The Training and Retention of Women in Science Technology Engineering Mathematics and Related Fields

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The Training and Retention of Women in STEM

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A thesis submitted to the faculty of Radford University in partial fulfillment of the requirements for the degree of Master of Fine Arts in the Department of Design Thinking.

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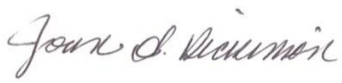

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Abstract

This study examined the factors that determined whether women will stay in science, technology, engineering, and math (STEM) related careers. While research on discrepancies between the number of men and women entering STEM-related majors and career paths has been conducted in the past, there was not much research that examined why these discrepancies existed and how to eliminate them. The purpose of this study was to use Design Thinking strategies to explore women's experiences as students and in a STEM-related profession to determine the factors that either keep them in STEM or drive them away. From there, solutions were developed that would help women remain in STEM.

The research began with a group of six educators who teach STEM curriculum who participated in a concept map activity. The goal of this activity was to identify career paths that are most closely associated with the field of STEM. Once these fields were determined, the researcher conducted a series of interviews. Eight women who did not enter a STEM major but ended up in a STEM career were interviewed. Three women who did enter a STEM-related major in college but ended up in a different career field were interviewed. The largest group of interview subjects was 13 women who studied STEM and remained in a related career. Using recordings and typed notes from the interviews, these different points of view were examined more closely in an Experience Diagram. Based on the interviews and Experience Diagramming, the researcher created eight unique Persona Profiles. Lastly, a group of three women who had participated in earlier portions of the study volunteered to meet once more to complete a Concept Posters activity. By comparing the experiences of different women, opportunities to support women in STEM began to emerge. Intentional and meaningful mentorship arose as one of the

main solutions to supporting women in STEM. Additionally, there was a need to represent women more equitably in many areas, including the media, leadership roles, and in awards and grant allocation. Finally, women need support to work outside of the home and raise a family (or be a caregiver of any type).

The majority of women interviewed for this study both majored in and work in a STEM-related career, but still faced challenges with being a woman in their profession. This study aimed to identify those challenges and develop solutions using the Design Thinking methods outlined above.

Acknowledgments

This thesis would not be possible without the support of the many incredible people in my life. Kristin Machac, thank you for your support, encouragement, and commitment to my success. Dr. Joan Dickinson, thank you for understanding my vision for this project and helping me execute it. To my thesis committee, I appreciate your thoughtful feedback during this process.

Furthermore, I want to extend a huge thank you to my mother, who always believed that I could complete this project, even when I did not believe in myself. It turns out you were right.

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Introduction

Regarding science, technology, engineering, and mathematics (STEM) related coursework and, more specifically, mathematics, researchers have concluded that there is no discernable difference in ability between boys and girls. Experts state that if gender differences do exist, they are small and only affect specific areas of math skill (Azar, 2010). However, girls and young women tend to lack confidence in their abilities related to the STEM field. This lack of confidence appears in their achievements in school and career. It also leads young women to leave the STEM career track. Female college students are 1.5 times more likely to leave STEM after taking the first course in the calculus series (Kuo, 2016). As a young girl, I felt this lack of confidence in math and science and often second-guessed my abilities. Later in life, I can still feel the ripple effect of this lack of confidence I experienced in school. While I do not know if a career in science or math was in my future, I do know that I quickly ruled out these possibilities because I believed that I was a keen humanities student, and not a scientist or mathematician.

Female confidence in STEM-related coursework is reflected not only in standardized test scores and choices made in higher education but also in career paths that women take. Although women make up half the workforce in the United States, they are underrepresented in STEM-related fields. According to a report published by the National Girls Collaborative Project (as cited by Anderson, 2016), women made up nearly half of the college-educated workforce but only 29% of the science and engineering workforce. The report also stated that women were significantly underrepresented in high-paying, math-intensive fields, earning only 19% of bachelor's degrees in engineering and only 18% of computer science degrees. Additionally, minority women comprised fewer than 1 in 10 employed scientists and engineers. This

discrepancy is especially problematic when considering the rate of growth in these job markets (Anderson, 2016).

In 2015, there were 9.0 million STEM workers in the United States, approximately 6.1% of all workers in the country. Companies like Amazon, IBM, and many others had thousands of STEM job postings listed. The STEM job market grew much faster than employment in non-STEM occupations over the last decade (Catalyst, 2016). Of those employed in STEM fields, women accounted for only a third of the workforce. If women were to compete for jobs in the growing field of STEM, they needed the confidence to develop their STEM skills. A heightened sense of confidence is also necessary if women expected to receive a competitive salary in STEM-related fields.

If the achievement gap and discrepancies in the workforce were to be reconciled, women had to feel empowered to pursue careers in the STEM field. Closing the gender gap in STEM careers was critical to creating a workforce that reflected our diverse population and allowed women to thrive in male-dominated fields. This study used design-thinking strategies to examine the various journeys that women took when entering STEM majors and conversely analyzed why women chose to pursue different careers rather than stay the course with STEM. It also examined the systems in place that either support or discourage women from pursuing STEM careers.

Definition of Terms

Concept Map: A design-thinking strategy that allows for different ideas to be displayed visually. A typical map includes concepts (nouns) and relational links (verbs) related to a given subject area. Joseph Novak created this strategy as a technique for organizing concepts that illustrate a thorough understanding of a given topic (LUMA, 2012, p. 38).

STEM: Science, Technology, Math, Engineering.

Experience Diagramming: A design-thinking strategy that helps to visualize event-based research. It helps the researcher consider the impact of critical moments in a person's experience. An experience diagram allows one to pinpoint key decisions, highlight when and how specific tools were employed, and identify others who were a part of the experience (LUMA, 2012, p. 36).

Persona Profile: An informed summary of the mindsets, needs, and goals typically held by key stakeholders. They are a fictional characterization drawn from real research data. Persona profiles are comprised of illustrations, descriptive text, and a photo portrait (LUMA, 2012, p. 34).

Verbatim: Using direct quotes and anecdotes from the study participants that capture their unique individual experience.

Concept Poster: a presentation format illustrating the main points of a new idea (LUMA, 2012, p. 75).

Literature Review

Women's Confidence and Achievement

Several factors pointed to women lacking confidence in their STEM abilities, and this lack of confidence emerged as early as elementary school. While factors show that the genders have differences in math confidence and achievement, they are not linked to actual math ability.

The "stereotype threat" was the prime culprit that leads to girls and young women lacking confidence in math. The stereotype that boys are better at math than girls has perpetuated since the 1960s and '70s (Price, 2008, p. 11). "The stereotype is damaging because it demoralizes young girls who might want to pursue careers in mathematics and engineering, and it may also influence how teachers treat male and female students" (Price, 2008, p. 11).

