessons learned about the research process:

Conducting the pilot study and the survey were highly rewarding, and the processes encompassing these two activities reflect a unique characteristic of the professional field of GIS. The women who participated in the pilot study were extremely enthusiastic and supportive of the research being proposed. They seemed excited to share their experiences and to learn more about other women in GIS through the results of the survey. The survey dissemination process was also highly successful and gratifying – many women responded directly to the emailed survey invitation and said that they would share it with their colleagues. The enthusiastic social media response to the survey was another surprise. In an online search of the survey title, it was found that many people, men and women alike, had tweeted about it and shared it on other social media platforms. All of these collective efforts led to 484 women completing the survey, which was a far higher amount than anticipated. Additionally, not only did the women answer the "easier" radio button and multiple choice questions, but they gave many lengthy and insightful comments. Many of the survey participants also contacted the thesis author directly to express interest in the results and to share that they thought it was an interesting study. Some of the comments given in the survey spoke about a supportive GIS community, and the experience described here confirmed this.

One of the reasons that such a strong response, in regard to both the number of responses and to the quality of responses, was surprising is that the size and scope of the study were very large. The thesis was inspired by two primary research questions and, through the process of reviewing the literature and conducting the pilot study, nine supplemental research questions were conceived. Each of these nine research questions formed a survey page, and each survey page had a number of

associated survey questions that would go towards answering the corresponding supplemental research questions. This resulted in the creation of a rather lengthy survey. That the women who participated were willing to commit a significant amount of time and energy was significant – and much appreciated.

Beyond the commitment of the survey participants, it was found that the analysis of such a large number of survey questions and the need to synthesize so many lines of thought were challenging. In retrospect, the survey could have been shortened to answer a selection of the supplemental research questions. However, since this was the first dataset of its kind to be created, value was seen in collecting as much information as possible. Since it is hoped that this project is a springboard for further research, creating such a large and varied dataset was important to collect the data, test different ideas, and assess the best approach to collecting high quality data. Future research studies may take a few, or even just one, of the aspects of the current study and further refine the design or delve into it in more depth.

Regarding specific aspects of the current study, and also mentioned in the thesis author's reactions to the results, there is one specific area that would be particularly fruitful for further research, which happens to have been one of the most challenging of the supplemental research question to design, analyze, and interpret – the hybrid nature of GIS, which is also tied to the concepts of vertical and horizontal segregation. The exercise of utilizing the Geospatial Technology Competency Model (GTCM) to come up with categories of GIS competencies that are either "technical" or "soft," in addition to attempting to translate the survey results along the hybrid paradigm, was problematic. The boundary between "soft" and technical skills is difficult to distinguish, possibly in general, and particularly for GIS. Because GIS is such an interdisciplinary field that requires an extremely diverse skillset, it is hard to truly delineate what constitutes a

highly technical role. It is possible that everyone in GIS, including men and highly technical people of both genders, must rely upon "soft" skills. Furthermore, what is technical in GIS? For example, would advanced cartography duties be considered as technical as programming by those outside GIS when using the more traditional definition of "technical" (given that cartography could be associated with design/artistic skills)?

The thesis author recommends further research that compares specific elements of the GTCM, as well as more specific industry/position related tasks and skills, with other models from outside of the GIS world of what constitutes "technical" or "soft" skills. It is necessary to come up with a GIS-specific model of what it means to be technical while at the same time structuring that model in such a way that makes it comparable to other STEM occupations. It would also be beneficial to conduct qualitative research that includes the viewpoints of GIS professionals on what they view as technical, and/or how other "soft" skills they employ might be complementary and necessary to the technical work that they do. Incorporating the perspective of diverse GIS professionals on what constitutes technical GIS work, and how "soft" skills are complementary, would aid in accomplishing researchers' recommendations to avoid having "gendered assumptions about skills and their value" (Roan and Whitehouse 2007, 31). The thesis author suspects that programming, for example, is coded as masculine and might be more valued (in certain contexts) than other aspects of GIS, which may be viewed as technical and highly-valuable in their own right.

C. Broad implications of research

In order to address the primary and supplemental research questions, the thesis author designed an empirical research project to gather original data and then analyze the results in a holistic and cohesive fashion. The hope was not only that the research questions might be answered, but also that the dataset gathered, its analysis, and the lessons learned throughout the research project

would serve as meaningful contributions to diversity discussions within GIS, as well as in other connected fields such as geography and STEM. Parts of this thesis could be published in shorter articles to academic and non-academic readerships to more widely disseminate the information gathered and lessons learned. The thesis could make contributions to career preparation discussions at grade school through university levels, as well as discussions about supporting women in the field.

The value of the original, empirical data that was collected and presented in this thesis goes beyond the thesis itself. Data of its kind had not yet been collected, and thus, in addition to helping explore the research questions central to the thesis, the data represent an important addition to both academic and non-academic GIS realms. The dataset and its analysis are a snapshot of what women's experiences in GIS look like now, and can be used by researchers to explore other related questions, while the design can be copied and modified for similar projects. Additionally, as is mentioned, GIS is not yet overtly included in STEM discussions – perhaps the findings of this thesis will contribute to GIS being explicitly considered, both in regard to diversity and in general, as part of future STEM conversations. Moreover, the data and the thesis findings can make meaningful contributions to diversity in GIS discussions for and by women in GIS.

