Spring 2019

Computing the Role that Women Hold in the Technology and Computing Fields

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COMPUTING THE ROLE THAT WOMEN HOLD IN THE TECHNOLOGY AND COMPUTING FIELDS

by

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(Under the Direction of Elizabeth Rasnick)

ABSTRACT

This research was conducted as a thesis project to study what roles women have played in information technology over time, how those roles have changed over time, and what caused those roles to change. It was also to study how personal life experiences may have affected their roles and careers in the technology field. Influential women in IT of the past were studied and compared to determine any common factors between them.

INDEX WORDS: Information technology, Women in STEM, Technology, Women, Programming, Women in technology, STEM, Computing, Women in the workforce, Grace Hopper, Katherine Johnson, Jean Jennings Bartik, Ada Lovelace, Women in IT

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B.S., Georgia Institute of Technology, 2014

A Thesis Submitted to the Graduate Faculty of Georgia Southern University

in Partial Fulfillment of the Requirements for the Degree

MASTER OF SCIENCE

STATESBORO, GEORGIA

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Electronic Version Approved:
May 2019

DEDICATION

I would like to dedicate this thesis to my mother. When I first started my undergraduate degree and had to pick a major, she inspired me to try Information Technology. She has since been a huge supporter, inspiration, and mentor along my journey. I wouldn’t be where I am today without her.

ACKNOWLEDGMENTS

I would like to acknowledge my family for their support in my studies. My mother was a huge help when it came time to bounce ideas around with, and she inspired my topic. My husband has been a huge supporter since the beginning, and has helped me keep all the pieces together along the way.

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CHAPTER 1

INTRODUCTION

Motivation for this Research

As a child, I was fortunate enough to grow up around computers. Both my mother and my father frequently used the family computer, and both were adept and skilled with technology. As I grew older, I used the computer frequently for various activities, such as to play games, browse the internet, and do school assignments. It was a big part of my life. When I began my undergraduate career and took my first Information Technology class, it felt natural to me. As I went into my upper level IT classes, I noticed there were less women in my classes, but I thought nothing of it. After graduation, I began my career in the IT industry. I had several jobs at various companies, and again, I noticed that I was one of few, or sometimes the only women in the room. It never bothered me, as I was confident in my abilities, but it began to raise some questions in my mind. At this point in my career, I've faired acceptably when it comes to how I'm treated in the industry, and how I'm respected, but even in today's times, I've still had several interactions with male coworkers where my advisement or opinion has been brushed aside and not trusted until the exact same opinion was stated by a fellow male teammate. Interactions like those were one of the key motivators for wanting to do more research on women in IT and how they've been treated.

I became intrigued about how women in IT have fared historically after reading an article about Grace Hopper, and seeing a movie film based on the career of Katherine Johnson. My eyes were opened to two very inspirational women who played huge roles in society and in IT, and to the fact that I had never even heard of them previously. It sparked an interest into how big of an impact women have made in the early days of computing and what kind of roles they played in key historical events. As I got deeper into my research, I began to wonder why we don't often hear of important women in IT history, even though there are historical events where women were the backbone of everything. Why are they being brushed over?

I then began to question why there seems to be a lack of women in the IT industry today. What is causing women to join the tech industry and then leave, or to not join the industry at all? What kind of influence does society have on this, or does it have much of an influence at all anymore? I also began to think about the possibility of common factors between women in tech, such as personality and upbringing. If there are any commonalities amongst women today, are they comparable to the factors that may be relevant to key IT women in the past?

Purpose of the Study

The purpose of this study is to learn about how much influence women played in the development and growth of information technology. It should also help us to better understand how a woman's personal life and upbringing may affect her career path in IT, and how much society plays a role in affecting her decision to stay in the industry or to leave. I also wanted to see how much these factors may have changed from the past to now.

Research Methodology

When conducting my research for this paper, I decided to research four influential IT women of the past. I chose these four women because I wanted to study several histories from women in different situations, and compare their experiences and beginnings to determine if there are any common factors between them. I conducted literature reviews to learn about the historical women, and to learn about their upbringing and their start into the world of technology, as well as their impact on it long-term. I then investigated the current status of women in the IT industry. I also took the time to research how the role of women in the industry has changed over time. I wanted to learn what influences affected how we see women in information technology positions today, versus how they were viewed in the past.

CHAPTER 2

SOCIETY'S INFLUECNCE

Historical Impact of Women in IT

When discussing the history of women in computing, Faruk Ateş said it well in his 2017 article: "Women invented the field. Then men pushed them out of it." With many programming or IT classes, students usually only learn the code or its uses. If any history behind the topic is given, it is usually brief or glossed over. It is something that isn't often taught in depth in IT or computing classes. But when it is taught, a key piece of information is left out: women were literally the mothers to the modern-day computing industry. A woman invented the first user-friendly computer program. Multiple women worked to make sure NASA's computers were accurate in the early days of space travel. Six women developed the foundations of software programming, but were not even invited to the celebratory dinner.[1] How did we go from a time where women were the innovators and drivers behind this industry to a time where we don't even talk about who started it all?

According to Janet Abbate, a lot of the reasoning behind why we don't often hear about women in the industry historically is because history focuses more on the hardware. Women of the time did not tend to have access to training or resources in order to build the hardware of the machines, like men did. During World War II, men designed and built the hardware of the first electronic digital computers, while women performed much of the hand-calculations and played the role of programmers and analysts.[2] An early job title that was given to the women performing these calculations was "computer", as they were "computing" the calculations. Elizabeth Phillips Williams played the role of a systems analyst in 1943,

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[1] Faruk Ateş, "A Brief History of Women in Computing – Hacker Noon," Hacker Noon, August 09, 2017, , accessed November 24, 2018, https://hackernoon.com/a-brief-history-of-women-in-computing-e7253ac24306.

[2] Janet Abbate, "Women and Gender in the History of Computing," *IEEE Annals of the History of Computing* 25, no. 4 (2003): 4, accessed January 02, 2019, doi:10.1109/mahc.2003.1253885.

after applying for a job that was posted because men the company wanted to hire had all gone to war.[3] She details in her writing how she was trained in a "paperwork simplification technique" that charted the way data would flow through an organization, and a device that pre-printed consecutive numbering on business forms. The forms were useful in improving companies' communication by eliminating duplicate or lost information from multiple departments' forms, and instead keeping track of company information on one set of continuous, carbon-copied forms. Elizabeth's job as a systems analyst involved helping to solve customer problems at company plants where department heads were not yet used to the new forms, and to document and analyze the flow of paperwork there.[4] These were the early days of flowcharts. She was being trained to prepare for the "age of automation" that was to come.

After the war, when men returned home, Elizabeth recalls how she was skilled enough now to train the former soldiers on how to do the job she had been doing for years. Her customers started hiring the male analysts over the female ones, and the men were quickly advanced up the career latter before they were completely familiar in the work.[5] In her opinion, the men were using the job as a "stepping stone" to a job they thought was better. I personally find this interesting, as these men were coming home to fill these empty roles that required time, analysis, and dedication, but then they were quickly moving on to another job that they deemed to be better. Could it have been because they lacked the skills of patience and precision that was often required for the job?[6] Or could it perhaps have been that these jobs were considered to be for women and therefore they needed something better?

Around this same time, many universities and schools began to offer computer science degrees and develop computer science departments, as well as offering isolated computing classes. Those who completed these new programs were able to stay informed of new computing concepts as the network

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[3] Elizabeth Phillips Williams, "A Systems Analysts Computer Watch: 1943-2003," *IEEE Annals of the History of Computing* 25, no. 4 (2003): 27, accessed January 06, 2019, doi:10.1109/mahc.2003.1253888.