This threat of being stereotyped begins as early as kindergarten. The National Center for Education Statistics' Early Childhood Longitudinal Program (as cited by Anderson, 2016) tracked two groups of children from 1998-1999 and 2010-2011. These students completed standardized testing from the Department of Education, and concurrently, their teachers were asked to rate their math-related abilities on a five-point scale. The researchers discovered that when kindergarten begins, girls represent 48% of children in the top 50th percentile for math performance, but by second grade, they only make up 38% of children in the top 50th percentile. Additionally, girls made up 33% of the 99th percentile in kindergarten, but by the end of second grade, they were only 15%. While these numbers were worrisome on their own, the author also stated that teachers perceived girls with nearly identical mathematical and behavioral profiles to be significantly less able than their male counterparts (Anderson, 2016).

Girls were not only experiencing negative perceptions of their math ability at school but at home as well. Low expectations amongst parents was another factor affecting low confidence in math for girls. The journal *Sex Roles: A Journal of Research* stated that parental attitudes about the sexes had an impact on girls' confidence. The research found that when parents endorsed the stereotype that math was a male domain, their daughters underestimated their math abilities (United Press International, 2005). A study published in the *Journal of Economic Perspectives* stated that mothers who endorsed a male-math stereotype underestimated their daughters' ability in math (Niederle & Versturlund, 2010).

These perceptions were essential for a child's confidence because children's self-evaluation of their academic competency appeared to be strongly related to their parent's appraisal of their academic ability, rather than their actual academic performance (Niederle & Vesterlund, 2010).

As one might predict, when girls felt a lack of support and confidence in their abilities from their parents and teachers, they began to believe they are not capable. In a study conducted in the Netherlands, girls were surveyed on their attitudes about STEM achievements. It was found that girls had low confidence and self-esteem in STEM-related fields compared to their male counterparts, and even derived less pleasure from STEM subjects. These factors contributed to fewer girls being motivated to pursue STEM-related coursework and programs, and they aspired less to STEM careers (van Langen, 2015).

Confidence in STEM subjects is an issue that has plagued young women for decades and has long-term effects on women in the workforce -- limited role models for young girls in STEM-related fields meant fewer women pursuing these types of professions. Goodman and Damour (2011) identified ways girls are harmed regarding STEM role models:

> The dearth of STEM role models harms girls in two ways. First, as girls begin to consider college majors and career trajectories, the choice of STEM fields is not reinforced by respected role models; second, the lack of female role models reinforces some negative stereotypes held by girls and young women about STEM fields. (p. 1)

If young girls did not see themselves reflected in fields requiring strong math skills, they would continue to believe their negative perceptions about their abilities. They would also deal with the negative attitudes held by their peers and professors.

Perceptions of Women in STEM

The perception of girls as inferior in STEM-related fields had ripple effects well beyond their time in grade school. Once women entered higher education, they were perceived by both their peers and professors as less capable. In a study published by the journal *PLOS ONE*, male biology students at the University of Washington ranked their female peers as less knowledgeable than their male peers, even if the female peer was a higher performer. The male students ranked their male peers higher by three-quarters of a GPA point than their female peers. Meanwhile, female students did not exhibit the same bias against their male peers (Grunspan, 2016).

In addition to their male peers, male faculty were less likely to respond positively to work produced by female students. In a study published by the *Journal of Applied Psychology*, it was shown that male professors responded to the inquiries of potential doctoral students if their name was a typical white male name. They would not respond to a name that sounded or was perceived as a female or a man/woman of color at the same rate (Akinola, Chugh, & Milkman, 2015).

Once women entered the workforce, they continued to face hardship and even discrimination from their male peers. In a study conducted by the American Institute of Physics, researchers looked at people who received physics PhDs in the United States in 1996, 1997, 2000, or 2001 and worked in the country in 2011. Results indicated that equally qualified women in terms of education, employment sector, and postdoctoral experience made, on average, 6% less than men (American Institute of Physics, 2017). A similar study asked a panel of academic psychologists to evaluate the qualifications of potential assistant professor candidates. Two candidate packets, labeled "Brian" and "Karen," were submitted to the panel for review. The group chose "Brian" 2:1 over "Karen," even though the application packets were the same (Anders, Ritzke, & Steinpreis, 1999).

What Do Women Have to Say?

In a research study published in *Frontiers in Psychology*, researchers surveyed 5,562 women who had a bachelor's degree in engineering to understand the high attrition rate in their field. The women were asked to share their opinion and experience on why women would leave engineering. Of the women surveyed, approximately 27% (1,464) of the participants chose to leave the field of engineering, 10% (554) never entered the field of engineering, and 60% (3,324) were still in the field as of 2009 (Chang, Fouad, Singh, & Wan, 2017).

The balance of work and home life was a significant factor for women who decided to leave engineering careers. With an expectation of 40+ hours of work a week, women stated that it was challenging to balance a career and home life. Women who had children shared that leaving work to care for a child and then returning was extremely challenging. There was limited flexibility in engineering, and as it was expressed in the study, there are limited opportunities to work part-time (Chang et al., 2017). Additionally, the study stated that childcare was a

significant expense that women had to consider when looking at their overall finances, which was tied to compensation. One participant of the study stated, “The cost of childcare was very high…in my case, it became financially illogical to continue working, and my job satisfaction alone was not enough to keep me there” (Chang et al., 2017, n.p.).

Beyond the issue of the high cost of childcare, unfair compensation was stated as a reason for women deciding to leave engineering. Women pointed to unfair pay between men and women who had the same skill level. In the study, a woman stated that the difference in pay made her consider a career change to a field that would pay more and went so far as to say that she would return to get an MBA rather than stay in her current position (Chang et al., 2017).

Lack of representation in engineering was stated as another reason women did not stay in their positions. Women said that it was challenging to be the only woman in the field:

> The biggest problem I experienced was a lack of a female mentor. My last two years working as an engineer, I finally found a female mentor; however, she was the comptroller of the company, not an engineer. I had no female to whom I could look up to. (Chang et al., 2017, n.p.)

The women in the study said that if they had a female mentor, they would have considered staying in their positions for a more extended period (Chang et al., 2017).

According to this study, violations of both ethical and moral standards were another reason women decided to leave their engineering jobs. One participant of this study reported that ethical concerns were not well-addressed and that her company often paid hefty sums of money to make their problems go away. Additionally, it was stated that “unmet safety needs took the form of unfair, and sometimes illegal, organizational practices and policies” (Chang et al. 2017, n.p.).

In the most extreme of situations, women stated that instances of discrimination and sexual harassment drove them out of their jobs in engineering. One participant in this study reported that her boss encouraged her to sleep with their customers, and when she refused to do so, her boss filed sexual harassment claims against her (Chang et al., 2017).

Current Initiatives to Address Inequalities in STEM

Despite the many reasons women chose to leave STEM, there were still initiatives and programs that are being implemented worldwide that encouraged girls and women to learn, to stay, and to succeed in STEM. People in the private sector, women who have found success in STEM, and even lawmakers took steps to create opportunities for women in STEM. In some cases, specific laws were put into place to protect women's rights, while in other cases, women worked to share their knowledge to support the next generation of women in STEM.

