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Patterns for Success: Women in Technology: Analyzing Top Technical Women for Repeated Mindsets, Life Experiences, and Career Navigation

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ABSTRACT

The purpose of this thesis is to discuss and discover why some women are so successful in the computing fields when public opinion continues to hold that computing is not a women's field because there are so few women in computing. The roots for this shortage begin in the American educational system, "Nationwide only about 20 percent of the bachelor's degrees in computer science go to women," according to a November 11, 2011 NPR story titled "Addressing the Shortage of Women in Silicon Valley". This shortage is well noted and heavily researched, Plausible solutions have been proposed and it is critically important to get women involved in technology because the future hinges on technology In order for women to play their rightful role in the future of academia, industry and education they must remain current and join the world of technology. Despite the shortage of women in the field there are women of note who have made successful contributions to the field. This study looks at nine women who have defied the odds by becoming successful technologists and seeks to identify the reasons why they have succeeded.

There has been a significant amount of research on women in technology – why more women are not entering into the hard sciences and what we can do to generate more interest. However, I think another angle needs to be examined. In order to predict how young girls will become interested in computing, I propose to study patterns of successful women in computing rather than study the patterns of failure examining why women do not enter into the field. That is to say, analyze successful women to discover patterns and commonalities between women who choose to enter into computing and uncover predictors of success.

This paper discusses common issues of recruitment and retention of women in technological careers and continues further to discuss research of women who have repeatedly offered great contributions to technological fields. Nine interviews were conducted and early

evidence of several patterns of common experiences, mindsets, and career paths have emerged. In order to thrive in the field of computing, women must learn the value of hard work, believe in their skills, and enjoy solving difficult problems.

Traditional issues have been well-documented, although it seems that wide-scale solutions have yet to be implemented and change has yet to be seen. This paper aims to provide parents, mentors, teachers, and counselors with a set of repeatable patterns, experiences, and signals to watch for in girls and women. It is necessary to identify girls and women with these traits, personalities, and interests, and encourage and facilitate an awareness and potential interest in the field of computing.

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THESIS

It is well-documented that women are traditionally underrepresented in the Science, Technology, Engineering, and Mathematics (STEM) fields. This is particularly true in the field of computer science where women have been underrepresented in the academic discipline as well as in all of the professional technological fields. Although the number of women in STEM is growing, the numbers of men in these fields still exceed those of women. According to a report published by the AAUW (American Association of University Women) entitled "Why So Few?: Women in Science, Technology, Engineering, and Mathematics," the imbalance of genders interested in pursuing STEM careers grows as girls and boys navigate each transitions from primary school into secondary school, higher education, and finally into the workforce.

> In elementary, middle, and high school, girls and boys take math and science courses in roughly equal numbers, and about as many girls as boys leave high school prepared to pursue science and engineering majors in college. Yet fewer women than men pursue these majors. Among first-year college students, women are much less likely than men to say that they intend to major in science, technology, engineering, or math. By graduation, men outnumber women in nearly every science and engineering field, and in some, such as physics, engineering, and computer science, the difference is dramatic, with women earning only 20 percent of bachelor's degrees. Women's representation in science and engineering declines further at the graduate level and yet again in the transition to the workplace (American Association for University Women).

The report also documents that among professionals in fields related to computer science, women are drastically underrepresented. Only 29.2% of database administrators, 27.5% of computer scientists and systems analysts, 22.4% of computer programmers, 20.9% of computer

software engineers, and 19.4% of computer hardware engineers are women (Catherine Hill, Christianne Corbett, and Andresse St. Rose).

The goal of this study is to identify patterns in behaviors and processes of successful women who are thriving in the field of technology in order to find repeatable actions which lead to success. According to Linda Rising, author of the book, *Fearless Change: Patterns for Introducing New Ideas,* being able to identify patterns of behavior that lead to success can help the novice understand her own decisions and behaviors, and recognize when she is being influenced negatively by societal pressures or implicit biases leading her away from pursuing a career in STEM. Rising notes that patterns provide solutions to problems (Rising 19). When a problem has already been solved, documenting a pattern provides a blueprint for success for future problem solvers who wish to avoid common pitfalls without reinventing the wheel. This study is intended to add to the blueprint for success and provide knowledge of what girls and women can do for themselves to avoid pitfalls that cause so many to leave the field of technology.

INTRODUCTION

This study is intended to contribute to the understanding of why there is a shortage of women in computing from an angle different from the traditional research in the field. Much of the research conducted focuses on the negative angle of why girls do not enter the field of technology such as implicit biases linking sciences with men, gender intelligence stereotypes, mindset of fixed intelligence, and an inaccurate self-evaluation in STEM fields. The aim of this study is to focus on the women who have succeeded and identify individual traits, backgrounds, and experiences that have led to their success, and then analyze these traits for identifiable

commonalities. Parents, teachers, advisors, and mentors can use this study to effectively guide and encourage girls and young women to enter and remain in the field of technology.

One reason women cite for not pursuing a career in technology is their belief that the field is dry and detached from human problems. On the contrary, technology directly impacts individuals and communities, improves lives and relieves suffering. The field of computing has the potential to reach and integrate people all over the globe.

> Scientists and engineers are working to solve some of the most vexing challenges of our time - finding cures for diseases like cancer and malaria, tackling global warming, providing people with clean drinking water, developing renewable energy sources, and understanding the origins of the universe. Engineers design many of the things we use daily - buildings, bridges, computers, cars, wheelchairs, and X-ray machines (American Association for University Women).

The fact that women are not participating equally in the development of technology, which pervades the modern world, is certainly a disservice to women who are missing out on an exciting, fulfilling and financially rewarding career. Perhaps more significantly, society at-large is being denied the unique contributions that women can make to the design and implementation of the technology.

> When women are not involved in the design of these products, needs and desires unique to women may be overlooked. For example, 'some early voice-recognition systems were calibrated to typical male voices. As a result, women's voices were literally unheard. ... Similar cases are found in many other industries. For instance, a predominantly male group of engineers tailored the first generation of automotive airbags to adult male bodies, resulting in avoidable deaths for women and children' (Margolis & Fisher cited in American

Association for University Women). With a more diverse workforce, scientific and technological products, services, and solutions are likely to be better designed and more likely to represent all users (American Association for University Women).