[4] Williams, "A Systems Analysts Computer Watch: 1943-2003," 28.

[5] Williams, "A Systems Analysts Computer Watch: 1943-2003," 33.

[6] Vardi, Moshe Y. "How We Lost the Women in Computing." *Communications of the ACM* 61, no. 5 (May 24, 2018): 9. Accessed September 25, 2018. doi:10.1145/3201113.

circles of alumni grew.[7] Due to various laws and social constructs of the time, the kinds of training or instruction that women could receive were much more limited than they were for men. It was often the case that women working as computers did not receive formal training in computing, and also did not directly enter the computing industry when they started working.[8] This new option of formal training could perhaps be a contributing factor to why men started delving into the world that women had dominated for so long.

Elizabeth eventually left her consulting role and ended up at a boat company as the highest paid woman there, but with a lower salary than the men. In the early 1960's, after six years of working there, she was set to present an in-depth proposal to the company upper management when there was a management change. The first thing her new boss did was the cut up her proposal, and then tell her that no lady should be working in a shipyard. Soon after, things changed quickly, and the company was filled with men who were working on learning how to use computers for the company's procedures. The current systems analysts were given non-systems work to do, which was ultimately why Elizabeth ended up leaving for good.[9] This makes me question why the company did not use existing resources and systems analysts to work on their new computers, and why they decided to bring in new men to learn them instead of training the long-time employees. Men in computing had started to move on from hardware and were beginning to investigate the software and analytics work that female computers had been doing for years.

Role Development Over Time

In the late 1960's, after decades of computing being accepted as "women's work" because of their patience and their ability to handle detail, similar to planning a dinner, computer programming was becoming a more respected industry, and the pay for a job in the computing industry increased. Men were

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[7] Abbate, "Women and Gender in the History of Computing," 6.

[8] Abbate, "Women and Gender in the History of Computing," 7.

[9] Williams, "A Systems Analysts Computer Watch: 1943-2003," 37-38.

beginning to learn more about programming and how it worked, and because jobs in the field were paying well, it must be prestigious. They wanted to be a part of it. Smear campaigns began to circulate in advertisements with the intention of discouraging the hiring of women for these computer and programming positions. [10] [11] They portrayed female computers as inefficient and prone to make errors, and were also depicted to be physically unattractive, plain, and dependent on her mother to make decisions. A series of ads claimed machines could do anything keypunch operators could do, but without gossiping, crying, suffering from morning sickness, or complaining. While there were also some positive portrayals of women in other advertisements, sexist ads persisted, and continued to push the mindset that women did not belong there.[12]

Professional associations were also created to push more educational requirements for the career. Aptitude, puzzle, and personality tests that favored men were created, circulated, and used by companies as a way to find the "ideal" programmer.[13] These tests perpetuated the modern-day stereotypical image of the awkward, nerdy, antisocial male "nerd" that we perceive to be computer programmers, and thus eliminated the reality that women were a key part in the foundation to this field, and the ones who built it from the ground up.

The smear campaigns of the 1960's proved to be successful in masculinizing the computer industry. However, in 1975, editorial directions changed and began to publish sympathy pieces that examined issues and bias that women faced in the programming industry. The negativity of the 60's

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[10] Rose Eveleth, "Computer Programming Used To Be Women's Work," Smithsonian.com, October 07, 2013, , accessed January 24, 2019, https://www.smithsonianmag.com/smart-news/computer-programming-used-to-be-womens-work-718061/.

[11] Ateş, "A Brief History of Women in Computing – Hacker Noon,".

[12] William F. Vogel, ""The Spitting Image of a Woman Programmer": Changing Portrayals of Women in the American Computing Industry, 1958-1985," *IEEE Annals of the History of Computing* 39, no. 2 (2017): 51-52, accessed October 22, 2018, doi:10.1109/mahc.2017.14.

[13] Chava Shapiro, "Women Used To Dominate Tech... Until They Were Pushed Out," The Wisdom Daily, August 11, 2017, , accessed January 24, 2019, http://thewisdomdaily.com/women-used-to-dominate-tech-until-men-pushed-them-out/.

hadn’t disappeared, however, it simply shifted. People were now writing about women in management positions as being aggressive, competitive, and unfeminine. I agree with Vogel when he says that the motivation for change of heart deserves more study. Was it because companies were facing a labor shortage, was it because of formalized equal opportunity practices and the fear of legal lawsuits, or was the sympathy genuine? The slander had not disappeared, it just moved to another group of women in the workforce.

By the 1980’s, there was a decline in the amount of active editorial interests into the issues women faced. Even though the sympathy declined, the extreme sexism of the 1960’s advertisements never returned.[14] Throughout the roller coaster of variety in women’s portrayal in advertisements, there was still a continued increase in the 1970’s in the numbers of women pursuing a degree in computer science. It increased until the mid-1980’s, when it began to decline, and has yet to recover. So what happened?

In the mid-80’s, there was another shift in culture. Technology became a gendered activity, which played a huge part in whether or not young girls thought that had a place in the world of computing.[15] Movie films would portray programmers to be male. Video game consoles were released and marketed as toys for young boys. Personal computers were portrayed in advertisements that mostly featured men and boys. Women that did appear in computer ads were usually sexualized and were portrayed as wives or product models. [16] All of this contributed to the idea that using new technology was better suited for men and boys.

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[14] Vogel, "The Spitting Image,” 54.

[15] Lori Cameron and Michael Martinez, "The Epic Journey of Women in Computing: Advances, Setbacks, and an Uncertain Future," IEEE Software Magazine | IEEE Computer Society, January 31, 2019, , accessed February 02, 2019, https://publications.computer.org/annals/2017/10/16/history-of-women-programmers-in-computing-gender/.

[16] Shapiro, "Women Used To Dominate Tech…”

Developing an Interest in Computing

Due to societal culture and the sway of advertising, family computers were more likely to be put in a son's room, which allowed much easier and convenient access for the son than the daughter. In *Unlocking the Clubhouse*, Margolis and Fisher studied and interviewed hundreds of computer science students at Carnegie Melon, and they detail how in their research more than half of the male students they interviewed kept the family computer in their room, or owned their personal computer, while only 17% of female students reported the same. One family questioned getting a separate computer for their daughter, because their son showed a more distinct interest in the family computer than she did. After purchasing a computer for their daughter, she thought it was a wonderful present and made great use of it. Her interest had not been apparent before because of the dominance of her brother's interest.[17]

The researchers of "Anatomy of an Enduring Gender Gap…" state a similar conclusion as Margolis and Fisher: male computer science students were more likely to report having their own computer. Because having access to IT-related materials at home increases the likelihood of developing an interest in computing, boys tend to be more confident than their female counterparts when entering college to begin their studies. Before entering college, the K-12 environment also plays an important role in fostering early interests. Increased exposure to computer labs and being called on in class are positive motivators for a girl's interest.[18] There have often been negative influences too, like the one described about a high school computing classroom in the late-1980's in *Unlocking the Clubhouse*:

> Researchers also observed the more advance computer science classes, where only one or two girls were enrolled. …Girls were perpetually teased about their bodies, their appearance, and their competence. The male teacher did not intervene on behalf of the girls. One of the women students asked the teacher why he always used football examples; he replied that she could do the programming assignments on anything she wanted. At that cue, a male student turned to her and mockingly said "Do it on sewing," which drew laughs from the other students. Another woman

[17] Jane Margolis and Allan Fisher, *Unlocking the Clubhouse: Women in Computing* (Cambridge, MA: MITPress, 2003), 23-24.