Many countries have implemented laws to ensure better equality between genders, including specific legislation supporting women in STEM. In France, a plan was launched to promote equality between men and women in the digital sector. The program helped women in the digital sector by offering orientation and continuing education and access to employment and entrepreneurship (Organization for Economic Cooperation & Development, 2018). In the United Kingdom, steps were taken to increase the percentage of women taking A-Levels in STEM subjects by 20% (OECD, 2018).

General Electric (GE) had a Women's Network program that provided professional development and other opportunities for women to grow their careers. According to GE's data, the Women's Network had 70,000 participants in 60 countries over the past 20 years. They provided over $1 million in scholarship donations to "develop, inspire, and retain female professional talent" (GE, 2020, n.p.). These programs were extended to women working at GE,

but they also worked with girls in middle school to help retain their interest in STEM. Camps hosted across the United States have been helping and have impacted up to 700 girls.

Globally, the G20 supported different programs that address gender inequality in STEM. In Bangladesh, a program called The Girl Effect "helps build young women's leadership voice and agency by training girls aged 18-24 in data collection techniques and mobile technology to collect real-time data in their communities" (OECD, 2013, p. 110). By teaching girls these digital skills, the Girl Effect aimed to help girls strengthen their voices within their communities.

Advice from Women to Women

As women continue to find their place in STEM, they imparted their wisdom to other women trying to find success in STEM industries. In an article published by the *Harvard Business Review*, author Laura Sherbin identified qualities that successful women in STEM have in common. In addition to displaying confidence and taking ownership of ideas, Sherbin stated that women who are successful in STEM invested heavily in peer networks. These networks created a system of support and trust for women and created opportunities that might not have otherwise existed (Sherbin, 2018).

Women pointed to building up proteges in their field as another key to finding success in STEM. The relationship between a woman sponsoring a woman and the woman being sponsored had mutual benefits. The women being sponsored could receive support, including someone to advocate for them, support them when they made mistakes, and even get help with they were up for promotion. For the woman who was sponsoring another woman, taking on this type of mentoring role can help boost her reputation as someone who could find and support new talent (Sherbin, 2018).

While research has been conducted that addresses STEM inequities, few studies have applied Design Thinking to this problem. Additionally, there are many individual businesses and government entities that have attempted to address the inequities in STEM, but have not developed one resource that could support a vast majority of industries. Therefore, the purpose of this study was to speak to women from a wide range of STEM-related careers, some of whom still work in STEM and some who have left, to identify their challenges and suggest solutions that could help women in any STEM-related field.

Research Study and Methods

Research Methods and Procedure: An Overview

Concept Mapping (Appendix A)

First, a group of educators and other individuals in science, technology, engineering, and mathematics (STEM) gathered to participate in a Concept Map activity. The group used a Concept Map to facilitate a conversation about the characteristics that someone in a STEM field may possess. For example, they examined the types of courses a typical student might take in their educational careers and the skills one might develop through that coursework. They also identified specific careers they would most closely associate with STEM. This activity was used to determine who should be interviewed for the second part of this study.

Interviews (Appendix B)

The Concept Map activity was used to narrow down a few essential careers or fields that the educators associated with STEM. Once these careers or general fields were identified, women who were in these career fields were asked to participate in an interview. There were three interview groups for this study. The goal of the interviews was to gain more in-depth insight into their experiences as a STEM student and how those formative experiences impacted their career choices later in life. The questions asked in the interview illuminated critical steps in their background that got them to the point where they were at the time of the interviews. The conversations helped the researcher understand what forces shaped a woman's decision to stay in STEM or leave to follow a different career path. The interviews ranged from 15-30 minutes and included 14 questions. The principal investigator developed the interview questions.

The first group of women that were interviewed were those who did not study STEM in college but pursued a STEM career later in their professional lives. The second group interviewed was women who studied STEM but then chose to leave the field. Finally, women who started in STEM-related courses and then stayed on a STEM path were interviewed.

Experience Diagramming (Appendix C and D)

As interviews were conducted, the interviewer created Experience Diagrams to display the three different groups of women visually. By comparing the experiences of these three groups of women, the researcher better understood the reasons why women choose to either pursue STEM as a career or change vocation paths. The Experience Diagramming activity happened with the interview subject as she shared her experiences with the interviewee with further detail added after the interview was completed. As the person being interviewed shared her experiences, the interviewer created a timeline that visually represented the journey that a person has taken to either stay or leave STEM.

By comparing the experiences of different women, opportunities to support their STEM journey began to emerge. The ultimate goal of this research is understanding the factors that keep women on the STEM track and what might deter one from staying in a STEM career. Once these women's experiences were compared, the researchers and participants could have conversations about possible tactics to address STEM retention.

Personas (Appendix E and F)

The interviews and Experience Diagramming activities completed in the first phase of this research led to the development of different Persona profiles by the principal investigator. These Persona profiles helped illustrate the various themes that emerged in the Experience Diagram in the form of an imaginary person who has shared experiences with the real interview

subjects. The researcher compiled the information contained in these Persona profiles. Eight Persona profiles were created to encapsulate the many different experiences the women shared with the researchers. The personas were used by the researcher and the thesis committee to create "how might we" statements.

Verbatim (Appendix G)

Personas are a helpful tool when looking at the experiences that so many shared in their respective STEM industries. Due to the specific nature of individual anecdotes, the Verbatim section of the research was meant to share stories and quotes that could not be generalized into a Persona. They were unique to the individual and, therefore, were shared separately. The goal of the Verbatim exercise was to provide more context and data for the committee in their creation of Statement Starters.

Statement Starters (Appendix H)

The researcher and the thesis committee brainstormed "how might we" statements. These statements were developed by examining the results of the Experience Diagram exercise, the Persona profiles that were designed, and the Verbatim section of research. This data led to the creation of three Concept Posters.

Concept Posters (Appendix I and J)

The researcher invited the women who were interviewed to participate in a Concept Poster activity. The Statement Starter session was shared with the group and was used to start a conversation around solutions for the retention of women in STEM. As the conversation was underway, a graphic designer took visual notes that were used to synthesize into three posters.

Sample, Subject, and Validity

For the Concept Map portion of the study, a purposive sampling technique was used as the researcher identified educators who are knowledgeable about STEM career paths. The group was comprised of six educators who teach at the middle and high school levels. There were two men and four women included in this Concept Map activity.

Three different groups of women were interviewed for this study:

- Group 1: women who studied STEM but did not stay in a STEM-related career. (n = 3)
- Group 2: women who did not study STEM but entered a STEM-related field. (n = 8)
- Group 3: women who studied STEM and remained in STEM. (n = 13)

A purposive sampling technique was used to recruit interview subjects and was based on the concept mapping exercise that identified careers closely associated with STEM. Twenty-four (n = 24) women participated in the interviews. In some cases, the participants from the Concept Mapping activity served as recruiters to find people who may fit into one of the different categories.

For Group 1 and Group 3, the researcher worked with personal and professional connections to identify women to be interviewed. Once the interview subjects were found, they were categorized into the appropriate interview group. The interview subjects were contacted by email, and the interviews took place either by phone or Zoom. In total, there were three women who fell into Group 1, while 13 women fell into Group 3.