Global humanitarian, environmental, industrial, and technological issues are increasingly complex. In order to move forward as a society and effectively solve the world's problems, we need all of our greatest minds, not just the male ones, to maximize innovation and creativity.

TRADITIONAL ISSUES – LITERATURE REVIEW

IMPLICIT GENDER BIAS

Disinterest is a reason often cited for why women do not enter into STEM fields. Research suggests that people are more likely to develop an interest in and pursue a career where they feel they belong and where they feel they can succeed. Why, then, might girls and young women feel that they do not belong or cannot succeed in technology? In our culture, subconscious beliefs and strong implicit biases link the sciences to men and the arts to women, and prevent women from identifying with the STEM fields. These links are so ingrained that even people who actively deny this stereotype incur some sort of implicit bias (Dweck). For example, studies have shown that elementary teachers unwittingly perpetuate the biases and stereotypes of our culture which discourage girls and young women from envisioning themselves in a technical field.

In school, girls are socialized towards the feminine ideal, even if subconsciously. "Teachers socialize girls towards a feminine ideal. Girls are praised for being neat, quiet, and calm, whereas boys are encouraged to think independently, be active and speak up" (Bailey). In addition, girls are socialized to value popularity over intelligence, whereas boys are more likely to place more importance on competence and independence (Bailey). Diane Reay, a Professor of Education at

Cambridge University, conducted a study of a third grade classroom looking at the self-defined groups of girls: “the nice girls, the girlies, the spice girls and the tomboys” (Reay). The interviews concluded that the term ‘nice girl’ was almost used as a negative term meaning “...an absence of toughness and attitude” (Reay).

> Furthermore, the girlies were a group of girls who focused their time on flirting with and writing love letters to boys, the tomboys were girls who played sports with the boys, and the spice girls espoused girl-power and played 'rate-the-boy' on the playground. Reay's research shows that each of the groups of girls defined their own femininities in relation to boys (Reay).

Clearly the socialization of gender is reinforced at school. Gender bias in school extends past socialization and is prevalent in learning materials, lesson plans, text books, and in interactions with teachers. “This type of gender bias is part of the hidden curriculum of lessons taught implicitly to students through the daily routines every day functioning of their classroom” (Marshall).

Sophia Chung, a software engineer at Facebook who gets her kicks from breaking the stereotype of being a woman in computing, describes her experiences in computing to The Huffington Post. She refuses to blend in with the men and stifle her self-expression, wearing “nail polish and four-inch heels,” and demanding that people take her seriously, nevertheless. She says “I'm proud of my career -- not just because I love what I do, but because it has challenged so many expectations on what women are capable of. And by challenging these stereotypes, women can break them down little by little until they no longer exist” (Chung).

Nathan Ensmenger, Assistant Professor of Information at the University of Texas, said his research showed that the qualifications of a computer programmer have been skewed to match

male characteristics. "Women were the first computer programmers but were slowly ousted from their position as the sociological aspects of computer science moved toward a male-dominated environment in the late '80s" (Ura).

Bringing awareness to the implicit biases we hold can help women asses their attitudes towards technology and discover if their own lack of interest is due a bias or genuine disinterest in the field.

DEVELOPED MINDSET

Additionally, the mindset that children develop throughout school and adolescence impacts their success in technological fields. Students with a growth mindset believe that intelligence is malleable and that new skills can be learned, whereas students with a fixed mindset believe that intelligence is inborn and new things cannot be learned. Girls tend to develop fixed mindsets via the messages received from parents and teachers (ie: praising them for intelligence and not for improvement) and learn from an early age that they are naturally perfect. Messages that praise natural skills teach children that they already have all of the skills that they need, and that intelligence is fixed in nature.

Malcolm Gladwell writes about the impact of one's mindset on her success in his article "The Talent Myth: Are Smart People Overrated?" He cites a psychologist at Columbia University, Carol Dweck, who conducted study at the University of Hong Kong where the classes were taught in English to test the impact of these mindsets. She asked a group of students if "they wanted to take a course to improve their language skills… Only the ones who believed in malleable intelligence expressed interest in the class" (Gladwell). Her research continues to state that "students who hold a fixed view of their intelligence care so much about looking smart that they act dumb" (Gladwell). When students are rewarded only for their

"talent," Gladwell says "they begin to define themselves by that description, and when times get tough and that self-image is threatened they have difficulty with the consequences" (Gladwell).

In another article, New York Magazine writer Po Bronson describes the effects of overly praising children for innate talents in his article "How Not to Talk to Your Kids: The Inverse Power of Praise."

> For a few decades, it's been noted that a large percentage of all gifted students (those who score in the top 10 percent on aptitude tests) severely underestimate their own abilities. Those afflicted with this lack of perceived competence adopt lower standards for success and expect less of themselves. They underrate the importance of effort, and they overrate how much help they need from a parent (Bronson).

Even though it may be more intuitive to praise children for their intelligence, it is important to teach and encourage a growth mindset by praising them for improving and for struggling to get where they are. Success in such demanding STEM fields requires a growth mindset and belief in one's own abilities to learn and tackle challenges. From an early age, children of both genders need to be encouraged to foster and develop these attitudes in order to increase their chances of future success in STEM.

LOW RETENTION RATES

Even when women do enter into a technical major in college, they are much more likely to leave than their male counterparts. Women who enter STEM majors in college tend to be well qualified. Female and male first-year STEM majors are equally likely to have taken and earned high grades in the prerequisite math and science classes in high school and to have confidence in their math and science abilities (Brainard & Carlin; U.S. Department of Education, National Center for Education Statistics; Vogt et al. cited in American Association for University

Women). Nevertheless, many of these academically capable women leave STEM majors early in their college careers, as do many of their male peers (Seymour & Hewitt, 1997 cited in American Association for University Women). For example, in engineering the national rate of retention from entry into the major to graduation is just under 60 percent for women and men (Ohland et al. cited in American Association for University Women).

Many causes have been cited for this low female retention rate in higher education and beyond. Work or study environments can be unwelcoming or unappealing to women. Introductory college courses often emphasize a focused and technical aspect of the field, whereas a course that describes the broad application of the discipline may be more appealing to women and capture their interest in the subject. Women with underdeveloped skills traditionally valued in technology courses such as spatial skills, frequently have no path to the higher-level courses. Women tend to hold themselves to higher standards and be discouraged by perceived failure.