[18] Linda J. Sax et al., "Anatomy of an Enduring Gender Gap: The Evolution of Women's Participation in Computer Science," The Journal of Higher Education 88, no. 2 (October 4, 2016): 261, accessed November 8, 2018, doi:10.1080/00221546.2016.1257306.

> student used football statistics in her program… She was ridiculed because she used the name of a baseball team instead of a football team.[19]

When women are put in situations like this, it can be very easy to see why, especially in this case, no female student would sign up for the next class level of computer science. In addition to adolescence being a difficult phase of life to go through, confidence-wise, the addition of possibly facing ridicule from their male classmates can put immense pressure on young female IT students and make it less likely for them to continue in the field. With fewer female students in the field, those who do remain may struggle to make friends with the similar interest for them to practice with, talk with, or bond over informal computer experiences with.

This is something that DuBow and her fellow researchers mention as a key factor that influences a woman's decision to study computer science: social support from peers. Adolescence is a time when students begin to seek affirmation and acceptance from each other. When a teenager's friend group has a positive outlook on technology and other STEM fields, it may be helpful to girls who struggle to overcome the negative culture around women succeeding in those typically male-dominated fields. [20] When they go to seek guidance or input on the topic, women in computing are seen as a positive group norm. If she receives negative or neutral feedback from her social network, this could actively discourage her interest in furthering her studies in IT.

A strong social group isn't the only thing that is mentioned by DuBow and others in their research as a contributing factor. They also suggest that a lot of the interest in computing starts at home. Children from families that are less educated or that have limited access to opportunity can be at a disadvantage.[21] Family members that don't place as high of a value on furthering education might not

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[19] Margolis, *Unlocking the Clubhouse*, 35-36

[20] Wendy Dubow, et al., "Multiple Factors Converge to Influence Womens Persistence in Computing: A Qualitative Analysis of Persisters and Nonpersisters," *2016 Research on Equity and Sustained Participation in Engineering, Computing, and Technology (RESPECT)*, 2016, 31, accessed November 14, 2018, doi:10.1109/respect.2016.7836161.

[21] Dubow, "Multiple Factors Converge to Influence Womens Persistence in Computing," 31.

provide the support and encouragement that is needed for a child who is displaying a desire to learn more or who is showing a curiosity in something new. They might not see the signs, they might not understand, or they might just not have the time or resources to help the child. But while having access to computer-related materials in the house can increase the likelihood of developing a computing interest, Sax and her fellow researchers say that supportive family members themselves are the earliest influence a student sees. Parents can act as a role model through their careers or through the opinion they give about the potential a child has to succeed. Providing encouragement one way or another when at a crucial decision path can influence their path in life and can affect the confidence level a child has about the subject afterwards.[22]

Furthering an Interest in Computing

According to the National Center for Education Statistics, in 2015 women earned only 18% of all the computer science degrees in the country. When you look at only women of color, It is even less.[23] In the United States in 2016, only 26% of those working in the computing industry consisted of women. Breaking that down even further: 3% of the working computing industry were African-American women, 5% were Asian women, and only 2% were Hispanic women.[24] Many high-tech companies agree that this isn't acceptable in today's modern world. In response to the reports that document the under representation of women, companies are committing resources to recruit more minorities into the industry. One company committed $300 million for workplace diversity, and another committed $50 million, while a third company published their goals of increasing the number of female engineers. Other

[22] Sax, "Anatomy of an Enduring Gender Gap," 261.

[23] Shana Vu, "Cracking the Code: Why Aren't More Women Majoring in Computer Science?" UCLA Newsroom, June 26, 2017, , accessed February 02, 2019, http://newsroom.ucla.edu/stories/cracking-the-code:-why-aren-t-more-women-majoring-in-computer-science.

[24] Holtzblatt, Karen, and Nicola Marsden. "Retaining Women in Technology - Uncovering and Measuring Key Dimensions of Daily Work Experiences." 2018. Accessed October 11, 2018.

organizations are partnering with schools and universities to encourage more participation in technology fields.[25]

One organization that is being sponsored by several major companies is called BRAID: Building, Recruiting, and Inclusion for Diversity. BRAID's goal is to increase the percentage of women and minorities in undergraduate computing programs by partnering with universities across the US. The BRAID research team "aims to pinpoint specific strategies to attract and retain women and students of color as computer science majors". The team is lead by UCLA professor Linda Sax, who says "We want to find out how CS departments can instill not only a sense of confidence in computing skills, but a sense of belonging within women and students of color." According to the United States Department of Education, the percentage of women who receive computer science degrees is the smallest amongst all of the STEM (Science, Technology, Engineering, Math) fields. In order to better understand what encourages students to complete a CS degree, Sax's team is conducting a study that includes syllabi analyses, faculty interviews, and student interviews.[26]

While the study is still several years from being complete, the team has reported several initial findings. Kathleen Lehman, the BRAID project manager at UCLA, says that a student's first impressions about computer science are often shaped by their introductory classes, and because women are less likely to have had any CS background from high school, they can be put at a disadvantage if an instructor assumes that all the students in their class have a background in coding already. She says that helping students build confidence in their studies and their work is key to retention in the programming world. Another determining factor for retention she says is collaboration. Strong peer connections are a contributor for encouragement to stay in the computer science major. [27] This idea concurs with what

[25] Holtzblatt and Marsden, "Retaining Women in Technology."

[26] UCLA Newsroom, "Cracking the Code."

[27] UCLA Newsroom, "Cracking the Code."

DuBow and her fellow researchers said: affirmation and acceptance from peers increases the likelihood that a woman will study computing.[28]

According to DuBow in her "Attracting and Retaining Women in Computing" article, undergraduate education is a building block for creating future technologists. In addition to not assuming that students have a coding background already, instructors should take care to make sure that they aren't perpetuating the stereotype of a "computer nerd" in their classroom language, in their homework and test examples, and in lab décor. She says, "It's important not to underestimate the power of simply saying, 'You should take on this role…or you did well on this project.'"[29]

While I agree that collaboration and a sense of confidence in the work are both important factors for retaining women in computing degrees, I also wonder if the lack of women in IT leadership roles plays a part in why there is still an underrepresentation of women in the industry today, and possibly why women aren't finishing their IT-related degrees. If you lack a mentor or someone to look up to when you're unsure of how to proceed on a path, it can leave you feeling frustrated and discouraged, and wondering if you could succeed in the future, both in your degree program while in school, and also in your future career path.

Modern-Day IT Workplace

In her article, DuBow states that research has shown that working women in IT are affected by a lack of role models and mentors, as well as inequities in performance and promotions, and inflexible work-life balance.[30] This statement is backed up by the outcome of the interviews done by Holtzblatt and Marsden. They defined several themes across multiple areas in a woman's work-life balance. One of the themes is that having a local role model plays a key influence for women in tech. Having that supportive

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[28] Dubow, et al., "Multiple Factors Converge to Influence Womens Persistence in Computing," 31.

[29] Dubow, Wendy. "Attracting and Retaining Women in Computing." *Computer*47, no. 10 (October 2014): 92. Accessed September 25, 2018. doi:10.1109/mc.2014.272.

[30] DuBow, "Attracting and Retaining Women in Computing," 92.

"push" by a trusted manager and having someone there to coach them in navigating advancement in the organization aids women in feeling supported and qualified for the next challenge.[31]

Heike Daldrup-Link states that there is a gender gap that increases the higher up you go on the career ladder, and she thinks we are all responsible. Very few women are making it to the top floor of STEM institutions, and those who do make it often report that they have to work twice as hard to be viewed as equal to men. STEM fields are still very male-dominated spaces, and Daldrup-Link suggests that women are doubting their own leadership potential because of the internalization of negative comments and culture they experience in these spaces. This leads to women disengaging mentally from the fields and becoming resentful. She herself was told in the workplace that she was not "leadership material" with comments that said she was "too outspoken," "too soft," "too calm," "too casual," "too rebellious," "intimidating," "not ready," and "would never be suited for a leadership position". Contradictory comments such as these have a major impact on how women perceive the career path, and the confidence they have to join and try to move up the ladder.[32] Having a supportive mentor in the workplace would help to eliminate the negative perception that has been developed and help to change the culture that is still perceived as normal.