For Group 2, the interview subjects were recruited in purposive sampling. Using a similar recruiting tactic of tapping into personal and professional connections, women who pursued STEM in an academic setting and have continued working in a career related to STEM were

asked to participate in these interviews. Again, emails were sent to subjects to recruit them for interviews, and the interviews were conducted by phone or Zoom.

Instrument Development

The researcher developed the research instruments in conjunction with professors from Radford's Design Thinking program. The researcher created several iterations of the research design, and through a process of feedback and refining, developed the procedure and interview questions. There were 14 questions for each interview, Groups 1 and 3, and 13 for interview Group 2. Questions 1-8 asked for general information from the interview subjects, including their job title, marital status, children, college attendance, and other relevant questions. Questions 9-14 were more open-ended in their design and encouraged the interview subject to reflect on their STEM experiences. For Group 2, the question "Did you have any mentors, teachers, or professors who encouraged your pursuits in STEM? Please explain your answer" was omitted because that group did not pursue STEM in their formal education.

Results

Concept Mapping

A group of six educators from the greater New England area convened a Zoom conference call to conduct the Concept Mapping activity. Their teaching experience ranged from a first-year teacher to department chairs with 10 years of experience in STEM education. Two male educators and four female educators participated in this activity. The grades that these educators taught ranged from 6th grade to seniors in high school. The types of STEM education that these educators covered in their classroom ranged from physics, biology, math, and innovation.

The participants were asked open-ended questions, and their answers were recorded using the whiteboard feature of Zoom. Keywords and phrases were recorded as they discussed the questions being posed. The first question was, “What qualities do successful STEM students possess?"

The first question garnered many different responses spanning from general skills to more specific technical skills. *Figure 1* shows the whiteboard after the group sufficiently answered the question with all of the different qualities listed on the whiteboard. All of the skills are color-coded in blue.

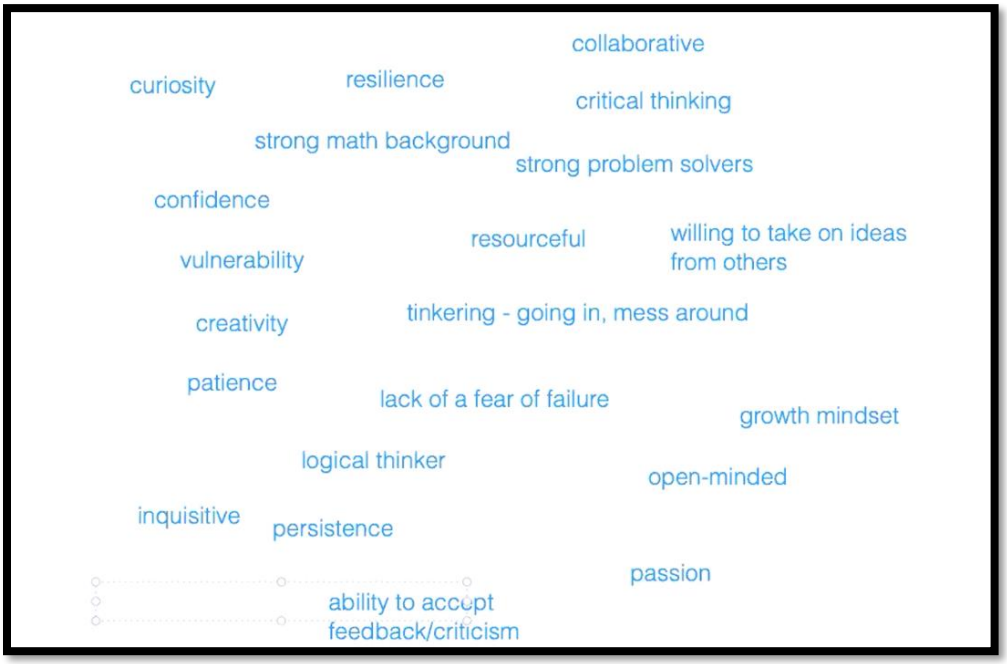


Figure 1. What qualities do successful STEM students possess?

Although qualities such as a strong math background tie directly to STEM, many of the traits listed by the educators were broader and could be applied to many different types of students. Curiosity, confidence, resilience, and strong problem-solving skills were among the first few skills that were brought up and would serve students in a variety of disciplines. Some of the skills that the educators mentioned during this first round of brainstorming were skills that are often discussed in Design Thinking and other fields of innovation. These included a lack of fear of failure, collaboration, the ability to tinker with different ideas/materials, and a growth mindset.

The second question posed to the group asked them to brainstorm career paths participants associated with STEM. They were asked to dig deeper beyond the apparent engineer, scientist, or mathematician. The educators elaborated on each letter in the acronym

STEM. One educator listed professions associated with engineering but broadened the scope to research, academic research, and teacher. In the math field, careers such as analysts were listed. When looking at the broader range of science, the educators listed epidemiologists, lab researchers, and biomechanics as other possible careers.

One of the Concept Mapping participant's insight was that while many white-collar jobs were the first to be listed in our brainstorm initially, many blue-collar jobs also required workers to possess a degree of STEM training and skills. The positions mentioned were carpenter, mechanic, electrician, and other types of trade work. Figure 2 shows a comprehensive look at the kinds of careers discussed during the second question of the Concept Mapping activity. All occupations that were considered are listed in green.

Figure 2. What types of jobs do you associate with STEM?

While some of the careers listed were jobs that would be considered traditional in STEM (medicine, lab researcher, engineer), it became clear through conversation that many fields associated with STEM were emerging as technology becomes more advanced. Coding, artificial intelligence (AI), and robotics were just a few careers mentioned that are becoming more prevalent in today's world.

The final question posed to the group asked the educators to consider what type of coursework would be valuable for STEM learners to take during their educational careers: "What types of classes should students be taking if they want to move into a STEM field?" Figure 3 shows the results of this conversation.

Figure 3. What types of classes should students be taking if they want to move into a STEM field? What skills should students hope to take away from STEM classes?"

Right away, Design Thinking and Computer Science was mentioned. Practical skills, such as taking a shop or robotics class, were important to the group. These hard skills are not only useful in STEM industries but also show potential employers that people have formal training in their respective fields.

As the conversation progressed, it became clear that while specific courses were helpful to look at, ultimately, what the question was asking the participants to think about was what skills students would take away from each class. The difference is that students already possess some skills intrinsically. This question looked at what an educator, such as the ones in this group, would hope to impart on his or her students by the end of a course. The pivot from the original question came when one participant offered the idea of an authentic challenge as a skill that he hoped students would take away from a course.

Some of the skills mentioned in this portion of the discussion included researching, reading, writing, and speaking. Research and investigative skills were mentioned, and particularly, the ability to read and understand research in academic literature was essential to this group. According to one participant, writing should be a skill that students learn: “I strongly believe writing because if you do it and you do not share it, it’s not science; it’s just messing around.” Public speaking was similarly crucial in conveying the ideas of students.