Appendix A – Pilot Study Interview Questions

1. Preliminary demographic questions:
    a. Age?
    b. Years of professional experience?
    c. Highest formal education?
    d. Do you have any form of certification?
    e. Job title?
    f. Type of organization that you are working for (for example, private company, self-employed, local/regional/state gov/non-profit)?
2. You are a busy person. Why did you give me your time? What interests you in this topic?
3. What do you like about Geographic Information Systems in general or specifically about a Geographic Information Systems related task(s) that is/are part of your job?
    a. (Possible additional question or variation on the above: What areas of Geographic Information Systems or of your job are you most excited about, or are you particularly good at?)
4. Were you formally trained in Geographic Information Systems (either undergrad, grad, certificate)?
    a. If so, did this training aid you in the acquisition of your job and in the actual execution of your tasks?
5. What was looking for a job in GIS like?
    a. Did you face any hurdles/challenges? What were they?
    b. Was it easy? If so, what made it that way?
    c. Was equal opportunity an influential factor (do you feel that it made a difference in being offered the position?)
6. In school or in a GIS work related environment, did/do you have someone that you would consider a mentor?
    a. Can you give examples of how that mentoring worked for you?
7. Are you part of any professional organizations?
8. Do you participate in any female related GIS groups?
    a. If so, why? What do you think their benefit is?
    b. If not, do you think there is any benefit to these kinds of groups?
9. Is networking important to you?
10. Do you think there is an underrepresentation of women in GIS?
    a. If so, do you think there is any benefit of increasing the presence of women (or increasing diversity in general) in the field? What would these benefits be?
    b. If not, is there another group do you think is underrepresented?
11. What is the main question that you have in mind that I should include in my surveys/interviews? And/or do you have a recommendation of who I should interview for the purpose of this study?
12. Would you be interested in a follow-up, results of this work, prefer an executive summary or full thesis?

Appendix B – Survey Invitation

Hello! Apologies for cross posting!

I am conducting a survey for my master's thesis about women who work in Geographic Information Systems professional roles. The project is exploring the representation of women in Geographic Information Systems and the experience of women who already work in the field.

I would like to invite women who are part of this listserv to take this survey. It should take about 30 minutes to complete. I am not collecting any personal information in the survey and IP addresses are not being recorded by the online survey instrument, so your identity will remain completely protected.

The survey asks simple questions about your work history and experience and your opinion of the GIS workspace.

If you are interested and do respond to the survey, it would make a great contribution to my thesis and hopefully deepen the understanding of the experience of women who work in GIS.

To participate, please follow this link: http://www.surveygizmo.com/s3/1688147/Women-in-GIS

Thank you so much for your time and attention!

Sincerely,
Livia Betancourt Mazur
Department of Geography
Hunter College, City University of New York

Appendix C – Chi-Squared Tables

Research Question A: Is GIS similar or dissimilar to IT in terms of its culture and women's experience of it?

Are you required to work long hours?

	yes	**no**	
expected	239.5	239.5	
observed	158	321	
			Ch-sq Test
			9.50102E-14
	yes	**no**	
O-E	-81.5	81.5	
(O-E)^2	6642.25	6642.25	**Ch-sq**
(O-E)^2/E	27.73382	27.73382	**55.46764092**

Does your work have flexible work arrangements (for example, telecommuting, alternative work schedules, etc.)?

	yes	**no**	
expected	238.5	238.5	
observed	361	116	
			Ch-sq Test
			3.33541E-29
	yes	**no**	
O-E	122.5	-122.5	
(O-E)^2	15006.25	15006.25	**Ch-sq**
(O-E)^2/E	62.91928721	62.91928721	**125.838574**

Is there a need to update your GIS skills regularly (i.e., learn new software/methods)?

	yes	**no**	
expected	239	239	
observed	436	42	
			Ch-sq Test
			1.32974E-72
	yes	**no**	
O-E	197	-197	
(O-E)^2	38809	38809	**Ch-sq**
(O-E)^2/E	162.3808	162.3808	**324.7615063**

Do you need to take continuing education courses and/or other trainings to update knowledge?

	yes	**no**	
expected	238.5	238.5	
observed	333	144	
			Ch-sq Test
			4.98494E-18
	yes	**no**	
O-E	94.5	-94.5	
(O-E)^2	8930.25	8930.25	**Ch-sq**
(O-E)^2/E	37.4434	37.4434	**74.88679245**

If there is an imbalanced ratio, with more men, do you feel that there is a male-dominated culture? For example "boys club" type situation? Do you feel excluded in any way from activities?

	yes	**no**	**n/a**	
expected	158.3333333	158.3333333	158.333333	
observed	125	258	92	
				Ch-sq Test
				6.58135E-22
	yes	**no**	**n/a**	
O-E	-33.33333333	99.66666667	-66.333333	
(O-E)^2	1111.111111	9933.444444	4400.11111	**Ch-sq**
(O-E)^2/E	7.01754386	62.73754386	27.7901754	**97.54526316**

Research Question B: Is vertical (and horizontal) segregation as prevalent in GIS as it is in IT and in science professions?