Another aspect of a good work-life balance that Holtzblatt and Marsden identify in their interviews is what they call "nonjudgmental flexibility". Having a team and a manager that allow everyone flexibility with personal life events without judgement is especially important for women with children.[33] Erica Weisgram and Amanda Diekman describe how women that want a family may be more likely to "opt out" of a STEM field based on their perception of whether or not a job path is considered to be "family-friendly" or not. When considering a future family path, women are more likely than men to lean towards a job that allows them to spend time with family, including being the primary caregiver for children, while men lean towards a job with a higher salary that allows better provision for the family.

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[31] Holtzblatt and Marsden, "Retaining Women in Technology."

[32] Daldrup-Link, Heike E. "The Fermi Paradox in STEM - Where Are the Women Leaders?" *Molecular Imaging and Biology*19 (September 18, 2017): 808. Accessed October 01, 2018. doi:10.1007/s11307-017-1124-4.

[33] Holtzblatt and Marsden, "Retaining Women in Technology."

This could also contribute to the reason why women look for jobs that have regular hours and less demands.[34]

Even if a company has flexibility and family-friendly policies, men with children are not as likely to take advantage of the opportunities, which in turn could make women more reluctant to take advantage of the policies for fear of being seen as needing a “handout” or being uncommitted to the job. Women also tend to be more aware of things like parental leave than men are, and the use of family-friendly policies among men is much lower than it is among women.[35] This contributes to women’s perception that the industry is surrounded in negative culture. Implementing and encouraging the use of family-friendly policies by both men and women would help employees feel more positively about their work-life balance, and would help women who have or want children to not feel singled out when she needs to take advantage of the flexibility her company offers.[36] Gill Kirton and Maxine Robertson say that society’s history of “gendering” traditional family responsibilities has absolutely influenced women’s ability to start and progress in an IT career with the way it is still centered around a masculine norm.[37]

Though more family-friendly policies in an organization would be an ideal end-goal, sometimes it needs to start with having less judgement in the hiring process. In her book *The Only Woman in the Room*, Eileen Pollack details a study done by Jo Handelsman. In the study, researchers both male and female showed to be more likely to hire, mentor, and give a higher salary to a job applicant with the name of John than an applicant of identical background and the name of Jennifer. When Pollack questions

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[34] Weisgram, Erica S., and Amanda Diekman. "Family Friendly STEM:Perspectives on Recruiting and Retaining Women in STEM Fields." *International Journal of Gender, Science and Technology*8, no. 1 (July 2014): 40. Accessed October 10, 2018.

[35] Weisgram and Diekman, "Family Friendly STEM:Perspectives on Recruiting and Retaining Women in STEM Fields,” 42.

[36] Weisgram and Diekman, "Family Friendly STEM:Perspectives on Recruiting and Retaining Women in STEM Fields,” 43.

[37] Kirton, Gill, and Maxine Robertson. "Sustaining and Advancing IT Careers: Women's Experience in a UK-based IT Company." *Journal of Strategic Information Systems*17 (February 1, 2018): 168. Accessed October 13, 2018.

Handelsman about the bias and prejudices, she says It is a problem, especially because the perceived idea and generalization about someone aren't necessarily true.[38]

> The problem with such prejudices is that whether the generality is true or not, the individual case may be different. The employer may hire a man and be surprised when he announces he's going on parental leave three months after starting work. Or he may hire the women and find out she has no intention of having children and is the best employee he's ever had…The point is that we miss characteristics about people when we judge them by group characteristics.[39]

Handelsman also challenged someone to produce data that women are "actually less productive, despite taking time for children". Even if someone used their "personal experiences" to justify hiring a male candidate over a female one, that is still a decision being made based only on feelings, which have likely been influenced by society and a negative work culture.[40]

Even if you take the possibility of taking time for family out of the equation, I think Handelsman's point can relate to other stereotypical perceptions of women. People with a similar mindset of those that told Daldrup-Link she was "too soft" and "not suited for a leadership position"[41] could also apply these group characteristics to any woman sitting opposite them in the interview room or the conference room. In her book, Pollack interviews a female friend, Leslie, who works to encrypt data at her job for the Department of Defense. Her friend Leslie was criticized at work for not being nice or polite at work, simply for speaking up in meetings. "If a woman speaks up at a meeting, she's considered not nice, even though a man can say the same thing and everyone is just fine with it…she offered [a

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[38] Eileen Pollack, *The Only Woman in the Room - Why Science Is Still a Boys' Club* (Boston, MA: Beacon Press, 2015), 250-251.

[39] Pollack, *The Only Woman in the Room*, 251.

[40] Pollack, *The Only Woman in the Room*, 250-251.

[41] Daldrup-Link, "The Fermi Paradox in STEM," 808.

younger colleague] some suggestions, which he totally blew off. Two weeks later a male colleague made the same suggestions, and the younger guy told him, 'oh, absolutely!'"[42]

The experience that Leslie described is not unusual in a typically-male-dominated industry, and it is just one example of the gender stereotyping, sexism, and discrimination that women face in such a masculine culture. Kirton and Robertson say that women often become "stoic survivors" and must be extraordinarily resilient and determined to "make it" to the senior levels of leadership in IT. Women often have to assimilate themselves into the culture and try to fit in into the already-established processes that cater to the masculine norm.[43]

So when it comes to addressing the still-lacking number of women in senior leadership positions, we are faced with several questions about why that is. Is it because women don't want to assimilate anymore, and society is struggling to change its idea of who can be a leader? Or is it because women are so doubtful in their own skillset that they don't believe in themselves? Or could it possibly be because society as a whole is slow to evolve and there are still prejudices and stereotyping about women in the industry that is holding them back? Based on my research, It is a combination of all of these, and while it is slow to change, learning more and becoming aware of the bias can help the workplace as a whole to become a better environment for everyone.

[42] Pollack, *The Only Woman in the Room*, 222-223.

[43] Kirton and Robertson, "Sustaining and Advancing IT Careers," 167-168.

CHAPTER 3

KEY WOMEN IN COMPUTING HISTORY

Women I Chose

While doing my research, I learned about numerous women who played important roles that shaped what computing is today. I choose four women to focus my research on: Ada Lovelace, Jean Jennings Bartik, Katherine Johnson, and Grace Hopper. I wanted to discover what motivated them to join the computing world, and what kind of obstacles they faced. Was there anything in common between these four women that could be seen as a trait of women who succeed in the technology world?

Ada Lovelace

Augusta Ada Byron, Countess of Lovelace, was the daughter of poet Lord George Gordon Byron and Lady Anne Isabella Milbanke Byron. Because her parent's marriage was not a happy one, Ada's mother left Lord Byron just weeks after Ada was born in December 1815.[44] Ada was raised solely by her mother and never met her father. Lady Byron had her own fascination with mathematics, and encouraged Ada to study mathematics, astronomy, and music. Ada's first great mentor was Mary Somerville, an astronomer. "Ada was very much attached to me, and often came to stay with me. It was by my advice that she studied mathematics. She always wrote to me for an explanation when she met with any difficulty. Among my papers I lately found many of her notes, asking mathematical questions," recalled Mary Sommerville.[45] She showed Ada that "women could make their mark in science."[46] Mary Sommerville was the one to introduce Ada to Charles Babbage "the father of the computer" at a

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[44] "Ada Lovelace," Biography.com, January 15, 2019, , accessed February 02, 2019, https://www.biography.com/people/ada-lovelace-20825323.