The importance of collaboration was mentioned in several different ways. One participant said that in her classes, “playing well with others” was a learning goal for her students. The group discussed the idea that working as a team was not always something that is emphasized in STEM but was vital to them. There was discussion of teamwork being a valuable skill, but perhaps not one that is needed. They posited that in the medical or research field, it might be more critical, while cooperation may not apply in other areas.

After this activity, the group took all of the ideas that were brainstormed and grouped them by theme. Figure 4 shows the groupings and themes found through this exercise.

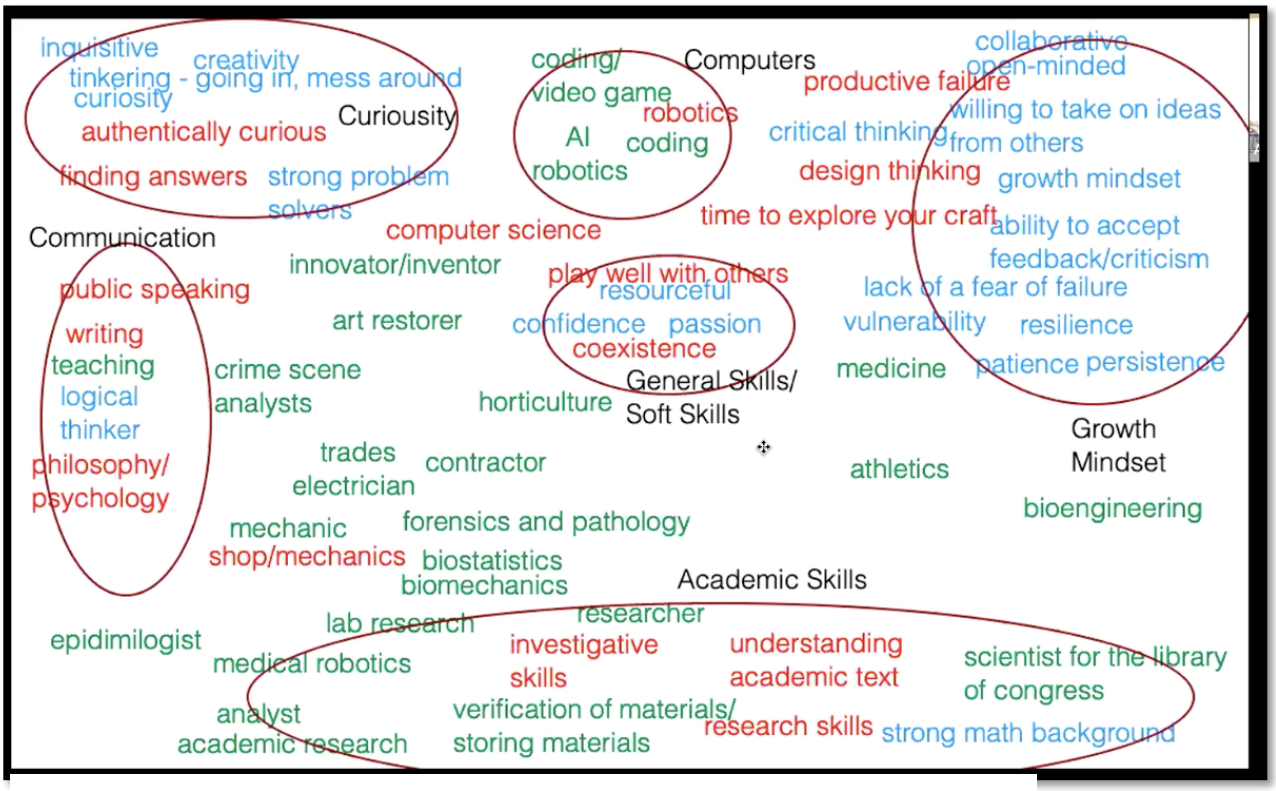


Figure 4. Grouping Results

The group identified six themes that emerged through the discussion. These themes are (1) general/soft skills, (2) academic skills, (3) curiosity, (4) growth mindset, (5) communication, and (6) computers.

The limitations of Zoom made the space to move each idea and to enclose every word or concept into the bubble difficult. The terms that are not directly in a bubble are careers. The group decided that they would organize the professions so that they were as close to the associated bubble as possible.

Interviews

A total of 24 interviews were conducted for this research. All of the subjects were women, but ages, careers, and experiences varied. The youngest participant was 3 years out of her undergraduate studies, and the older women had careers that spanned over 40 years. Sixteen were in healthcare-related jobs, and four were current or former engineers. One woman worked in finance, one woman was an architect, one woman worked as a home health educator for the Head Start program, and one worked in Geographical Information Systems (GIS), where she tracked wildfires. See Figure 5.

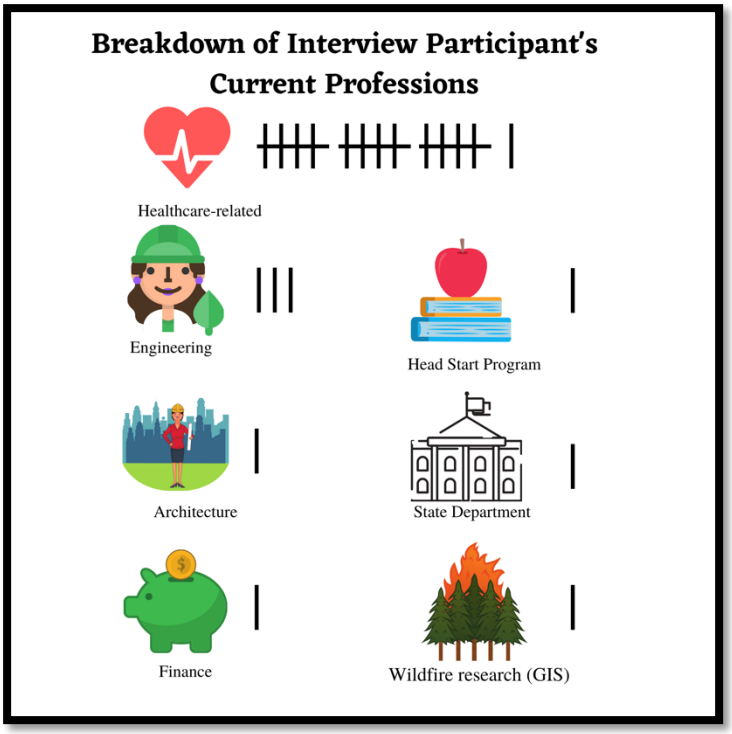


Figure 5. Breakdown of Interview Participants' Current Professions

Most of the women (19 out of 24) stated that they were married at the time of the interview. Only one woman said that she was divorced, while the other women simply stated "single" as their marital status. Two women interviewed identified as a member of the LGBT community. Of the women interviewed for this study, 12 had children, one woman was expecting her first child, and the remaining 11 women did not have any children. Four of the women interviewed had young children (10 years old or younger), and the other eight women had adult children (20 years old or older).