University and workplace environments are crucial to retaining women in technology. Women tend to need a sense of community, and many times as the only woman in a department or class, this can be difficult to find. The university and workplace must foster connections, mentorships, and networks to help women feel supported and included in the environment (American Association for University Women). Wilson cites research by Moses showing that "women prefer activities where social interaction is encouraged, and collaboration is often discouraged in academic computer science" (Wilson). Beginning even in high school, according to Oliveri, a male-dominated environment can deter girls from developing an interest. "All-girls schools tend to encourage girls to pursue areas of study that are typically male-dominated. In particular, studies have shown that, in a coeducational school setting, boys often dominate computer labs, which discourages girls from learning about computers" (Oliveri).

Another issue with retaining female college students pursuing STEM majors is that the curriculum usually begins with very focused and technical courses, thereby not exposing women to the many applications of the topic until much later. Women have more of a desire for social or humanitarian problems, and beginning a curriculum front-loaded with technical courses can cause them to miss the application of the skills they are learning and lose interest (American Association for University Women). Associate Dean of Students Francisco Santamarina at the University of Chicago discusses the high turnover rate of the heavy math and science majors. "Once [the undergraduate students] are exposed to the broad offerings that a liberal arts institution like this has to offer, it begins to open their minds to new areas," Santamarina said (Stanek).

In a field where women may feel that they do not belong for a variety of reasons, including their perception of a successful person in technology as the stereotypical geeky male, it is important to provide extra support and encouragement. For example, low test scores in engineering disciplines is very common, yet for a woman who already feels that she is not in the right place, earning a low score on a test can be enough for her to change to a non-STEM major. It is important for professors to explain expectations and say things like "getting an 80 on this test means you are doing well" as opposed to allowing the students to arbitrarily judge their skills based on a low test score. In order for a woman and a man to be perceived as equal in a male-dominant field, women must be exceptional while men need only to achieve average scores (American Association for University Women).

A recent study conducted at Stanford University "corroborated what we already know from other national and international research. Stereotypes, or cultural beliefs, that link masculinity and technology, while disconnecting femininity and technology, create false expectations that

men are naturally better engineers and computing professionals than women are" (Cohoon). Because of this, women often hold themselves to a higher standard since they already feel out of place as the minority. This desire to achieve at a high level can cause unrealistic expectations that will eventually lead to the leaving the field.

Another study measured self-evaluations of men and women with tasks that were associated with gender.

> As hypothesized, for a masculine task, significant gender differences were found for all three measures: Females' self-evaluations of performance were inaccurately low, their confidence statements for individual questions were less well calibrated than males; and their response bias was more conservative than males'. None of these gender differences were found for feminine and neutral tasks. As hypothesized, strong self-consistency tendencies were found. Expectancies emerged as an important predictor of self-evaluations of performance for both genders and could account for females' inaccurately low self-evaluations on the masculine task (Beyer and Bowden).

Women's inaccurately low self-evaluation can deter them from developing their abilities and achieving success, causing them instead, to leave the field.

While many of these traditional issues hold true, more and more women have succeeded in spite of (and perhaps because of) the obstacles and challenges in front of them. It is my goal to investigate the successes, experiences, and mindsets of women who are successful in technology and devise strategies for girls and young women to make it to the top in STEM fields.

STUDY

Thirty women from various fields and levels in technology were contacted with a request for interview. Twelve responded including one woman who preferred not to discuss the subject.

Subsequently, nine interviews were scheduled and conducted. The biographies of the interviewees and the interview questions can be found in Appendices I and II respectively.

Women were selected for the study for their repeated success in the field of technology, consistent influence in their respective fields, and long tenure in the discipline. These women have made repeated contributions to the field and are top performers in the field. The women span across age range, accomplishments, and geography.

LIMITATIONS

In an attempt to select women with long-standing influence in the field of technology, women of younger generations were excluded. The women interviewed grew up, for the most part, around the time when computing technology was emerging, whereas the experiences of younger generations who grew up immersed into a world of technology may be different. Despite generational differences, however, I believe similar stories will still stand true in comparison as the nature of technology development has not changed in that it still requires a strong work ethic, desire to solve problems, and the will to succeed past repeated failure.

A future study can span more age ranges to compare with the generation interviewed here. Ideally many more people would be interviewed as well: both women and men, in and out of technology, those who began in technology and left, those who began elsewhere and were later drawn to technology, and those who avoided it altogether. The patterns can be more meaningful within the context of the broader population when comparing to those who left technology or succeeded in other fields.

PROCEDURE

The interview questions were designed to draw out experiences and factors that have led woman to their great successes. The intention was to discover the impact of early life, messages received as a child, and early career experiences in order to identify patterns of how the logical

mind, work ethic, and strong drive to tackle challenges were developed. The questions were purposefully casual in nature in order to identify individual traits and understand the workings of a successful woman's mind. Each question was designed with regard to a hypothesis of experiences indicative to success (see appendix II) such as early independence, connection with a father figure, influence of mentors, mentality of perfection, love of problem solving, and strong drive and work ethic. Women in many interviews alluded to my hypotheses by mentioning my questions in conversation before they were asked. As the interviews were conducted, many interviewees brought up new points that I had not anticipated that I was able to identify in following and previous interviews.

The interviews lasted between thirty and forty-five minutes and began with a guided narrative by the interviewees about their life and to what they attribute their success. This piece of the conversation was meant to be casual to gauge what the interviewees brought up naturally without leading questions. In many cases, the narrative answered all of my questions and touched on many of the similar points that lead to success. During the second part of the interview, I asked the interviewees the questions which they had not answered on their own accord. Transcripts were recorded of each conversation.

Analyses of Findings By Traits

Hard Work

The nature of computer science involves difficult problems and many failures before success is reached, and therefore in order to reach that success, one must have the persistence and belief in one's own work ethic. A study of the relationship of twelve factors to the success of computer science students showed a negative correlation between those who attributed luck to their success as opposed to hard work or effort (Cantwell-Wilson, Shrock). Those who believe in the value of their own hard work may be more likely to succeed.

Many of the interviewed women cited their mindsets for hard work. In some cases, the interviewee was influenced by an unstable family or needing to support her siblings and/or parents at a young age. In several cases, she had a job in high school to support her and/or her family, and saw early on the direct effect of working hard and receiving a pay check.