[45] Robin Hammerman and Andrew L. Russell, *Ada's Legacy - Cultures of Computing from the Victorian to the Digital Age* (ACM Books), 19.

[46] Richard Holmes, "Computer Science: Enchantress of Abstraction," Nature 525 (September 03, 2015): , accessed November 8, 2018, doi:10.1038/525030a.

reception. At the reception, Babbage had on display an early model of a calculating machine, which Ada was fascinated by. The early prototype of the Difference Engine that captured her attention was at the time able to compute polynomial expressions, count to 10,000, and other things. According to witnesses at the reception, Ada quickly grasped the significance of the machine. Babbage began inviting her, along with a chaperone, to his frequent "Saturday evenings" parties where people from all over who were knowledgeable in politics, culture, and science, would come to socialize and mix.[47]

In the 1830's, Ada had a well-rounded circle of intellectual minds to call her support system. She had her three mathematics tutors, one of whom was William Frend, who was once a teacher to Ada's mother. Another tutor was Frend's son-in-law Augustus De Morgan, a professor at the University of London, with whom Ada frequently corresponded with about calculus and her mathematical studies.[48] In a letter De Morgan wrote to Ada's mother, he made an assessment of Ada's facility with mathematics:

> I never expressed to Lady Lovelace my opinion of her as a student in these matters. The power of thinking on these matters which Lady L[ovelace] has always shown from the beginning of my correspondence with her, has been something so utterly out of the common way for any beginner, man or woman, that this power must be duly considered by her friends…whether they should urge or check her obvious determination…to get beyond the present bounds of knowledge.[49]

In addition to her tutors, Ada also had her mentor Somerville, Babbage, her mother, and her scientifically-minded husband, William King, Earl of Lovelace, who she married in 1835 [50], with whom she could converse with about the many intellectual topics she enjoyed studying. This allowed her to become well-exposed to advanced mathematics of time period. [51]

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[47] Hammerman and Russell, *Ada's Legacy*, 17-18.

[48] Hammerman and Russell, *Ada's Legacy*, 19.

[49] Hammerman and Russell, *Ada's Legacy*, 20.

[50] Holmes, "Computer Science: Enchantress of Abstraction," 31.

[51] Hammerman and Russell, *Ada's Legacy*, 22.

After setting aside his un-finished work on the Difference Engine, Babbage began to work on a new project that he called the Analytical Engine. The design of the Analytical Engine had several features in common with modern-day computers, such as adopting a mechanism to do conditional testing on immediate results, which permitted the branching of calculations. Babbage took a set of plans for the Analytical Engine to a conference in 1840, where his presentation was seen by Luigi Menabrea, a professor of mechanics and construction at the University of Turin, and later the prime minister of Italy. Menabrea published a description written in French of the Analytical Engine in a Swiss journal in October 1842. Ada was first encouraged to examine and translate into English Menabrea's manuscript by Charles Wheatstone, a scientist who later invented the telegraph. Along with encouragement from Babbage, Ada spent the winter of 1842-1843 translating the writing and adding her own notes and thoughts along side the original piece. Babbage mentioned that when complete, her notes extended around three times the length of Menabrea's original writing, showing that she completely connected and understood the difficult and abstract questions that were presented.[52]

In her writing, Ada detailed how codes could be created for the Analytical Engine to handle both letters and symbols as well as numbers. She also discussed a potential method for it to repeat a series of instructions, something we today are familiar with in programs as looping.[53] Among the notes that she made and collaborated with Babbage on was a table-algorithm for computing the series of Bernoulli numbers, which grants her authorship of the first algorithm intended for a computing machine.[54] She also raised the question of if the Analytical Engine could think. She went on to conclude that it "has no pretensions to originate anything". These notes were referenced by Alan Turing in 1950 in his paper titled 'Computing machinery and intelligence' where he lists potential objections to the possibility of artificial intelligence. When referencing Ada's thoughts about an engine thinking, he initially agreed but then

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[52] Hammerman and Russell, *Ada's Legacy*, 22-24.

[53] Biography, "Ada Lovelace."

[54] Hammerman and Russell, *Ada's Legacy*, 29-30.

wondered, “A better variant of the objection says that a machine can never ‘take us by surprise’…Machines take me by surprise with great frequency.”[55]

She had plans to draft many other scientific papers, but Ada Lovelace died young at the age of 36 from uterine cancer. She had many poet and scientist friends visit her at the end of her life, and she continued to value scientific and technological advances until the end.[56] I wonder how much more she would have gone on to analyze and theorize about had she not died so young in life. With the contributions she did make though, they were not widely discovered and publicized until the 1950s, when B.V. Bowden republished them in *Faster Than Thought: A Symposium on Digital Computing Machines*. After then, she received many posthumous honors for her work, and in 1980, the United States Department of Defense named a new computer language after her, called “Ada”.[57] Every October, an international Ada Lovelace Day is celebrated to promote women in science.

Jean Jennings Bartik

Jean Jennings Bartik, who was better known as “Betty” by her friends and family, was born to William and Lula Jennings on December 27, 1924. She grew up on a farm in Missouri with her six siblings. Her father was a school teacher, and her mother, though she had only completed school through the eighth grade, was also intelligent and proficient in algebra and geometry. From an early age, Betty was enraged by the unfair “male chauvinist environment” that occurred when she was paid less than her brothers for the same chores. In her family however, this masculine attitude did not apply when it came to intellect. Women in her family were often considered to be bright or brighter than the men. Betty’s grandmother was also a schoolteacher, and valued education. She encouraged her own children to be educated when they showed interest, which resulted in Betty’s father, aunt, and her two uncles all becoming school teachers.

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[55] Holmes, "Computer Science: Enchantress of Abstraction," 32.

[56] Holmes, "Computer Science: Enchantress of Abstraction," 32.

[57] Biography, “Ada Lovelace.”

When Betty entered school, she scored well, and quickly advanced through the grades, even skipping the sixth grade.[58] She did well in math, and often received encouragement and offers of extra assistance by her favorite teacher, Miss Madeira. Her teacher helped her with her Latin lessons once a week, and frequently took time after studies to listen and encourage Betty's fantasies and ambitions. Miss Madeira was the friend of Betty's Aunt Gretchen, who was an English teacher with a master's degree, and who Betty deemed to be her role model. Aunt Gretchen would come home to visit every summer, and, even though she had just a teacher's salary, offered to all of her nieces and nephews a loan to pay for college classes for two years.[59]

In 1941, Betty went to college at the Northwest Missouri State Teachers College, now know as Northwest Missouri State University. During her time at college, the United States entered World War II, and her college began offering instruction for the Navy sailors. Because she was a math major, she took analytic geometry, trigonometry, and physics classes, and she was the only civilian and only woman in the classes.[60] In her last semester of classes before graduating, Betty's calculus teacher Dr. Ruth Lane offered her alternative career paths she could take with her math degree. Betty applied for two different jobs that were looking for "computers" to hire, one of which was at Aberdeen Proving Ground. Betty completed the requirements for graduation in January 1945, at the age of twenty. She went home to await a job offer from the companies she applied to, but she did not hear back from Aberdeen until several months later, when she received a telegram telling her to report as quickly as possible.[61]

Betty was hired by Aberdeen in spring 1945 to be a computer and calculate trajectories for guns. She went through training classes for the work, with an instructor named Adele Goldstine. Betty was

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[58] Jean J. Bartik, *Pioneer Programmer: Jean Jennings Bartik and the Computer That Changed the World*, ed. Kim D. Todd and Jon T. Rickman (Kirksville, MO: Truman State University Press, 2013), 27-34.