What sector is your position in (state, federal, local government, non-profit, startup, etc.)?

	state	**federal**	**regional**	**local**	**non-profit**	**start-up**	**for profit**	**education**	**other**	
expected	53.2	53.2	53.2	53.2	53.2	53.2	53.2	53.2	53.2	
observed	76	43	5	107	37	11	144	39	17	
										Ch-sq Test
										7.59793E-67
	state	**federal**	**regional**	**local**	**non-profit**	**start-up**	**for profit**	**education**	**other**	
O-E	22.8	-10.2	-48.2	53.8	-16.2	-42.2	90.8	-14.2	-36.2	
(O-E)^2	519.84	104.04	2323.24	2894.44	262.44	1780.84	8244.64	201.64	1310.44	**Ch-sq**
(O-E)^2/E	9.771428571	1.955639098	43.66992 48	54.40676692	4.933082707	33.47443609	154.9744	3.790225564	24.63233083	**331.6083**

How many women and how many men work in GIS departments?
Is there an underrepresentation of women in GIS?

	men	**women**	
expected	5533	5533	
observed	6465	4601	
			Ch-sq Test
			2.96727E-70
	men	**women**	
O-E	932	-932	
(O-E)^2	868624	868624	**Ch-sq**
(O-E)^2/E	156.9897	156.9897	**313.9794**

Do you feel that there are enough women in your department?

	def. not	**prob. not**	**ambivalent**	**prob. yes**	**def. yes**	
expected	92.8	92.8	92.8	92.8	92.8	
observed	60	89	148	101	66	
						Ch-sq Test
						8.33E-11
	def. not	**prob. not**	**ambivalent**	**prob. yes**	**def. yes**	
O-E	-32.8	-3.8	55.2	8.2	-26.8	
(O-E)^2	1075.84	14.44	3047.04	67.24	718.24	**Ch-sq**
(O-E)^2/E	11.59310345	0.155603448	32.8344828	0.724568966	7.739655172	**53.04741379**

Research Question/Purpose C: To gather information that might help in forming and influencing thought on mentoring relationships and networking groups.

If you chose to participate in a formal mentoring program, would you prefer to have a male or female mentor? Why?

	female	**male**	**no pref.**	
expected	159.3333333	159.3333333	159.333333	
observed	86	22	370	
				Ch-sq Test
				3.04182E-94
	female	**male**	**no pref.**	
O-E	-73.33333333	-137.3333333	210.666667	
(O-E)^2	5377.777778	18860.44444	44380.4444	**Ch-sq**
(O-E)^2/E	33.75174338	118.3709902	278.538354	**430.6610879**

Would it be the same for informal mentoring (meaning, would you prefer to network with other females)?

	female	**male**	**no pref.**	**both**	
expected	118.75	118.75	118.75	118.75	
observed	32	8	175	260	
					Ch-sq Test
					5.27767E-78
	female	**male**	**no pref.**	**both**	
O-E	-86.75	-110.75	56.25	141.25	
(O-E)^2	7525.5625	12265.5625	3164.0625	19951.5625	**Ch-sq**
(O-E)^2/E	63.37315789	103.2889474	26.6447368	168.0131579	**361.32**

Female professional groups:

Good (Yes)? Bad (No)?

	yes	**no**	
expected	217	217	
observed	368	66	**Ch-sq Test**
			1.27554E-47
	yes	**no**	
O-E	151	-151	
(O-E)^2	22801	22801	**Ch-sq**
(O-E)^2/E	105.0737327	105.0737327	**210.147465**

Are you part of any female professional groups?

	yes	**no**	
expected	233.5	233.5	
observed	134	333	
			Ch-sq Test
			3.30339E-20
	yes	**no**	
O-E	-99.5	99.5	
(O-E)^2	9900.25	9900.25	**Ch-sq**
(O-E)^2/E	42.3993576	42.3993576	**84.7987152**

Would you like to be?

	yes	**no**	
expected	200	200	
observed	293	107	
			Ch-sq Test
			1.40446E-20
	yes	**no**	
O-E	93	-93	
(O-E)^2	8649	8649	**Ch-sq**
(O-E)^2/E	43.245	43.245	**86.49**

Is your supervisor male (Yes) or female (No)?

	yes	**no**	**n/a**	
expected	159.6666667	159.6666667	159.666667	
observed	336	121	22	
				Ch-sq Test
				8.02616E-71
	yes	**no**	**n/a**	
O-E	176.3333333	-38.66666667	-137.66667	
(O-E)^2	31093.44444	1495.111111	18952.1111	**Ch-sq**
(O-E)^2/E	194.7397356	9.363952679	118.697982	**322.8016701**

Do you feel that you would like to meet other women who work in GIS? Why or why not?

	yes	**no**	
expected	233	233	
observed	406	60	
			Ch-sq Test
			8.12787E-58
	yes	**no**	
O-E	173	-173	
(O-E)^2	29929	29929	**Ch-sq**
(O-E)^2/E	128.4506438	128.4506438	**256.901288**

Have you ever been the only woman in the room (at meetings, events, etc.)? If so, how did that make you feel?

	yes	no	
expected	238	238	
observed	401	74	
			Ch-sq Test
			8.78425E-51
	yes	**no**	
O-E	163	-164	
(O-E)^2	26569	26896	**Ch-sq**
(O-E)^2/E	111.6344538	113.0084034	**224.642857**

Have you ever obtained a job through a personal connection?