Tina Groves, a senior product manager at IBM, grew up in a small village in rural Saskatchewan with a population less than 400. She knew from an early age that if she wanted to get out of that town, she would have to work her way out. She worked to earn scholarships so that she could attend University. Terri Cooper, Vice President, Operations at Trace|3, was labeled "gifted" in the fourth grade, and because of the program in which she was placed, she had to "learn how to study and learn how to work hard." The program would pull her out of class for a full day to do special projects, and she had to work hard to keep her spot. She remembers her teacher saying "I believe in you."

Dean Constance Knapp, Dean of the Seidenberg School of Computer Science and Information Systems at Pace University, remembers thinking that it never occurred to her that she couldn't do something because she could always just work harder at it.

Pollyanna Pixton, is a founding partner of Accelinnova, president of Evolutionary Systems, and director of the Institute for Collaborative Leadership, discussed her mindset of persistence and very passionately believes in working hard. "Persistence means solving problems in the best way you can. Keep after them until you can find a solution." She is proud of the point in her career where she says "I get days off!"

Linda Rising, independent consultant, author the book *Fearless Change: Patterns for Introducing New Ideas,* and a Ph.D. from Arizona State University in the field of object-based

design metrics, never heard the message that she was perfect as many young girls do, but instead received the message that she had to work harder.

Those who believe that luck or innate abilities lead to success as opposed to trusting in their ability to solve difficult problems, will have a more difficult time. This relates directly to the growth mindset which is so important for a computer scientist. She must feel that the amount of work she puts in directly impacts the amount that she learns, and this can be achieved through a strong work ethic and a desire to work hard.

Influence of a Father Figure

Throughout the interviews, a similarity began to emerge of a father figure teaching the interviewee the value of hard work and how she just needed to put her mind to something in order to succeed. From this influence, it was understood from a young age that the interviewee must work hard in order to succeed. This resonated with her throughout her career as she worked hard to solve problems, balance a family and a career in some cases, and move up through the ranks in her company to tackle more complex social problems. Nearly all of the interviews led to discussion of a father figure without a prompting question. There is the possibility to explore further the nature of the positive father complex, as described by Carl Jung's theories on the human psyche. A woman with a positive father complex is likely to be trusting of the male gender and develop their self-esteem from the basis of relationships with men. The characteristics of the positive father complex are being organized, hard-working and responsible (Alho).

Ms. Groves discussed her ideas about the difficulties that women in computing face, including the difficulty of navigating a male-dominated conversation especially if she came from a family situation where the father was always right. This situation might feel similar to living

up to a father's expectations, or feeling uncertain about how to challenge and speak up around men.

Dawn Curlee, Vice President of Human Capital at Tendril, was introduced to programming at the age of six by her father who had purchased one of the first Mac computer ever made. He taught her how to program in BASIC and she attests being introduced to programming at such a young age to falling in love with it.

Dean Knapp believes her dad raised her as he would a boy. He always told her to just put her mind to everything and then she would get it. "My dad was a huge influence and we were always very close." She spoke of him with great pride in describing him as a risk-taker, and a "guy's guy."

Ms. Pixton remembers her father always saying that any job worth doing is worth doing right. We are the only one we are held accountable to. She wants to be able to say that she has done the very best at whatever she takes on.

Atefah Riazi, Acting General Manager of New York City Housing Authority, believes that she inherited her genetic mindset from her father and that risk-taking is an innate part of one's character. She attributes much of her success to her ability to take risks and move throughout her career, which she learned from her father.

INDEPENDENCE

For a woman to succeed in a technological field at the high level of the women interviewed, she must be resilient to negativity, competitive men, and stereotypical roles. She must be comfortable enough to follow her passions regardless of whether they match her prescribed career path. She must be able to say to herself: "that is what I love, and I will put in the work to go do it." When combined with a work ethic comparable to these nine women, this

independent mindset will allow them to do whatever their hearts desire and pursue their interests and passions.

For Ms. Groves, independence was developed early on through supporting her family and her strong desire to see more outside of her small town of Saskatchewan.

Ms. Cooper worked through high school because she had a desire to be independent, have money, and demonstrate that she was able to do these things.

Mary Flanagan, a digital artist who runs a game research lab at Dartmouth, thought college was great because whatever she was interested in learning, she could because there were people who could help her. She always had an independent sense to follow what she loved.

Gail Harris, an independent consultant in computer technology solutions, told a funny anecdote that demonstrates her independence about a time when her car was damaged and she called her husband for help. Upon ending the call, her husband's coworkers, who had overheard his side of the phone call, said to him "it's nice to know Gail sometimes needs her man." Gail also is happy to be an independent consultant, find her own clients, and solve her own problems.

Dean Knapp was always an independent child, and at age seventeen began college because she wanted so badly to be on her own. She has always wanted to travel and see the world.

Ms. Pixton says she grew up with the women's movement ingrained her and had an independent mother and three very independent sisters. She discussed the difficulties in having these ideas ingrained in her and having to spend time to make her own opinions and philosophies.

Ms. Riazi's parents encouraged out of the box thinking from a young age. They always told her to become what she wanted to be and do what she wanted to become.

Ms. Rising is pleased to be an independent consultant and her own boss. She says that she does whatever she wants to do.

Success in technology relies upon an individual's ability to work on a difficult problem and to self-direct and solve the problems at hand. Additionally, especially for women to be successful in technology, they must have the independence and confidence to be the only woman in the room, and pave their own way with few female role models in a male-dominated field. She must be strong enough to go against the mainstream, break stereotypes, and succeed.

MENTOR

Many women had mentors throughout their careers, which has been cited as a key in retaining women in technology.

> Mentoring can facilitate positive socialization among women to STEM fields by encouraging interaction with successful individuals and by providing career and psychosocial (i.e., combining aspects of psychological and social behaviors) support. This support helps women overcome perceived gender role barriers (Amelink).

Many of the mentors were male, but given the time period, the probability of else in a technological company being male would have been much greater than being a woman. When the women did have a mentor, they noted that it was much easier to navigate relationships within the company with a support system and some guidance. Elizabeth Stark writes in The Huffington Post about the value of mentors.

> First, they provide crucial guidance and support for younger people in the field. Second, they serve as models of what a potential technologist or entrepreneur would strive to be in the future. Third, they provide essential connections, introductions, and relationships that a budding coder or founder could not muster up on her own (Stark).