[59] Bartik, *Pioneer Programmer*, 39-40.

[60] Bartik, *Pioneer Programmer*, 42-48.

[61] Bartik, *Pioneer Programmer*, 56-58.

frequently impressed by her instructor.[62] In June 1945, computers at Aberdeen were informed of a new machine being built that they needed math majors to work on. The new machine was called the Electronic Numerical Integrator and Computer (ENIAC). Betty interviewed for the open position on the team of five, and was hired. The rest of the team was Kathleen McNulty, Marlyn Wescoff, Ruth Lichterman, and Betty Snyder. In their training, they were taught to program punch card equipment by connecting wires between the holes in a plugboard that told the machine what to do.[63]

After their initial training, Betty Jean and Betty Snyder were studying the accumulator of the ENIANC to try to learn how it worked when a man came into the room they were studying in and interrupted them. He introduced himself as John Mauchly, a co-inventor for the ENIAC, and helped teach them how the accumulator worked. He then encouraged them to ask questions of him anytime they needed help. The ENIAC women learned about function tables, which stored the drag function for trajectories, that would be used to store programs. A couple of months later, a sixth woman joined the team: Fran Bilas. While working together to figure out how to program the ENIAC to calculate trajectories, they determined that they could use the master programmer, or the control unit of the ENIAC, to reuse code. It had “stepper switches” that allowed repetition of a program and movement down different paths depending on if a sign in the accumulator was positive or negative. This was an example of what we now call if-then statements, and the first days of a stored program computer.[64]

On February 15, 1946, the world was shown the first computer to successfully run a program. Snyder and Betty were instructed just two weeks prior to program a trajectory for the demonstration. They developed flowcharts for the steps, then the programming sheets for the pedals, and everything else needed for the program to successfully execute. The program was to compute the trajectory of a shell that took thirty seconds to reach its target. In the demonstration, the program only took twenty seconds to execute, but had the same calculations been done by hand, it would have taken a female computer thirty

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[62] Bartik, *Pioneer Programmer*, 60-61.

[63] Bartik, *Pioneer Programmer*, 65-67.

[64] Bartik, *Pioneer Programmer*, 75-80.

to forty hours to do. After the demonstration, no one congratulated or recognized Snyder or Better. They also were not invited to the celebratory dinner afterwards. When a short newsreel was filmed about the ENIAC, the ENIAC women were posed as models and were treated as if they knew nothing about the machine. They were brushed aside and looked over.[65]

Recognition would not come to the ENIAC Programmers until 1985. Betty and the other ENIAC women were inducted into the Women in Technology International Hall of Fame in 2002. In addition to working on the ENIAC, Betty also went on to program the Binary Automatic Computer (BINAC), and work on the Universal Automatic Computer (UNIVAC).[66] Jean, as she went by in her later years, passed away on March 23, 2011.

Katherine Johnson

Katherine Johnson, maiden name Coleman, was born on August 26, 1918 in White Sulphur Springs, WV, to Joshua and Joylette Coleman. Katherine's mother was a school teacher, and her family valued the importance of education and set high expectations for their children.[67] She was an intelligent child and was skilled with numbers from an early age.[68] Her parents encouraged her obvious talent for math, and sent her and her siblings to secondary school 100 miles away, as there was no Negro secondary school where they were. [69]In a video interview posted online by *Makers*, Katherine says, "They tell me I counted everything. Everybody studied at a big table, and after I finished mine, I helped them get theirs.

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[65] Bartik, *Pioneer Programmer*, 91-101.

[66] "Betty Jean Jennings Bartik," Content - IEEECS, , accessed February 04, 2019, https://www.computer.org/web/awards/pioneer-betty-jean-bartik.

[67] "Katherine Johnson." The Human Computer Project. Accessed February 05, 2019. https://www.thehumancomputerproject.com/women/katherine-johnson?fbclid=IwAR3juKe0OvIzQ40THJL2Tm3v7qEiz7aOIOf6i3JtpKGppbFW69MYYlAXRnM.

[68] The Editors of Encyclopaedia Britannica, "Katherine Johnson," Encyclopædia Britannica, February 22, 2019, , accessed February 27, 2019, https://www.britannica.com/biography/Katherine-Johnson-mathematician.

[69] The Human Computer Project, "Katherine Johnson."

And I was the youngest. I wound up ahead of my brother, maybe two grades. I don't remember how many. I entered college. I was 15. I was gonna be a math teacher because that was it. You could be a nurse or a teacher."[70] She started attending high school at an early age, then started college at 15 and later graduated with highest honors from West Virginia State College with a degree in mathematics and French in 1937. While at the college, she found a mentor in W. W. Schieffelin Claytor, the third African American to earn a Ph.D. in Mathematics. "He said, 'You'd make a good research mathematician.' I said, 'Oh, what do they do?' He said, 'You'll find out.' So he had me take all the courses in the catalog. Sometimes I was the only person in the course."[71] She began working as a teacher after graduation, until she was offered a spot as one of the first three black students at West Virginia University, where she enrolled in the graduate math program. After leaving the school to start a family with her husband, she returned to teaching after her daughters were older.[72]

In 1952, after hearing about open positions in the all-black West Area Computing section at the National Advisory Committee for Aeronautics in the Langley laboratory, Katherine and her family moved closer for her to pursue the opportunity.

> He [Claytor] said you're very lucky, Langley has a post for black mathematicians, just opened it up to women. They had a pool of women mathematicians. They just wanted somebody to do all the little stuff, while they did the thinking. We were called computers, women computers. I had been there less than a week when this engineer came in and wanted two women computers and Mrs. Vaughn sent me over to the flight branch. And we never went back.[73]

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[70] Johnson, Katherine. "Katherine Johnson, NASA Mathematician." *Makers* video, 4:43. February 2, 2018. https://www.makers.com/profiles/591f267c6c3f646439558630?fbclid=IwAR2v517o7G9BXGg8h4oIvb24uBqnvXB6BvlO46TsCq-ArE-4B_wQ9QUUAXk.

[71] Johnson, Katherine. "Katherine Johnson, NASA Mathematician." *Makers* video, 4:43. February 2, 2018. https://www.makers.com/profiles/591f267c6c3f646439558630?fbclid=IwAR2v517o7G9BXGg8h4oIvb24uBqnvXB6BvlO46TsCq-ArE-4B_wQ9QUUAXk.

[72] Sarah Loff, "Katherine Johnson Biography," NASA, November 22, 2016, , accessed January 04, 2019, https://www.nasa.gov/content/katherine-johnson-biography.

[73] Johnson, Katherine. "Katherine Johnson, NASA Mathematician." *Makers* video, 4:43. February 2, 2018. https://www.makers.com/profiles/591f267c6c3f646439558630?fbclid=IwAR2v517o7G9BXGg8h4oIvb24uBqnvXB6BvlO46TsCq-ArE-4B_wQ9QUUAXk.

She began work at NACA in summer 1953 and spent the following four years in the Flight Research Division analyzing data from flight tests.[74] The group of women that she worked with were known as the West Computers, and because NACA was still segregated, the West Computers were all African American women. The West Computers group performed complex mathematical calculations for the program engineers that were considered to be crucial to the success of the early space program.[75]

> Oh, they felt terrible that, here we sat and the Russians had a vehicle riding around, looking down on you. So we set out to send somebody up there and look down too. They'd called up a group of engineers and have a briefing as to what they were gonna have to do. And I asked, could I go? They said, women don't ever go to those. I said, is there a law against it? They said, no, we'll let her go ahead. I wanted to know what it was they were looking for. So I wound up doing what it was they were trying to find out.[76]

From 1957 on, Katherine's career continued to be successful at NACA, later NASA in 1958. She provided math that was used in a series of lectures given to engineers who formed the Space Task Group. In 1960 she coauthored a report that detailed equations for an orbital spaceflight, and was the first woman in the Flight Research Division to receive credit as a research report author.