Twenty-three (n = 23) out of the 24 women or 95% of the women interviewed for this study were Caucasian. One woman self-identified as an immigrant to the United States, and the one non-White woman was a first-generation immigrant to the United States. Only one of the women lived out of the United States in Canada.

To better understand and examine the findings from the interviews, the researcher used Design Thinking methods to summarize and analyze the results. The Experience Diagrams were used to identify bright spots, pain points, and opportunities throughout a woman's career. The varied perspectives and experiences that were examined in the interviews required the development of eight unique Persona profiles. Finally, a section titled "Verbatim," was created for stand-out stories that could not be generalized.

Experience Diagrams

The development of Experience Diagrams began by creating a timeline of the interview subject's life from the early years to the present day. From there, the researcher's interview notes were organized into three categories: Pain Points, Bright Spots, and Opportunities. The information was then placed into the spreadsheet under the appropriate column of the timeline. Some of the women interviewed had many anecdotes and experiences to share with their researcher; meanwhile, others had fewer experiences that pertained to this study. For this reason, some of the spreadsheets are less robust than others. Figure 6 shows an example of an Experience Diagram for one interview subject.

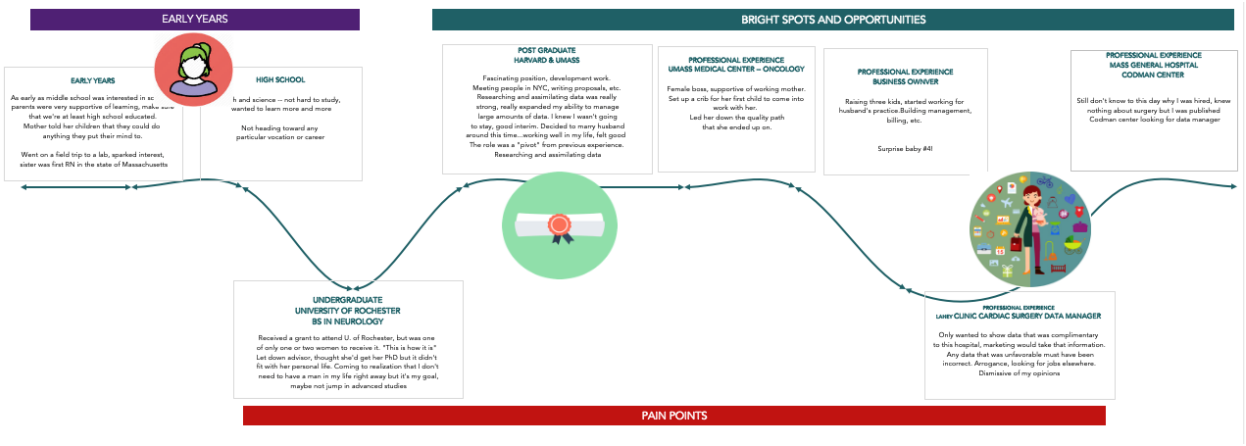


Figure 6. Experience Diagram

Personas

After conducting 24 interviews with women, Persona profiles were developed to summarize the experiences of the participants. These Personas were used as the launching point of the "how might we" statements generated by the researcher and the research committee. Due to the small sample size, some of the Personas are based on two participants, while others draw on the experiences of three or more women. See Appendix F for Persona profiles.

Jamie's experience was drawn from three women in engineering who expressed having lots of support and role models in college, but who felt that women were underrepresented and looked down upon in their respective industries.

Rebecca's experience was based on two women in engineering who had fewer positive experiences in college, but who felt more valued in industries. While Rebecca's experience was not as common, it should be noted that some women do have positive occurrences once they begin their careers.

Alison was based on two women who work in healthcare data analysis. She was meant to represent the women who had strong math proficiency from a young age and who had an interest

in healthcare, but felt that they were either not drawn to a medical degree or who were steered away from an MD.

The Persona of Eleanor was developed from marrying the experiences of two women who were both in healthcare administration, are approximately the same age, and who have children who are around the same period. These women had the support to work and raise families, and they did not perceive any barriers in the career due to their gender.

Bethany was based on the women who were in the second phase of their career. Bethany worked and raised children while supporting her husband's professional and educational pursuits. With her children grown and out of the house, Bethany struggled with the fact that she did not have a Master's or higher degree; she felt that she was an expert in her field, but had to convince her managers that this was true.

Mary was the CEO of a woman-owned healthcare company and had made it a point to hire diverse people to her team. After years of working for other people and dealing with sexism in the workplace, Mary decided to pave her way. Despite being the boss, Mary still encountered sexism when she was presumed to be a secretary rather than the boss.

Susan's Persona was developed by looking at the experiences of two women who work in information technology. Susan had varying degrees of support in her STEM career, but she found in her professional life that her bosses were often fair to all employees and rewarded people based on merit.

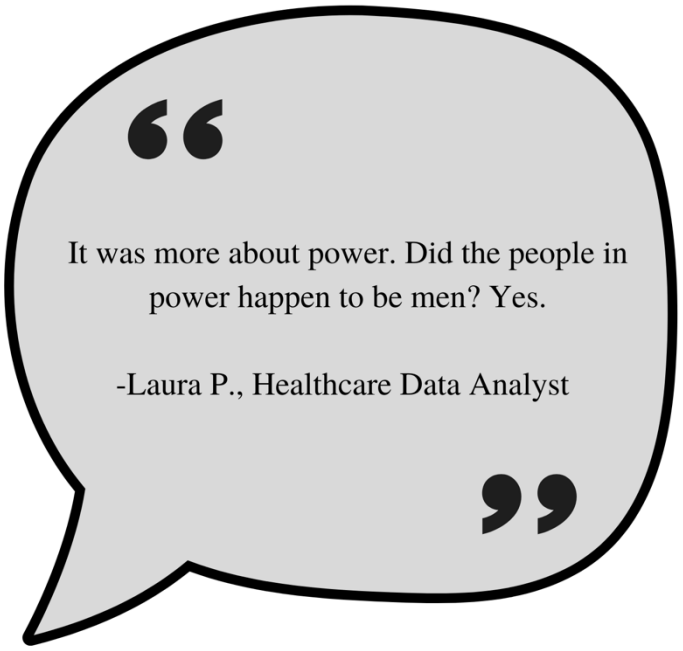
Finally, Lydia was developed to highlight the experience of women who immigrated to the United States and had strong STEM mentorship in their youth. From a young age, Lydia was passionate about architecture, which is part of the reason that she continued to deal with gender inequality in her field.

Verbatim

The Personas compiled for this study are intended to help the researcher track trends from the interviews conducted earlier. However, there were many individual experiences shared by the women that were specific to their profession that could not be grouped. Due to their value in understanding women's involvement in STEM, the researcher shared these direct quotes with the thesis committee so they could get a full picture of the data received. The experiences and stories were summarized with direct quotes from the women who were interviewed. They were meant to give specific examples of pain points and opportunities that arise for women in STEM. The names used below are pseudonyms to protect the confidentiality of participants.