Ms. Riazi did not have mentors until later in her career in her mid-thirties. She believed that it was helpful to have those mentors.

Ms. Pixton had several mentors, including one very influential man named Frank who gave her a programming job after she learned to write programs to do her physics homework for her. Frank encouraged her to pursue graduate school when she approached him for a recommendation for the Peace Corps. She had other mentors as the time went along, and quickly learned the value of these connections and "knowing someone on the committee," as she says.

Dean Knapp's Aunt Mary was a role model for her when she was in her early career in New York City, as Mary was the only woman in her family with a job. She also had a male mentor who was her boss when she worked at the New York Times who promoted her to manager despite her doubt that she could do it.

Ms. Harris took a programming class in college because she needed it for astronomy, and in that class, she did so well that the TA, who did not know she was only taking the course for astronomy, wrote on her exam "see you next year in computer science!" That comment made her rethink her major and switched to computer science.

Ms. Groves discussed many of her colleagues in computing and believes that the women who have been successful have figured out how to have sponsor or mentor higher up in the company. Without that, it seems to be a huge stall in career development, particularly after women have children she says.

> The socialization of women as compared to men is particularly relevant to their success in the sciences and engineering, because women are often less confident in and more alienated by the culture of fields that do not fit with their own learned styles. That traditional SME education has emphasized individual competition and offered few

opportunities for cooperative and interactive learning may have contributed to the loss of women in the recent past (Ginorio; Seymor).

PROBLEM SOLVER

The field of computer science requires a sharp logical mind, the ability to problem solve, and the desire to tackle hard problems. "Every practitioner of the discipline must be skilled in four basic areas: algorithmic thinking, representation, programming, and design" (Denning). Algorithmic thinking involves creating "step-by-step procedures that give unambiguous results when carried out by anyone (or by a suitable machine)" (Denning). Representation involves organizing data to facilitate the algorithmic processing, while "programming enables people to take algorithmic thinking and representations and embody them in software that will cause a machine to perform in a prescribed way" (Denning). Finally, "design connects the other three skills to the concerns of people, though the medium of systems that serve them. Design includes many practical considerations such as engineering tradeoffs, integrating available components, meeting time and cost constraints, and meeting safety and reliability requirements" (Denning).

Each woman identified with solving problems, using her brain to think about difficult and complex ideas, and the majority included the 'truth' of mathematics. Each described her love of logic, rationalizing about things, and some included philosophy. Many love to read and feel that the education process is never-ending.

Ms. Riazi describes her interest in learning and solving problems, no matter if they are technical, organizational, or social. IT people are problem solvers, she says, and are attracted to things that are broken.

Ms. Pixton described her love for mathematics and logic, and even took a course in philosophy on symbolized logic. Her circuits class in college was fascinating to her, where was able to make adders and subtracters. She loves to think and solve problems.

Dean Knapp was drawn to technology because she liked the rational thinking and the opportunity to problem solve.

Ms. Harris was drawn to mathematics because the answer was known and she liked to be able to logically prove and demonstrate that she was right. Similarly, Dawn was drawn to math and science because with writing papers there were shades of gray, but with math and science, there was always a right answer.

Ms. Cooper has a very strong desire to achieve and learn new things and thrives on the complexities involved with the field of managed services and learning how to pull a business together.

Ms. Groves liked the problem solving aspect of computer science, but was fascinated with the idea of creating animations. When she finally was far enough along in college to take an animations class, she was disappointed by its tedious and repetitive nature. By that point, though, she had moved into the business side of technology and was turned on by how amazing technology can be in solving problems and solving tedious jobs so people can be freed up to do more interesting things.

Moving into Management

Connected with their desires to solve problems, as many of the women moved into management, the most common reason cited being a desire to solve more complex problems. After years of experience with development and field work, women felt that the problems became black and white and easy to solve. In an effort to pursue more difficult things, many women accepted promotions and shifted into management-level positions where they found the work to be more interesting and rewarding. Managing people, motivating people, and handling complex relationships between workers became more interesting problems than development.

Ms. Riazi describes her interest in diverse problems and problems with a social and human impact. She likes complex problems and grew bored with strict technical problems and wants to see an impact on the world.

Ms. Pixton believes that managing people is more interesting than software. Software has breadth but not as much depth, she says. According to her, the problems of software are not really complex and after a while, one gets to the point where she sees a problem and knows how to do it. People are always different and always changing, and that is more interesting than anything.

Ms. Curlee was excited to take on the new challenges outside of technology. The challenge for her became less about the black and white problem solving and more about politics and navigating relationships.

For Ms. Cooper, programming was never a love and she quickly moved into management. Her experience with technology gives her the credibility to manage data centers worldwide.

PERFECTIONIST

Many women identified with the mindset of perfectionism in one way or another. A few referred to their nature as closer to striving for excellence rather than an obsessive need for perfection. Most have pride in their work and always strive to be better, do things more efficiently, and to learn more. In particular, Ms. Curlee mentioned that the highest percentage of the employees at her company, Tendril, are ISTJ on the Meyers & Briggs scale, which is defined as hard-working, perfectionist, responsible, analytical, and organized (Meyers & Briggs) – many similar characteristics to the positive father complex discussed earlier, and also an effect of the messages of a fixed mindset that young girls tend to receive.

Ms. Pixton's father taught her the importance of doing quality work and learning that any job worth doing is worth doing right. She believes in doing her best work.

Although Dean Knapp does not directly identify as a perfectionist, she says that she overprepares for lectures and teaching, and has taken to a time-management technique called 'time-boxing' which allots a fixed period of time for each task to avoid overly perfecting every task.

Ms. Curlee found difficulty in realizing that she could not please everybody all the time. She takes pride in her work and has always been an overachiever, so being in a position where the demands always exceeded her capacity and always having to say no to people is difficult.

Ms. Cooper is competitive in the sense that she always wants to achieve at a high level. She competes with herself to always be better and always achieve and grow.

Ms. Groves said "computer science is a profession that rewards perfectionists. After all, software either works or it doesn't. There's not a lot in between." It is more about an attitude of excellence, she says, than a neurotic OCD.