	yes	**no**	
expected	230.5	230.5	
observed	245	216	
			Ch-sq Test
			0.176803
	yes	**no**	
O-E	14.5	-14.5	
(O-E)^2	210.25	210.25	**Ch-sq**
(O-E)^2/E	0.912148	0.912148	**1.824295011**

Have you had difficulties finding a mentor?

	yes	**no**	
expected	232.5	232.5	
observed	174	291	
			Ch-sq Test
			5.77133E-08
	yes	**no**	
O-E	-58.5	58.5	
(O-E)^2	3422.25	3422.25	**Ch-sq**
(O-E)^2/E	14.71935484	14.71935484	**29.4387097**

Research Question E: Pipelines to GIS

Did you ever have a GIS internship?

	yes	**no**	**n/a**	
expected	157.3333333	157.3333333	157.333333	
observed	224	236	12	
				Ch-sq Test
				1.48957E-44
	yes	**no**	**n/a**	
O-E	66.66666667	78.66666667	-145.33333	
(O-E)^2	4444.444444	6188.444444	21121.7778	**Ch-sq**
(O-E)^2/E	28.24858757	39.33333333	134.248588	**201.8305085**

If so, did that internship lead to a full-time position?

	yes	**no**	**n/a**	
expected	136	136	136	
observed	92	124	192	
				Ch-sq Test
				4.6964E-09
	yes	**no**	**n/a**	
O-E	-44	-12	56	
(O-E)^2	1936	144	3136	**Ch-sq**
(O-E)^2/E	14.23529412	1.058823529	23.0588235	**38.35294118**

Research Question F: Does the number of years in the GIS field have any bearing on the results of the survey questions?

Do you think there is an underrepresentation of women in GIS?

	yes	**no**	
expected	236	236	
observed	300	172	
			Ch-sq Test
			3.82295E-09
	yes	**no**	
O-E	64	-64	
(O-E)^2	4096	4096	**Ch-sq**
(O-E)^2/E	17.3559322	17.3559322	**34.7118644**

Do women face bias as GIS professionals?

	yes	**no**	
expected	236.5	236.5	
observed	229	244	
			Ch-sq Test
			0.490382404
	yes	**no**	
O-E	-7.5	7.5	
(O-E)^2	56.25	56.25	**Ch-sq**
(O-E)^2/E	0.237843552	0.237843552	**0.4756871**

Is this bias unique to GIS (Yes) or is it more general (No)?

	yes	**no**	**n/a**	
expected	154.6666667	154.6666667	154.666667	
observed	26	320	118	
				Ch-sq Test
				3.10399E-64
	yes	**no**	**n/a**	
O-E	-128.6666667	165.3333333	-36.666667	
(O-E)^2	16555.11111	27335.11111	1344.44444	**Ch-sq**
(O-E)^2/E	107.0373563	176.7356322	8.69252874	**292.4655172**

Was getting to where you are in your career easy (Yes) or difficult (No)?

	yes	**no**	
expected	206	206	
observed	190	222	
			Ch-sq Test
			0.114904437
	yes	**no**	
O-E	-16	16	
(O-E)^2	256	256	**Ch-sq**
(O-E)^2/E	1.242718447	1.242718447	**2.48543689**

Do you view attaining the next step in your career as having challenges?

	yes	**no**	
expected	234	234	
observed	385	83	
			Ch-sq Test
			2.73607E-44
	yes	**no**	
O-E	151	-151	
(O-E)^2	22801	22801	**Ch-sq**
(O-E)^2/E	97.44017094	97.44017094	**194.880342**

Does your gender play a role in what you view those challenges to be?

	yes	**no**	
expected	231.5	231.5	
observed	184	279	
			Ch-sq Test
			1.00999E-05
	yes	**no**	
O-E	-47.5	47.5	
(O-E)^2	2256.25	2256.25	**Ch-sq**
(O-E)^2/E	9.746220302	9.746220302	**19.4924406**

Research Question/Purpose G: Exploration of factors relating to work-life balance.

Is work-life balance an important characteristic of a job? How important is it to you?

	not important	neutral	important	very important	
expected	118.5	118.5	118.5	118.5	
observed	3	24	142	305	
					Ch-sq Test
					4.8639E-105
	not important	**neutral**	**important**	**very important**	
O-E	-115.5	-94.5	23.5	186.5	
(O-E)^2	13340.25	8930.25	552.25	34782.25	**Ch-sq**
(O-E)^2/E	112.5759494	75.36075949	4.66033755	293.521097	**486.1181435**

Would you say that in your current job you have a good level of work-life balance?

	definitely!	yes, but could be better	a little	not at all	i don't know/care	
expected	95	95	95	95	95	
observed	186	187	62	38	2	
						Ch-sq Test
						1.73E-66
	definitely!	**yes, but could be better**	**a little**	**not at all**	**i don't know/care**	
O-E	91	92	-33	-57	-93	
(O-E)^2	8281	8464	1089	3249	8649	**Ch-sq**
(O-E)^2/E	87.16842105	89.09473684	11.4631579	34.2	91.04210526	**312.9684211**

Are work-family issues more relevant to women than to men?

	yes	no	
expected	235.5	235.5	
observed	317	154	
			Ch-sq Test
			5.88374E-14
	yes	**no**	
O-E	81.5	-81.5	
(O-E)^2	6642.25	6642.25	**Ch-sq**
(O-E)^2/E	28.20488323	28.20488323	**56.4097665**