Pat M., a pharmacist by training, was working in the field of clinical pharmacy as a consultant in fraud, waste, and abuse at the time of the interview. She shared a story of working in a retail setting early on in her career as a pharmacist: "I was working in the pharmacy, and this guy came in and said, 'I want to talk to the pharmacist.' When I said, 'speaking,' he said, 'no, I want to talk to *that* guy.' *That guy* was a porter or something. 'Best of luck!'"

Laura P. worked in clinical effectiveness at a hospital in Massachusetts. When asked if she thought that it is hard to pursue STEM as a career and to stay in STEM subsequently, Laura said, "I think it's more about power. Did the people in power happen to be men? Yes."



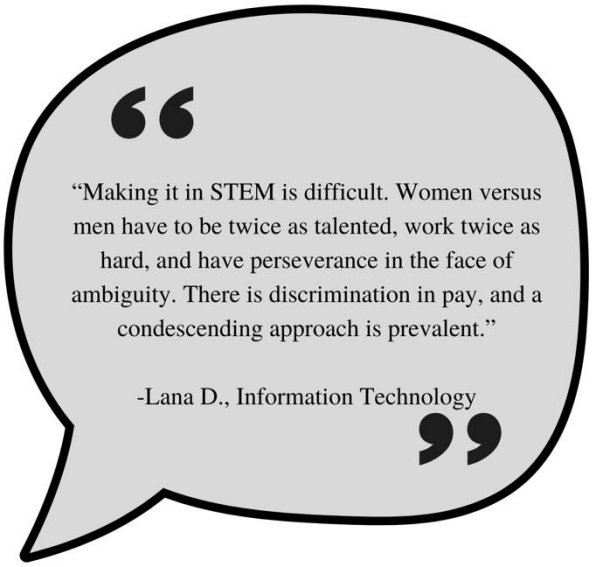
Jacqueline F. worked at hospital in Boston as the Director of Clinical Support Services. She had been working at the hospital in many different roles and at varying levels of

responsibility for 28 years. Upon reflection, Jacqueline made the following statement about the perception of women in the hospital: “Women are just bitches, guys can do the same thing and are brilliant.”

Emily H. received her master’s degree from a university in New Hampshire in GIS. Emily shared that she found her master’s program to be very difficult and that it just did not “click.” She had a challenging experience with her advisor, who tried to push her towards the sociological aspects of the program rather than the hard sciences. During her thesis dissertation, that same advisor asked Emily, who was moving to Canada to begin her Ph.D. research, if she was moving “to become a stay-at-home-wife.”

Luckily for Emily, her experience was better in her Ph.D. program. She runs a women’s group that is named for a satellite she and her peers use to collect data. This group seeks to create a community for women in a 90% male and White-dominated industry. They amplify each other’s voices through Twitter and different storytelling events.

Lana D. worked in healthcare data and technology. She had many anecdotes about being a woman in STEM, but she shared a story about being at a symposium with a panel of women that stood out. A woman on the panel was asked what necessary trends in character are needed for women in leadership. She responded that often these characteristics are aggressiveness and other testosterone-equivalent qualities like lack of consideration or empathy. Lana then said, “Making it in STEM is difficult. Women versus men have to be twice as talented, work



twice as hard, and have perseverance in the face of ambiguity. There is discrimination in pay, and a condescending approach is prevalent."

Cindy J. shared a story of working with a man who was frustrated that she had more knowledge and technical skills than she did, and in his frustration, called her a bitch. She continued by saying, "I have been called a bitch more than once just because I had knowledge and confidence and claimed my place in the room." She stated that, of course, these situations were inappropriate and demoralizing, but she was older when they occurred. She wondered if she were a younger woman if the offensive language would have been harder for her to handle.

Monica L. was the only medical doctor that was spoken to for the interviews of women in STEM. She practiced medicine for 25 years before moving into healthcare quality. She expressed that everyone but her parents discouraged her from pursuing medicine and that she was discouraged from becoming a doctor, "every step of the way." Even after she received her medical license, she dealt with sexist jokes, harassment, and being pushed aside.

Statement Starters

The researcher and the committee met in a Zoom conference room to discuss the results from the interview portion of the research and to brainstorm "how might we" statements. The following list is the statements that were brainstormed in the hour-long session:

1. How might we get male STEM dominated fields more accustomed to and respectful of female leadership?
2. How do we make STEM less intimidating for women?
3. How might STEM professions support women who choose to have families?
4. How might we prepare women for inequality in the workplace?
5. How might we normalize more inclusive conversations?

6. How might we have better female representation in STEM in the media?
7. How can we support mentors to encourage mentees to pursue STEM?
8. How might we provide leadership training opportunities?
9. How might we have better access to professional credentials?

These statements were the launching point for the final Design Thinking workshop that was conducted for this research.

Concept Poster

The final Design Thinking workshop for this study invited the women who contributed to the Concept Map and the women who were interviewed to participate in an interactive activity. To begin this activity, the principal investigator shared a brief overview of the research, with a focus on Statement Starters. Once the material had been introduced to the group, they opened the conversation up and explored potential solutions for three different statements.

Three women who participated in earlier activities were available to complete the Concept Poster activity. One woman, a middle school biology teacher, participated in the Concept Map activity. The two other women, an architect, and a GIS Ph.D. candidate, had been interviewed by the researcher. The researcher also invited a graphic designer who took visual notes while the conversation was in progress. These notes (Appendix J) were eventually used to create a Concept Poster that summarized the findings of this activity. Figures 7 and 8 show the notes taken during this session.