NON-LINEAR CAREER PATH

Several of the women found themselves moving from career to career, or laterally within a company, in an attempt to follow their interests and find more interesting things. Many women repeated the same story of becoming bored in one position and shifting to another that would suit their interests and fuel their desire for challenges. There is a universal desire to always learn and a belief that the learning process never ends. Many women had diverse interests outside of work and pursue other activities in order to continue to achieve and learn in many disciplines.

Ms. Rising went from being a practicing software engineer, to teaching and consulting with just a Master's degree, to a PhD in computer science. She has, as she says, an enormous

number of degrees in computer science, math, and chemistry. Now she is an independent consultant, speaker, and advisor.

Ms. Riazi describes her career as a patchwork of jobs. Her first job was as an engineer for a government entity in New York. She began as an electrical engineer and travelled around working in the plant. She was either promoted or made a lateral move every three years. She worked for governments, private industries, and not for profit organizations in the fields of marketing, manufacturing, as the head of policies, head of audits, and now the general manager of the New York Housing. The most challenging part of a job is the first six months, and she has the mindset of a risk-taker to make so many career moves and not settle into a sense of stability.

Ms. Pixton began with working on a deep sea manganese mining project, then moved to Honeywell to build sea positioning systems, and back to school for a Masters in computer science. After this, she went to Switzerland to manage the development of control systems for electrical power plants, then to San Francisco to work as a product manager for systems for nuclear power plants, then to manage the electric stock exchange for the Swiss banks, and back to Salt Lake City to be an executive for a technology department at a bank. Finally, after all of this, she moved into consulting and leadership development. About five years ago, she formed Accelinnova, which focuses on leadership development and consulting. When in high school and in college, she was a dancer, but abandoned that after she decided it involved too many changes of clothes.

Dean Knapp says “there is no such thing as a linear career. There is this fantasy of a linear career, but in reality it bounces around. It pays to be independent to survive and get what you want in a bouncy career.” She worked in many jobs beginning with the New York Times before she returned to her original dream of teaching.

Ms. Harris has many interests outside of her career as an independent technology consultant including figure skating, gymnastics, and skiing. Her second career, she says, will to be a ski instructor, and she already has her first level of certification. She says she just does not want to spend every day, month after month, doing the same thing. Not one thing interests her, and she just wants to do new things.

Ms. Flanagan moved through her career by following what she loves. She earned her MFA in film making and learned to code through film animation. She now works on board games and some iPad apps as a game designer. She has always figured things out as she needs them and moves towards the activities that she loves.

Ms. Curlee has worked in the areas of leadership and cultural high performance, consulting, and business. She built the Information Technology group as the Senior Vice President of Global Technology Solutions. She also worked in telecommunications as an Associate Partner at Accenture. She currently works at Tendril as the Vice President of Human Capital.

Ms. Cooper works in global information technology operations running data centers, mainframe, and database administrations reports. She has recently made a move to VAR to act as Vice President of Operations and COO by the end of the year. She will solve problems dealing with managed services, client relations, and market analysis. Although she has not acted in some of these roles before, she is excited for the challenge and the opportunity to try new skills.

Ms. Groves is currently a senior product manager at IBM. Before that, she worked in development ranging from the technical side to prototyping the application with the customer, to

specifying database design, functional requirements, and system requirements. She has an interest in data visualization and loves turning data into pictures.

PATTERNS AND CONCLUSIONS

The experiences revealed through the interviews showed key similarities, patterns that are perhaps indicative to their successes. Valuable lessons were learned as young children, driving them to the great places they have gone. A strong work ethic, the mindset of enjoying a challenge and the subsequent joys of regarding failure as an opportunity to learn and a desire to always strive to be better and find harder problems to solve were instilled in them from a young age.

These values were formed by the respondents' earlier experiences. Each learned the value of hard work early in life, many from their fathers, and noted their strong desire to follow their passion always in search of harder, more complex problems to solve. The majority were independent by high school, by taking care of younger siblings, taking care of the family, or working at a part-time job to earn money for themselves or to help support the family. A few had early experiences with technology, introduced by a technical dad, but most expressed an early desire to solve problems. All mentioned a desire to succeed, and identified with being a perfectionist on some level and striving for excellence.

PERSONAL IMPACT

On a personal note, as woman in computing graduating into my career, speaking with these nine women was like having a conversation with myself. Many of the experiences were common among the women and resonated with me as well. At the end of high school, I took up ballet out of boredom with the problems that I was solving and saying that ballet was the hardest thing I could do. One woman had a similar experience, but left dance after several years of seriously pursuing it because she just did not want to change her clothes so often (my reason is

not liking to have my hair in a bun). Aside from that very close experience, listening to very successful women speak about their desires to work hard, challenge themselves, persist through hard times, and always find bigger and better problems to solve was akin to my own interests and values. Perhaps this common insatiable desire for independence, greatness, and challenges is indicative to success in this field.

During the research process, many common issues resonated with me more than I thought they would. I describe myself as confident, independent, and hard-working, but upon reading so many studies of the difficulties of women trying to make it in computing, I could not help but see some of myself in them, similarities that I had not noticed before. Recently, I was the sole developer for a grant-based web art project that was designed as an interactive web app. When the time came to upload the application to a web server, I found myself recoiling in fear. I had never deployed anything to a server and compared myself to my male peers who had prior experience with servers in the past and knew already how to do it. I was afraid of messing up the server or the project and then looking dumb asking for help. After consciously recognizing this instinctual fear, I was reminded of the literature for this discussion, and repeatedly reminded myself that it is okay to mess it up, that trying and failing is the best way to learn and that I am probably incorrectly estimating my skills (as so many girls entering technology do).

Another example occurred when my software engineering class took the final computer science standardized test. During the test, I felt like I did not know any of the questions and found myself thinking that the guys (the rest of the class) would know what they were doing. Then, again, I recognized this and was very surprised to see these thought patterns creeping into my head. This also happened when I received a low score for my standards in networking class and was hard on myself for not doing better. Come to find out, the average was much lower, and

the highest score was only a bit above mine. My expectations do not match the expectation that the course is a hard course and low grades are common.

A final example happened when I began interviewing for entry-level jobs. I became nervous when the time came to discuss salary and was afraid to negotiate or ask for a higher salary.