Do you think that women are more responsible (than men) for caring for children and elderly family members?

	yes	**no**	
expected	236.5	236.5	
observed	369	104	
			Ch-sq Test
			3.74971E-34
	yes	**no**	
O-E	132.5	-132.5	
(O-E)^2	17556.25	17556.25	**Ch-sq**
(O-E)^2/E	74.23361522	74.23361522	**148.46723**

Do you think more policies should be implemented geared specifically towards women that would allow for better work-family balance?

	yes	**no**	
expected	232.5	232.5	
observed	239	226	
			Ch-sq Test
			0.546601452
	yes	**no**	
O-E	6.5	-6.5	
(O-E)^2	42.25	42.25	**Ch-sq**
(O-E)^2/E	0.18172043	0.18172043	**0.36344086**

Is work-life and work-family an issue for men and women alike?

	yes	**no**	
expected	236.5	236.5	
observed	359	114	
			Ch-sq Test
			1.95104E-29
	yes	**no**	
O-E	122.5	-122.5	
(O-E)^2	15006.25	15006.25	**Ch-sq**
(O-E)^2/E	63.45137421	63.45137421	**126.902748**

Do you feel that gearing work-family policies with women in mind alienates women?

	yes	**no**	
expected	232	232	
observed	306	158	
			Ch-sq Test
			6.38753E-12
	yes	**no**	
O-E	74	-74	
(O-E)^2	5476	5476	**Ch-sq**
(O-E)^2/E	23.60344828	23.60344828	**47.2068966**

If your company does have flexible work arrangements available, do you avail yourself of them?

	yes	**no**	
expected	220.5	220.5	
observed	339	102	
			Ch-sq Test
			1.54382E-29
	yes	**no**	
O-E	118.5	-118.5	
(O-E)^2	14042.25	14042.25	**Ch-sq**
(O-E)^2/E	63.68367347	63.68367347	**127.367347**

Do you feel comfortable doing so?

	yes	**no**	
expected	169	169	
observed	286	52	
			Ch-sq Test
			4.13703E-37
	yes	**no**	
O-E	117	-117	
(O-E)^2	13689	13689	**Ch-sq**
(O-E)^2/E	81	81	**162**

Research Question/Purpose H: The collection of demographic information.

Race/ethnicity

	Hispanic/ Latino	**Black or African American**	**White**	**Asian**	**American Indian or Alaska Native**	**Native Hawaiian or Other Pacific Islander**	
expected	73.16666667	73.16666667	73.16667	73.16666667	73.16666667	73.1666667	
observed	24	8	374	26	4	3	
							Ch-sq Test
							0
	Black or African American	**White**	**Asian**	**American Indian or Alaska Native**	**Native Hawaiian or Other Pacific Islander**	**Hispanic/ Latino**	
O-E	-49.16666667	-65.1666667	300.8333	-47.16666667	-69.16666667	-70.1666667	
(O-E)^2	2417.361111	4246.694444	90500.69	2224.694444	4784.027778	4923.36111	**Ch-sq**
(O-E)^2/E	33.03910402	58.04138193	1236.912	30.40584662	65.38534548	67.2896735	1491.072893

Age

	21-30	**31-40**	**41-50**	**51-60**	**61-70**	
expected	93	93	93	93	93	
observed	121	184	94	56	10	
						Ch-sq Test
						3.34E-39
	21-30	**31-40**	**41-50**	**51-60**	**61-70**	
O-E	28	91	1	-37	-83	
(O-E)^2	784	8281	1	1369	6889	**Ch-sq**
(O-E)^2/E	8.430107527	89.04301	0.0107527	14.72043	74.07527	**186.2795699**

Research Question I: Is continuing education an important aspect of enhancing GIS careers that is both encouraged by employers and that is taken advantage of by women? Are women GIS professionals being given opportunities to get the knowledge and training that they need?

Do you feel that taking continuing education classes is necessary to your current work?

	yes	**no**	
expected	235.5	235.5	
observed	386	85	
			Ch-sq Test
			9.7156E-44
	yes	**no**	
O-E	150.5	-150.5	
(O-E)^2	22650.25	22650.25	**Ch-sq**
(O-E)^2/E	96.17940552	96.17940552	**192.358811**

Do you feel that taking continuing education classes would be necessary to obtaining a different position?

	yes	**no**	
expected	234.5	234.5	
observed	371	98	
			Ch-sq Test
			1.95752E-36
	yes	**no**	
O-E	136.5	-136.5	
(O-E)^2	18632.25	18632.25	**Ch-sq**
(O-E)^2/E	79.45522388	79.45522388	**158.910448**

On-the-job learning related questions:

Does your position have many learning opportunities?

	yes	**no**	
expected	236	236	
observed	358	114	
			Ch-sq Test
			2.87176E-29
	yes	**no**	
O-E	122	-122	
(O-E)^2	14884	14884	**Ch-sq**
(O-E)^2/E	63.06779661	63.06779661	**126.135593**

Are you required to accomplish tasks that push you to learn new things?

	yes	**no**	
expected	236.5	236.5	
observed	401	72	
			Ch-sq Test
			1.06775E-51
	yes	**no**	
O-E	164.5	-164.5	
(O-E)^2	27060.25	27060.25	**Ch-sq**
(O-E)^2/E	114.4196617	114.4196617	**228.839323**

If so, do you enjoy that aspect or is it a hardship?

	yes	**no**	
expected	213	213	
observed	388	38	
			Ch-sq Test
			1.6924E-64
	yes	**no**	
O-E	175	-175	
(O-E)^2	30625	30625	**Ch-sq**
(O-E)^2/E	143.7793427	143.7793427	**287.558685**

Research Question J: Is putting the word "Women" in front of "GIS" to come up with the phrase "Women in GIS" wrong?