> We needed to be assertive as women in those days – assertive and aggressive – and the degree to which we had to be that way depended on where you were. I had to be. In the early days of NASA women were not allowed to put their names on the reports – no woman in my division had had her name on a report. I was working with Ted Skopinski and he wanted to leave and go to Houston ... but Henry Pearson, our supervisor – he was not a fan of women – kept pushing him to finish the report we were working on. Finally, Ted told him, "Katherine should finish the report, she's done most of the work anyway." So Ted left Pearson with no choice; I finished the report and my name went on it, and that was the first time a woman in our division had her name on something.[77]

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[74] NASA, "Katherine Johnson Biography."

[75] Encyclopaedia Britannica, "Katherine Johnson."

[76] Johnson, Katherine. "Katherine Johnson, NASA Mathematician." *Makers* video, 4:43. February 2, 2018. https://www.makers.com/profiles/591f267c6c3f646439558630?fbclid=IwAR2v517o7G9BXGg8h4oIvb24uBqnvXB6BvlO46TsCq-ArE-4B_wQ9QUUAXk.

[77] J. J. O'Connor and E. F. Robertson, "Katherine Coleman Goble Johnson," Cardan Biography, , accessed January 05, 2019, http://www-history.mcs.st-and.ac.uk/Biographies/Johnson_Katherine.html.

This report contained theory used in launching, tracking, and returning vehicles from space.[78] It was referenced when she worked on the flight path and trajectory analysis in 1961 for Alan Shepard and the Freedom 7, America's first human spaceflight.[79]

In 1962, NASA was preparing for John Glenn's orbital mission. IBM computers in three locations were programmed to calculate the orbital equations for the trajectory of Glenn's capsule. Astronauts were hesitant to put their lives in the hands of the calculating machines that had been prone to blackouts. "John Glenn said, tell her. He knew that I was the only woman that worked on it. He said, if she comes up with the same answer that they have, then the computer's right. It took me a day and a half to compute what the computer had given them. Turned out to be the exact numbers that they had."[80] John Glenn insisted that Katherine Johnson be asked to re-run and re-calculate the same equations by hand that the computer had done. The calculations were good, and the flight was a success.[81]

Katherine later went on to work on the Apollo 11 mission in 1969, helping to send three men to the Moon.[82] She considers that work to be one of her greatest contributions to space exploration. "I felt most proud of the success of the Apollo mission. They were going to the moon. I computed the path that would get you there. You determined where you were on Earth when you started out and where the moon would be at a given time. We told them how fast they would be going and the moon would be there by the time you got there."[83] She also contributed to the work done on the Space Shuttle and Earth Resources

[78] Cardan Biography, "Katherine Coleman Goble Johnson."

[79] NASA, "Katherine Johnson Biography."

[80] Johnson, Katherine. "Katherine Johnson, NASA Mathematician." *Makers* video, 4:43. February 2, 2018. https://www.makers.com/profiles/591f267c6c3f646439558630?fbclid=IwAR2v517o7G9BXGg8h4oIvb24uBqnvXB6BvlO46TsCq-ArE-4B_wQ9QUUAXk.

[81] NASA, "Katherine Johnson Biography."

[82] Encyclopaedia Britannica, "Katherine Johnson."

[83] Johnson, Katherine. "Katherine Johnson, NASA Mathematician." *Makers* video, 4:43. February 2, 2018. https://www.makers.com/profiles/591f267c6c3f646439558630?fbclid=IwAR2v517o7G9BXGg8h4oIvb24uBqnvXB6BvlO46TsCq-ArE-4B_wQ9QUUAXk.

Satellite. "I loved going to work every single day," she said. She was named either author or co-author on 26 research reports when she finally retired from NASA in 1986 after spending 33 years working at Langley.[84] Katherine was awarded the Presidential Medal of Freedom by President Obama in 2015. A film based on her story and the women she worked with was released in 2016. [85]

Grace Hopper

Grace Brewster Murray was born in New York City on December 9, 1906 to Walter Fletcher Murray and Mary Campbell Van Home. Grace's father was a life insurance executive, her mother was a skilled mathematician, and both of her parents made sure Grace had access to any book she wanted and provided an environment that allowed her curious and ambitious nature to flourish[86], as they raised Grace, her brother, and her sister to value education and hard-work. At the age of seven years old, Grace's curious nature made her determined to learn how an alarm clock worked. She dismantled one of the family clocks to study the mechanisms, and when she couldn't put it back to together, she found another clock to try on. She still couldn't figure it out, and this pattern continued until all seven clocks in the house were in pieces.[87]

In 1924, the custom for the time was for affluent young women to complete their education, work for a few years, and then start a family, so Grace delighted her mother by starting college at Vassar College in Poughkeepsie, New York.[88] She decided to major in mathematics and completed her Bachelor of Arts degree in mathematics and physics in 1928. After completing her master's degree in mathematics at Yale University and marrying her husband Vincent Hopper in 1930, she returned to Vassar to work as a

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[84] NASA, "Katherine Johnson Biography."

[85] Encyclopaedia Britannica, "Katherine Johnson."

[86] Beyer, Kurt W. *Grace Hopper and the Invention of the Information Age*. Cambridge: MIT Press, 2012, 25.

[87] "Grace Murray Hopper." Famous Scientists. December 08, 2016. Accessed February 05, 2019. https://www.famousscientists.org/grace-murray-hopper/.

[88] Beyer, *Grace Hopper*, 25.

mathematics assistant, where she was later promoted through the ranks until she became an associate professor in 1941.[89] While working at Vassar, she continued her studies at Yale and became one of the first women to earn a Ph.D. in mathematics in 1934.[90] She also took advantage of a faculty perk and audited classes in almost every science, and then some. She found mathematics to be a link between all the subjects, and was able to make her own classes more relevant for the students taking them, regardless of major.[91] After the Pearl Harbor attacks in November 1941, Grace was determined to join the military. She was refused because of her small stature, but after two years of persistence, and an exemption waiver for her size[92], she was successful and enlisted in December 1943. After graduating first in her class from training in June 1944, she was given the highest training rank: battalion commander.

After her training, Grace was assigned to work in the Computation Laboratory at Harvard and served on the Mark I computer programming team lead by Howard Aiken. The Mark I was 51 feet long and was powered by electricity to perform calculations using mechanical parts and punch card instructions. “When I first saw Mark I, my first thought was, ‘Gee, that’s the prettiest gadget I ever saw,’” says Grace when discussing her early days in the Navy.[93] The machine ran constantly, and its operators often spent their nights next to it so it could be repaired when something broke.[94] After the war ended, Grace stayed in the Navy Reserves and remained working on the Mark II and Mark III computers at the Harvard Computation Lab until 1949.[95] While working on the Mark II, a moth shorted out the computer,

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[89] Famous Scientists, "Grace Murray Hopper."

[90] "Grace Hopper." Biography.com. April 02, 2014. Accessed February 05, 2019. https://www.biography.com/people/grace-hopper-21406809.

[91] Beyer, *Grace Hopper*, 27-29.

[92] "Grace Hopper." History of Scientific Women. Accessed February 05, 2019. https://scientificwomen.net/women/hopper-grace-45.

[93] *The Queen of Code*. Directed by Gillian Jacobs. Produced by Colin Hanks, Sean Stuart, and Steven Leckart. January 28, 2015. Accessed October 08, 2018. https://vimeo.com/118556349.