> Sara Laschever, co-author of "Women Don't Ask: Negotiation and the Gender Divide," [found that] "20 percent of women say they never negotiate at all. And in the current recession, which has made many job seekers feel grateful for any work they can find, even a part-time toehold can feel like a victory"… "Instead, young women regularly set lower salary targets for themselves than men do, and there's a direct correlation between what they aim for and what they get. Because men aim so much higher, they come away with a lot more" (Fairbanks).

I, as well, have stumbled upon a pitfall that so many women in technology face. With awareness, however, this can be changed and next time I interview, I will be more likely to negotiate to earn the value of my worth.

Women like myself can benefit from the knowledge of these issues alone in order to avoid the pitfalls, avoid becoming discouraged, and realize that they are not alone with these issues.

Recommendations and Community Impact

While writing my conclusions, I overheard a conversation on the subway between two men and a woman, all three probably in their mid-twenties. The woman was talking about not being able to learn the harmonica, and one of the men said it was so easy to learn. She replied promptly she had tried to learn many instruments but just couldn't. The man encouraged her by saying that "anyone can learn an instrument, it just takes dedication. No one's good at it right

from the beginning," he said, "there aren't really any 'naturals.'" She replied with a shrug. Two stops passed and the conversation continued. Then the second man said something about not being able to learn piano despite being able to play guitar. The woman replied by saying "all you have to do is believe that you can do it, and you can." Here she was, encouraging a growth mindset for this man, while just a few minutes prior, she was insisting on her fixed mindset towards learning an instrument.

In some respects, we have identified the problems – one needs to adopt a growth mindset and just "believe" as this woman said – yet the problem still exists because that same person cannot take her own advice. Adopting a growth mindset, solving problems of underrepresented women in technology, and taking the advice of the research that has been done is more difficult than it seems.

In conducting my research and studies, it is clear that as a community, we can identify many problems as well as potential solutions to them, yet have not put widespread solutions into action. Problems with stereotypes and perceptions are difficult to solve and change; however many actions we take even as simple as changing the way we speak to children, can have a large impact on the problem. This research will allow teachers, mentors, and parents to identify thoughts, behaviors, and experiences in girls and women in order to encourage them to pursue fields where they have great potential to succeed. When these patterns are recognized, it is necessary to talk to girls, and have honest conversations about the difficulties discussed here to help guide them and encourage them.

APPENDIX I: BIOGRAPHIES OF INTERVIEWED WOMEN

COOPER, TERRI. INTERVIEWED 13 MARCH, 2012.
Vice President, Operations at Trace|3

Terri has spent over 20 years in Information Technology working in all facets of IT. At Trace|3 Terri is responsible for product development of a Managed Services offering and building out and operating the resulting practice for Trace|3. Terri is also responsible for establishing the internal operations function of the company leveraging her years of experience in building best practices and right sizing processes to reduce costs and deliver high quality service in support of the business.

Terri spent 5 years at CSG International. At CSG Terri was responsible for IT Operations for the Service Bureau (Software as a Service) and Managed Services businesses as well as support for internal IT operations around the world. This included Data Centers, BCP, Product Support and Operations, Infrastructure and Network Operations, Vendor Management, Platform Architecture and Engineering.

Terri accepted a position in 2002 with structure, a subsidiary of Level 3 at the time) changing her focus from software development to Infrastructure and Data Center operations. Structure provided Data Center outsourcing services. She was responsible for the design and deployment of a corporate wide PMO. Terri soon took on the role of Vice President, Technology Services. In that capacity her responsibilities included the Mainframe and Open Systems lines of business as well as the PMO, Disaster Recovery and Service Desk functions.

Terri joined Level 3 Communications in 1999 as Director, Revenue Systems. She was responsible for the selection and implementation of Level 3's billing platforms supporting both customer and Intercarrier billing. She was also responsible for managing the testing and production support organizations.

Terri started her career in 1989 with Accenture (formerly Anderson Consulting) developing and implementing customer care and billing solutions at major US based communications providers. While with Accenture she was able to develop expertise in both custom system development as well as the implementation of commercial off the shelf products. This gave her deep exposure to all aspects of the development processes across both types of programs.

Terri serves as a Middle School Sunday School teacher and on the Community Outreach and Capital Finance Campaign Committees at Lutheran Church of Hope in Broomfield, Colorado.

Terri received her Bachelor of Science degree in Economics from Purdue University in West Lafayette, Indiana.

CURLEE, DAWN. INTERVIEWED 12 MARCH, 2012.

As the VP of Human Capital of Tendril, Dawn Curlee's area of focus is in the area of Cultural High Performance. She is working to achieve a corporate environment of candor, mutual accountability and trust. Prior to Tendril, Dawn spent 10 years working with executives around the globe from start-ups to Fortune 100 companies in the areas of Leadership and Cultural High Performance. As the President of Verdure Corporation, her work has ranged from Personal Effectiveness Coaching (individuals), to High Performance Workshops (teams and organizations) to Cultural Transformation Initiatives (companies). She has worked with hundreds of executives during the course of her consulting career. Dawn brings a unique business executive perspective to the HR function, as her experience prior to consulting was with Level 3 Communications as the Sr. Vice President of Global Technology Solutions. She was responsible for building the Information Technology group into an organization of over 500 employees on

three continents. Prior to that, she was an Associate Partner with Accenture in the telecommunications practice. Dawn holds a BS degree in Industrial Engineering (Computer Science) from Stanford University.

FLANAGAN, MARY. INTERVIEWED 19 MARCH, 2012.

Mary Flanagan is an innovator focused on how people create and use technology. Her groundbreaking explorations across the arts, humanities, and sciences represent a novel use of methods and tools that bind research with introspective cultural production. As an artist, the collection of over 20 major works range from game-inspired systems to computer viruses, embodied interfaces to interactive texts; these works are exhibited internationally. As a scholar interested in how human values are in play across technologies and systems, Flanagan has written more than 20 critical essays and chapters on games, empathy, gender and digital representation, art and technology, and responsible design. Her three books in English include Critical Play (2009) with MIT Press. Flanagan founded the Tiltfactor game research laboratory in 2003, where researchers study and make social games, urban games, and software in a rigorous theory/practice environment. She is the Sherman Fairchild Distinguished Professor in Digital Humanities at Dartmouth College. Find more about Mary at http://www.maryflanagan.com; http://www.tiltfactor.org.