The term "Women in GIS" is a good way to categorize, or describe, women who work in GIS (Strongly agree, disagree, etc.)

	strongly disagree	**disagree**	**neutral**	**agree**	**strongly agree**	
expected	94.8	94.8	94.8	94.8	94.8	
observed	40	87	194	126	27	
						Ch-sq Test
						4.73E-41
	strongly disagree	**disagree**	**neutral**	**agree**	**strongly agree**	
O-E	-54.8	-7.8	99.2	31.2	-67.8	
(O-E)^2	3003.04	60.84	9840.64	973.44	4596.84	**Ch-sq**
(O-E)^2/E	31.67763713	0.641772152	103.804219	10.26835443	48.48987342	**194.8818565**

The term "Women in GIS" is not a good thing – it separates and alienates women who work in GIS from men.

	strongly disagree	**disagree**	**neutral**	**agree**	**strongly agree**	
expected	94.2	94.2	94.2	94.2	94.2	
observed	23	90	185	129	44	
						Ch-sq Test
						4.26E-38
	strongly disagree	**disagree**	**neutral**	**agree**	**strongly agree**	
O-E	-71.2	-4.2	90.8	34.8	-50.2	
(O-E)^2	5069.44	17.64	8244.64	1211.04	2520.04	**Ch-sq**
(O-E)^2/E	53.81571125	0.187261146	87.5227176	12.85605096	26.75201699	**181.133758**

You identify yourself as a (if you had to pick one): (a) "woman in GIS" (b) GIS professional (no gender)

	woman…	**no gender**	
expected	238	238	
observed	29	447	
			Ch-sq Test
			8.14248E-82
	woman…	**no gender**	
O-E	-209	209	
(O-E)^2	43681	43681	**Ch-sq**
(O-E)^2/E	183.5336134	183.5336134	**367.067227**

References

Adam, Alison, Marie Griffiths, Claire Keogh, Karenza Moore, Helen Richardson, and Angela Tattersall. 2006. "Being an 'it' in IT: Gendered Identities in IT Work." *European Journal of Information Systems* 15 (4): 368–378. doi: 10.1057/palgrave.ejis.3000631.

Ahuja, M K. 2002. "Women in the Information Technology Profession: A Literature Review, Synthesis and Research Agenda." *European Journal of Information Systems* 11 (1): 20–34. doi: 10.1057/palgrave/ejis/3000417.

Bastalich, Wendy, Suzanne Franzway, Judith Gill, Julie Mills, and Rhonda Sharp. 2007. "Disrupting Masculinities: Women Engineers and Engineering Workplace Culture." *Australian Feminist Studies* 22 (54): 385–400. doi: 10.1080/08164640701578765.

Beede, David N., Tiffany A. Julian, David Langdon, George McKittrick, Beethika Khan, and Mark E. Doms. 2011. "Women in STEM: A Gender Gap to Innovation." *Economics and Statistics Administration Issue Brief*. http://files.eric.ed.gov.proxy.wexler.hunter.cuny.edu/fulltext/ED523766.pdf

Blickenstaff, Jacob Clark. 2005. "Women and Science Careers: Leaky Pipeline or Gender Filter?" *Gender and Education* 17 (4): 369–386. doi: 10.1080/09540250500145072.

Bury, Rhiannon. 2010. "Women, Work and Web 2.0: A Case Study." *New Technology, Work and Employment* 25 (3): 223–237. doi:10.1111/j.1468-005X.2010.00250.x.

Castaño, Cecilia, and Juliet Webster. 2011. "Understanding Women' S Presence in ICT : The Life Course Perspective." *The International Journal of Gender, Science and Technology* 3 (2): 364–386. http://genderandset.open.ac.uk/index.php/genderandset/article/viewFile/168/333

Cech, Erin A, and Mary Blair-Loy. 2010. "Perceiving Glass Ceilings? Meritocratic versus Structural Explanations of Gender Inequality among Women in Science and Technology." *Social Problems* 57 (3): 371–397. doi: 10.1525/sp.2010.57.3.371.SP5703.

Charmaz, Kathy. 2008. "Grounded Theory." In *Qualitative Psychology: A Practical Guide to Research Methods*, edited by Jonathan A. Smith, 81-110. London: SAGE Publications, Ltd.

Cheryan, Sapna, John Oliver Siy, Marissa Vichayapai, Benjamin J. Drury, and Saenam Kim. 2011. "Do Female and Male Role Models Who Embody STEM Stereotypes Hinder Women's Anticipated Success in STEM?" *Social Psychological and Personality Science* 2 (6): 656-664. doi:10.1177/1948550611405218

Cross, Christine, and Margaret Linehan. 2006. "Barriers to Advancing Female Careers in the High-Tech Sector: Empirical Evidence from Ireland." *Women in Management Review* 21 (1): 28–39. doi: 10.1108/09649420610643394.