[94] Famous Scientists, "Grace Murray Hopper."

[95] Biography.com, "Grace Hopper."

and Grace and her colleagues joked about literally “debugging” a computer, and sparked the term’s popularity.[96]

When Grace began work in the private industry, she joined Eckert–Mauchly Computer Corporation, later taken over by Remington Rand[97], where she oversaw programming for the UNIVAC computer.[98] She began to study an issue the prevented computers from being more widely-used: the difficulty of understanding the code used to give instructions to computers. Grace began to work on a compiler that would be used by the computer to translate user-friendly language into machine code. She and her team completed the A-0 system compiler in 1952. "Nobody believed that," she said. "I had a running compiler and nobody would touch it. They told me computers could only do arithmetic."[99] The compiler used subroutines that were each assigned a call number. “All I had to do was to write down a set of call numbers, let the computer find them on the tape, and bring them over and do the additions. This was the first compiler,” said Grace.[100] After completing the A-0 compiler, Grace was named the Director of Automatic Programming, and in her department worked to develop a computer language that used English words instead of mathematical symbols that would allow non-specialists to understand what the program was doing. “There was a large number of people in the country who did not like symbols. They were not mathematicians. And they hated symbols. So let them write their programs in English. Just common sense,” says Grace.[101] The compiler-based program that resulted was the FLOW-MATIC.[102]

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[96] Famous Scientists, "Grace Murray Hopper."

[97] History of Scientific Women, "Grace Hopper."

[98] Biography.com, "Grace Hopper."

[99] History of Scientific Women, "Grace Hopper."

[100] Famous Scientists, "Grace Murray Hopper."

[101] *The Queen of Code*. Directed by Gillian Jacobs. Produced by Colin Hanks, Sean Stuart, and Steven Leckart. January 28, 2015. Accessed October 08, 2018. https://vimeo.com/118556349.

[102] Famous Scientists, "Grace Murray Hopper."

In spring 1959, computer experts from industry and the government convened at the Conference on Data Systems Languages (CODASYL), and Grace served as a technical consultant to help define the needs of a new computer language, COBOL. Common Business-Oriented Language took Grace's FLOW-MATIC language and extended it, combining it with ideas from COMTRAN, the equivalent at IBM.[103] COBOL later became the most dominant computer language used in business in the 20th century.[104] In the late 1960's through the late 1970's, Grace was the director of the Navy Programming Languages Group for the Office of Information Systems Planning in the Navy, and later received her rank of captain in 1973.[105] As the group's director, she worked on a standardization program for COBOL by developing validation software that tested a version of COBOL to see if it was compatible with all computers.[106]

Although she retired from the Navy in 1986 at the age of 79, she never went completely into retirement, and worked as a consultant until she passed away in her sleep on January 1, 1992, at the age of 85. Grace received many awards in her lifetime, including the National Medal of Technology in 1991 from President Bush (41), the newly instituted Computer Science Man-of-the-Year award from the Data Processing Management Association[107], and (posthumously) the Presidential Medal of Freedom from President Obama in 2016[108]. In 1997, the US Navy commissioned a destroyer to be named after her: USS Hopper.[109]

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[103] History of Scientific Women, "Grace Hopper."

[104] Famous Scientists, "Grace Murray Hopper."

[105] History of Scientific Women, "Grace Hopper."

[106] Famous Scientists, "Grace Murray Hopper."

[107] Famous Scientists, "Grace Murray Hopper."

[108] Biography.com, "Grace Hopper."

[109] Biography.com, "Grace Hopper."

CHAPTER 4

CONCLUSION

Comparisons

The years of lifetime between the women I chose spans from 1815 with Ada Lovelace, all the way through now with Katherine Johnson, who is still living. Culture, society, and the expectations that are assumed of women have changed drastically in that timespan. But when I look at the four women I chose to profile, one key thing jumps out at me as being the same for all of them: they all had supportive mothers who valued education and intelligence, even though it may not have been the norm at the time for a girl to be educated. All four family environments looked positively on furthering one's schooling, no matter if the child was a boy or a girl. Every woman had someone to look up to and take inspiration from as a mentor that provided encouragement, support, and guidance early on in their lives and careers. In their childhoods, they all received positive responses to curiosity and the desire to understand.

In addition to having supportive parents, Ada and Jean both had very strong social networks with whom they could collaborate with. Ada frequently wrote to her peers to ask questions and learn more about things she did not understand. Katherine also had supportive colleagues, those who respected her work and helped others see the value in her work. Neither Ada nor Katherine let having children slow them down in their work, and continued to work and progress in their careers. Jean did stop working on computing machines for a short while to raise her children, but took the time to earn a master's degree while doing so.[110] Grace did not have children.

Both Grace and Katherine loved the work they did, and made no secret of it. Grace worked well past the age of retirement, as did Katherine. They did not allow societal barriers to discourage them and continued to grow and improve until the end of their careers. I think this stems from their childhood, and having their curiosities encouraged and having their intellect nurtured and mentored. Neither of these

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[110] Juavinett, Ashley. "5 Facts about Jean Bartik, Expert Programmer of the World's First Computer." Massive. October 06, 2017. Accessed January 06, 2019. https://massivesci.com/articles/jean-bartik-eniac-programmer/.

women had their ambitions stifled, but instead they took inspiration from their work and imagined things others could not.

Something interesting I find about these women is the number of strong individuals they had to look up to. They not only had their mothers to look up to and take inspiration from, they also had other family members, teachers, and peers. Ada had her mentor Mary Somerville, a female astronomer who also shared Ada's love of math. Jean had her well-educated Aunt Gretchen, and her calculus professor Dr. Ruth Lane. Katherine's mentor was the highly-educated Dr. Claytor, the third African-American to earn a Ph.D. in mathematics. Between their mothers and their mentors, each of them was a minority, and not the typical "norm" for the computing or mathematical fields at the time. I believe this may have been an influencing factor in changing how the women viewed the fields, and encouraged them to see a different kind of path for themselves.

Future Research

This research could be expanded through a larger comparison group of women in IT. There would be value in including influential women from more time periods to gain more perspective about what society expected of them at the time. It would be enlightening to see a more in-depth examination of what women have experienced over time in this industry. Are there any other common factors or traits that are shared between these computer-minded women? If so, were the women who did not have these traits still able to succeed, or were they as successful as those that did have the commonality?

In future studies, women from today's society should also be included, from multiple generations, and from different levels on the corporate ladder. An interview could be conducted to ask them about their childhood, their education, what kind of support their family gave them, their career, and their experience in the workplace. I've come up with a few potential questions that I believe could add value to the interview. The questions are listed below.

How did you first gain interest in the IT industry?

Tell me what role education played in your childhood and school years.

How supportive were your family members and peers of your schooling and your ambitions?

What was your experience like when you first joined the workforce?

What are your experiences when it comes to how you were treated in the workplace versus how you saw your male colleagues being treated?

What do you most enjoy about working in the tech industry?

Was there anyone you considered to be a mentor or a role model for you?

What are your hopes for the next generation of women in the IT industry?

What are your thoughts on the pressures working women face when they are making family decisions, such as putting off your career to care for children?

By furthering and expanding on this study, I think the results could be helpful for researchers and analysts to make more informed decisions about how best to recruit and keep women in the computing industry. It could also be beneficial for improving the work-life balance of women currently in the industry, both by companies learning to not maintain the typical masculine norm, but also to be more open-minded and value an employee’s skillset. Teaching a more balanced history of computing to students might also help to improve upon the stereotypical nerdy, male computer science student, and change the mental image to include a variety of faces of all sorts.

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