GROVES, TINA. INTERVIEWED 18 MARCH, 2012.
Senior Product Manager, IBM Canada

Tina Groves leverages her 25 years' experience in analysis, event processing and information-driven applications to lead the collaborative decision making area. Her achievements include a design patent and a project included in The Smithsonian Institute's Time Capsule of 1995 for exemplifying unique application of current technologies.

HARRIS, GAIL. INTERVIEWED 13 MARCH 2012.
Executive and Principal Consultant, Instantiated Software Inc.

Successful in delivering the right systems to achieve business goals using her visionary leadership style and strong communication skills to inspire trust and foster teamwork. These systems invariably increase revenues, attract new customers, build market share and improve operational efficiency.

Embraces agile approach, valuing individuals and interactions over processes and tools, working software over comprehensive documentation, customer collaboration over contract negotiation and responding to change over following a plan.

Successfully applies and adapts appropriate technologies, methodologies and industry best practices using a deep understanding of the purpose and effects of systems, packages, procedures and methods.

Excellent in business and technical analysis with polished presentation skills for explaining complex technical concepts to non-technical audiences.

Expert in software project management, software engineering and system development, delivering enterprise IT projects on multiple platforms applying a whole-system perspective.

Experienced in delivering secure, web-enabled case management, billing, administrative, customer facing and other software systems to financial, human resources, administrative, and government sectors.

KNAPP, CONSTANCE. INTERVIEWED 20 MARCH 2012.
Constance (Connie) A. Knapp is the Interim Dean and a Professor of Information Systems at Pace University's Seidenberg School of Computer Science and Information Systems. She has served as a faculty member since 1985. She earned a PhD in business from the City University of New York Graduate Center, an MBA from Fordham University and a BA in mathematics

from the State University of New York at New Paltz. Prior to joining Pace University, Connie worked for fifteen years in various industries: in insurance as a programmer and a management scientist, in time-sharing as a corporate trainer, and in newspapers as a manager of financial information systems.

PIXTON, POLLYANNA. INTERVIEWED 25MARCH 2012.

An international collaborative leadership expert, Pollyanna Pixton developed the models for collaboration and collaborative leadership through her thirty-eight years of working inside and consulting with corporations and organizations. She helps companies create workplaces where talent and innovation are unleashed—making them more productive, efficient, and profitable.

Pollyanna is a founding partner of Accelinnova, president of Evolutionary Systems, and director of the Institute for Collaborative Leadership. She speaks and writes on topics of creating cultures of trust, leading collaboration, and business agility. Her models are found in the book she co-authored, Stand Back and Deliver: Accelerating Business Agility, (Addison Wesley Professional, July 2009).

Ms. Pixton was primarily responsible for building the Swiss Electronic Stock Exchange, developing sophisticated control systems for electrical power-plants throughout the world, and converting complex technologies and data systems to merge large financial institutions. Her background includes leading the development of e-commerce projects, real-time applications, positioning systems, and original computational research. In 2004, she was selected as one of thirty Visionary Women to Watch, a program that recognizes women who bring new insight to their fields, and in 2010 she was selected for achieving that vision

as 30 Women to Watch, awarded by Utah Business Magazine. Pollyanna is a sought-after keynote speaker and lecturer at universities in the areas of business ethics, organizational development, and collaborative leadership.

Her education includes a master's degree in computer science, three years of graduate studies in theoretical physics, and a bachelor's degree in mathematics. Contact her at ppixton@accelinnova.com.

RIAZI, ATEFEH. INTERVIEWED 26 MARCH 2012.

Atefeh (Atti) Riazi is a senior IT executive and a philanthropist. She has served in both the public and the private sector as a CIO managing large scale Technology projects and initiatives. Currently, as the CIO of NYCHA Atti is responsible for all aspects of technology with the mission to deploy smart building and energy initiatives aimed to reduce the agency's carbon footprint while focusing on deploying broadband services aimed to reduce the digital divide. Atti is also the Executive Director of CIOs Without Borders - a global non-for-Profit organization, focused on using technology and innovation for the good of humanity. She was recently the Senior Partner and Global Chief Information Officer of Ogilvy and Mather Worldwide, a leading global Marketing and Communications agency with 497 offices in 125 countries supporting more than 2,300 clients. In her role as CIO, her focus was in driving the technology strategy to create efficient business processes across the organization. Throughout her career, she has had a tremendous track record of innovation and successful large-scale deployments allowing for productivity gains and competitive advantage. Atti has managed the global systems and infrastructure network supporting an integrated, cross-discipline organization providing marketing communications across all media. Atti was ranked in #49 amongst the top 100 global CIOs. Under Atti's leadership Ogilvy and Mather has earned a place on InformationWeek's 500

list of innovative IT organizations. Atti is a graduate of electrical engineering with over 23 years experience managing large organizations, private and public, in the manufacturing, engineering, advertising and transportation sectors. Most recently, she was Vice President and CIO of Technology for MTA New York City Transit responsible for implementing the $1.5B MetroCard in New York City. Prior to that she was the Sr. VP of Manufacturing. Atti has published many articles and studies. She speaks frequently on issues involving technology, organizations and work. . She has delivered keynote addresses and seminars globally and serves on the Board of major financial and marketing organizations.

RISING, LINDA. INTERVIEWED 13 MARCH 2012.
With a Ph.D. from Arizona State University in the field of object-based design metrics, Linda Rising's background includes university teaching and industry work in telecommunications, avionics, and tactical weapons systems. An internationally known presenter on topics related to patterns, retrospectives, agile development, and the change process, Linda is the author of numerous articles and four books—*Design Patterns in Communications, The Pattern Almanac 2000, A Patterns Handbook,* and *Fearless Change: Patterns for Introducing New Ideas,* written with Mary Lynn Manns. Find more information about Linda at www.lindarising.org.

APPENDIX II: INTERVIEW QUESTIONS

1. Tell me a bit about yourself. What is your background – education, career, early life?
2. What was school like for you? Did you enjoy it; rather do your own work; hate it?
3. If mentioned hard work at some point: Where do you think you got the mindset to work hard and persevere?
4. Did you have any mentors throughout your career or early life? Parents, bosses, colleagues?

5. If moved away from technology into management: What made you decide to take that switch?
6. Would you say you were an independent child?
7. Would you describe yourself as a perfectionist or an overachiever? Or are you satisfied without making things perfect?

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