Department of Labor. 2013. "Computer and Information Technology Occupations." Accessed June 9, 2015. http://www.dol.gov/wb/stats/Computer-information-technology.htm

Department of Labor. 2014. "Highest and Lowest Paying Occupations." Accessed June 9, 2015. http://www.dol.gov/wb/stats/highest_lowest_paying-occupations_2014.htm

Department of Labor. 2014. "Latest Annual Data." Accessed May 6, 2015. http://www.dol.gov/wb/stats/latest_annual_data.htm

Department of Labor. 2014. "Traditional (Female-Dominated) Occupations, 2014 Annual Averages." Accessed June 10, 2015. http://www.dol.gov/wb/stats/TraditionalOccupations.pdf

Domosh, Mona. 2000. "Focus Section: Women in Geography in the 21st Century: Unintentional Transgressions and Other Reflections on the Job Search Process." *The Professional Geographer* 52 (4): 703–708. doi:10.1080/00330124.2000.9628417.

Elwood, Sarah. 2008. "Volunteered Geographic Information: Future Research Directions Motivated by Critical, Participatory, and Feminist GIS." *GeoJournal* 72 (3-4): 173–183. doi:10.1007/s10708-008-9186-0.

George, Yolanda S., David S. Neale, Virginia Van Horne, and Shirley M. Malcom. 2001. "In Pursuit of a Diverse Science, Technology, Engineering and Mathematics Workforce: Recommended Research Priorities to Enhance Participation by Underrepresented Minorities." http://www.aaas.org/.

Gilbert, Melissa, and Michele Masucci. 1999. "Moving Beyond 'Gender and GIS ' to a Feminist Perspective on Information Technologies: The Impact of Welfare Reform on Women's IT Needs." In *A Companion to Feminist Geography*, edited by Lise Nelson and Joni Seager, 305–321. Massachusetts: Blackwell Publishing.

Glover, Judith. 2002. "Women and Scientific Employment: Current Perspectives from the UK." *Science Studies* 15 (1): 29–45. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.488.4614&rep=rep1&type=pdf

Guerrier, Yvonne, Christina Evans, Judith Glover, and Cornelia Wilson. 2009. "'Technical, but Not Very...': Constructing Gendered Identities in IT-Related Employment." *Work, Employment & Society* 23 (3): 494–511. doi: 10.1177/0950017009337072.

Guthrie, Ruth, Louise Soe, and Elaine Yakura. 2009. "Support Structures for Women in Information Technology Careers." *International Journal of E-Politics*, *2*(1), 30–44. doi:10.4018/jep.2011010103

Heilbronner, Nancy N. (2012). "The STEM Pathway for Women: What Has Changed?" *Gifted Child Quarterly*. doi:10.1177/0016986212460085

Hewlett, Sylvia A., and Carolyn Buck Luce. 2005. "Off-Ramps and On-Ramps: Keeping Talented Women on the Road to Success." *Harvard Business Review OnPoint Article*, 1–12. http://www.hbrp.pl/biblioteka/hmm/retaining_employees/resources/9416.pdf

Hill, Catherine, Christianne Corbett, and Andresse St Rose. 2010. "Why so few? Women in Science, Technology, Engineering, and Mathematics." American Association of University Women. 1111 Sixteenth Street NW, Washington, DC 20036.

Klawe, Maria, Telle Whitney, and Caroline Simard. 2009. "Women in Computing – Take 2." *Communications of the ACM*, 52 (2): 68-76. doi:10.1007/s00415-011-5991-3

Kohlstedt, Sally Gregory. 2004. "Sustaining Gains: Reflections on Women in Science and Technology in 20th-Century United States." *NWSA Journal* 16 (1): 1–26.

Kwan, Mei-Po. 2002. "Is GIS for Women? Reflections on the Critical Discourse in the 1990s." *Gender, Place and Culture* 9 (3): 271–279. doi: 10.1080/096636902200000388.

Landivar, Liana Christin. 2013. "Disparities in STEM Employment by Sex, Race, and Hispanic Origin." *American Community Survey Reports*. http://www.census.gov/prod/2013pubs/acs-24.pdf.

Mcewen, Lindsey, Janice Monk, Iain Hay, Pauline Kneale, and Helen King. 2008. "Strength in Diversity: Enhancing Learning in Vocationally-Orientated, Master's Level Courses." *Journal of Geography in Higher Education*, 32 (1): 101-119.

National Center for Women and Information Technology. 2013. "Did You Know: Demographics on Technical Women." Accessed July 4, 2015. https://www.ncwit.org/blog/did-you-know-demographics-technical-women

National Science Foundation, National Center for Science and Engineering Statistics. 2013. "Women, Minorities, and Persons with Disabilities in Science and Engineering: 2013 (Short)." http://www.nsf.gov/statistics/wmpd/2013/pdf/nsf13304_digest.pdf.

Nosek, Brian A., Mahzarin R. Banaji, and Anthony G. Greenwald. 2002. "Math= Male, Me= Female, Therefore Math≠ Me." *Journal of Personality and Social Psychology* 83, (1): 44.

Orser, Barbara, Allan Riding, and Joanne Stanley. 2012. "Perceived Career Challenges and Response Strategies of Women in the Advanced Technology Sector." *Entrepreneurship & Regional Development*, 24 (1-2): 73-93. doi:10.1080/08985626.2012.637355

Pavlovskaya, Marianna. 2009. "Non-quantitative GIS." In *Qualitative GIS: A Mixed Methods Approach*, edited by Meghan Cope and Sarah Elwood, 13-37. London: SAGE Publications, Ltd.

Pavlovskaya, Marianna, and Kevin St. Martin. 2007. "Feminism and Geographic Information Systems: From a Missing Object to a Mapping Subject." *Geography Compass* 1 (3): 583–606. doi: 10.1111/j.1749-8198.2007.00028.x.

Prescott, Julie, and Jan Bogg. 2011. "Segregation in a Male-Dominated Industry: Women Working in ihe Computer Games Industry." *International Journal of Gender, Science and Technology*, 3 (1): 1–23.

Roan, Amanda, and Gillian Whitehouse. 2007. "Women, Information Technology and 'Waves of Optimism': Australian Evidence on 'Mixed-Skill' Jobs." *New Technology, Work and Employment* 22 (1): 21–33. doi: 10.1111/j.1468-005X.2007.00181.x.

Rosenbloom, Joshua L., Ronald a. Ash, Brandon Dupont, and LeAnne Coder. 2008. "Why Are There so Few Women in Information Technology? Assessing the Role of Personality in Career Choices." *Journal of Economic Psychology* 29 (4): 543–554. doi: 10.1016/j.joep.2007.09.005.

Schuurman, Nadine. 2002. "Women and Technology in Geography: A Cyborg Manifesto for GIS." *The Canadian Geographer, Focus: Equity for Women in Geography* 46 (3): 258–265.

Silva, Joseli Maria. 2010. "On Not Excluding Half of the Human in Human Geography: Interview with Janice Monk." *Revista Latino-Americana de Geografia E Genero,* 1 (1): 153–156. doi:10.5212/Rlagg.v.1.i1.153156.

Singh, Kusum, Katherine R. Allen, Rebecca Scheckler, and Lisa Darlington. 2007. "Women in Computer-Related Majors: A Critical Synthesis of Research and Theory from 1994 to 2005." *Review of Educational Research* 77 (4): 500–533. doi: 10.3102/0034654307309919.

Solís, Patricia, Joy K. Adams, Leslie a. Duram, Susan Hume, Al Kuslikis, Victoria Lawson, Ines M. Miyares, David a. Padgett, and Alexander Ramírez. 2014. "Diverse Experiences in Diversity at the Geography Department Scale." *The Professional Geographer* 66 (2): 205–220. doi:10.1080/00330124.2012.735940. http://www.tandfonline.com/doi/abs/10.1080/00330124.2012.735940.

Solís, Patricia, and Ines M. Miyares. 2013. "Introduction: Rethinking Practices for Enhancing Diversity in the Discipline." *The Professional Geographer* 66 (2): 169–172. doi:10.1080/00330124.2012.735920. http://www.tandfonline.com/doi/abs/10.1080/00330124.2012.735920.

Sonnert, Gerhard. 1999. "Women in Science and Engineering: Advances, Challenges, and Solutions." *Annals of the New York Academy of Sciences* 869 (1): 34–57. doi: 10.1111/j.1749-6632.1999.tb08353.x.

Tapia, Andrea H., and Lynette Kvasny. 2004. "Recruitment Is Never Enough: Retention of Women and Minorities in the IT Workplace." In *Proceedings of the 2004 SIGMIS Conference on Computer Personnel Research: Careers, Culture, and Ethics in a Networked Environment*, ACM: 84–91.

Trauth, Eileen M. 2002. "Odd Girl out: An Individual Differences Perspective on Women in the IT Profession." *Information Technology & People* 15 (2): 98–118. doi: 10.1108/09593840210430552.

Turner, Sandra V., Phyllis W. Bernt, and Norma Pecora. 2002. "Why Women Choose Information Technology Careers: Educational, Social, and Familial Influences." Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans, Louisiana, April 2002.

Ullman, Ellen. 2013. "How to Be a 'Woman Programmer.'" *The New York Times*, May 18. http://www.nytimes.com/2013/05/19/opinion/sunday/how-to-be-a-woman-programmer.html?_r=0.

Watts, Jacqueline H. 2009. "'Allowed into a Man's World' Meanings of Work-Life Balance: Perspectives of Women Civil Engineers as 'Minority' Workers in Construction." *Gender, Work & Organization* 16 (1) (January): 37–57. doi: 10.1111/j.1468-0432.2007.00352.x.

Wentling, Rose Mary, and Steven Thomas. 2009. "Workplace Culture That Hinders and Assists the Career Development of Women in Information Technology." *Information Technology, Learning, and Performance Journal* 25 (1): 25–42.

Xu, Yonghong Jade. 2008. "Gender Disparity in STEM Disciplines: A Study of Faculty Attrition and Turnover Intentions." *Research in Higher Education* 49, (7): 607-624.

Zeldin, Amy L., Shari L. Britner, and Frank Pajares. 2008. "A Comparative Study of the Self-Efficacy Beliefs of Successful Men and Women in Mathematics, Science, and Technology Careers." *Journal of Research in Science Teaching* 45, (9): 1036-1058.