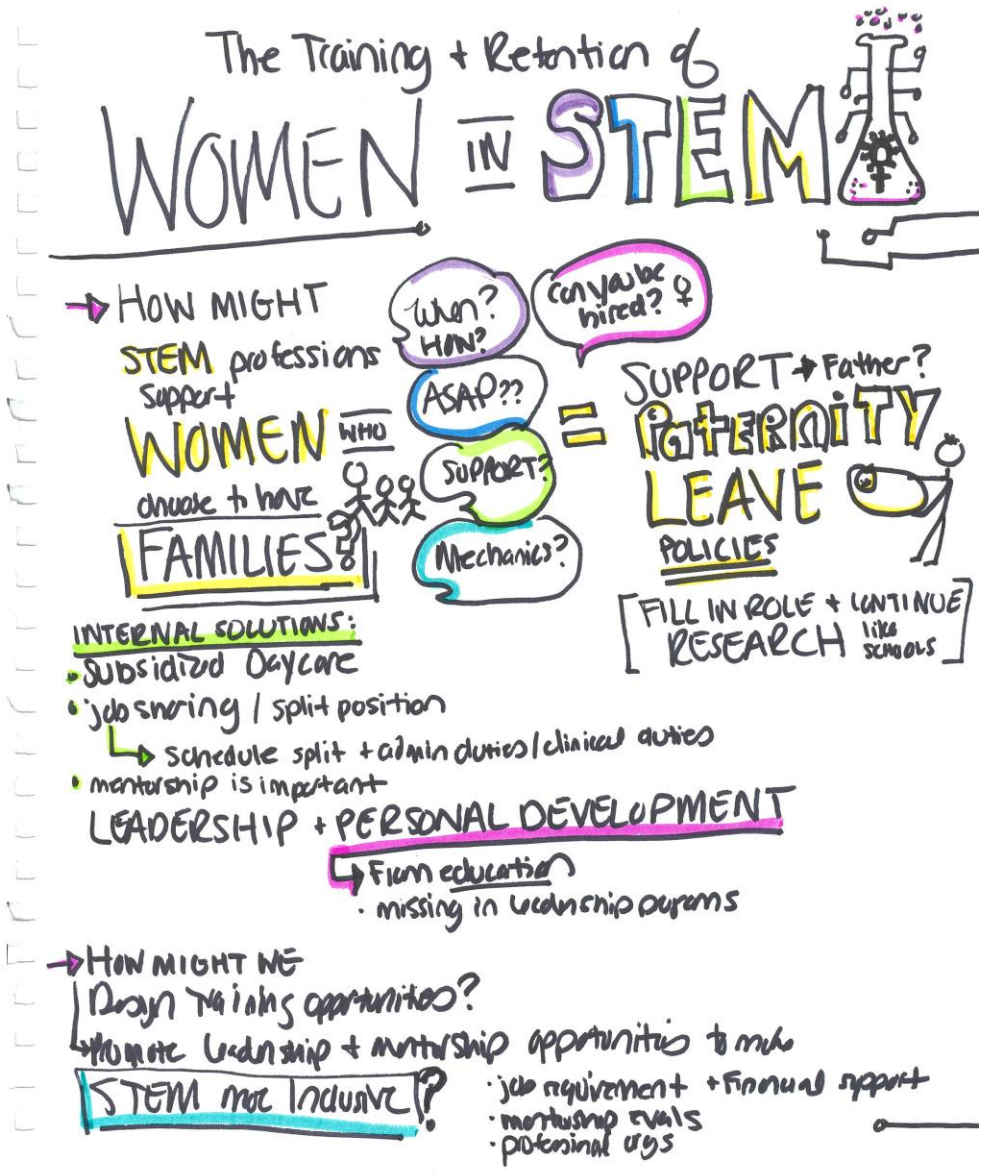


Figure 7. Page One of Graphic Notes

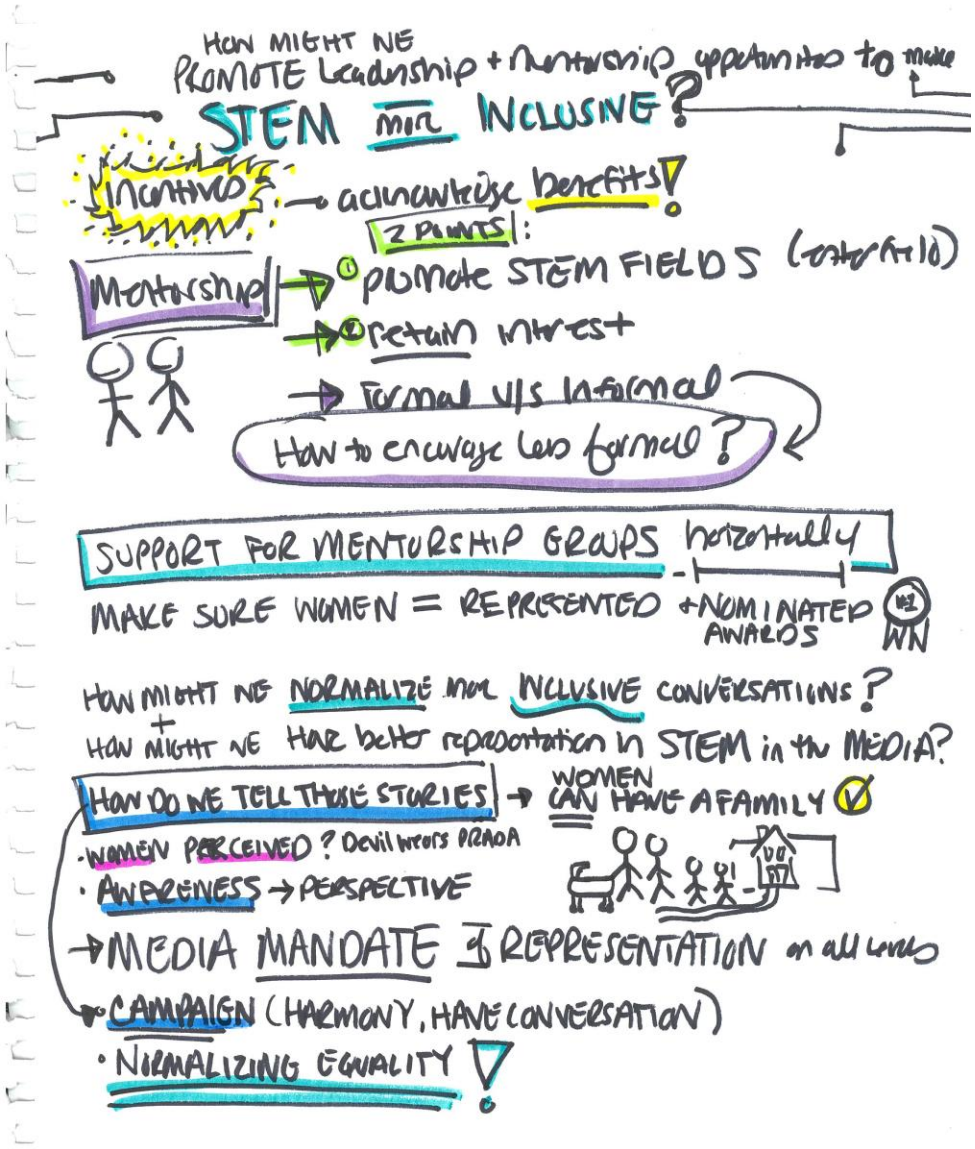


Figure 8. Page 2 of Graphic Notes

The group was presented with a brief overview of the research methods and findings, and then spent the majority of the hour together thinking of solutions to the Statement Starters. The group initially focused on the question of "how might STEM professions better support women who choose to have families?" The results of this conversation were captured by the graphic designer taking visual notes. The discussion included many different challenges that women and

parents generally face in the workforce. The group brainstormed many ideas to solve the issues that families might face when they try to balance parenting and working and generated three leading solutions: (1) job-sharing, (2) subsidized daycare and paternity leave, and (3) better mentorship and leadership opportunities to promote personal and professional growth.

The robust conversation about work/life balance (or lack of) in STEM led to examining the statements regarding mentors and leadership. The women discussed a number of the proposed Statement Starters and decided that a few of them could be combined, and this would be a better representation of the ideas they were trying to convey. The statement starter they developed asks, “how might we provide leadership and mentorship opportunities to make STEM more inclusive?”

The second Statement Starter that was examined garnered the most solutions. Mentorship was discussed in more detail. First of all, the women agreed that mentors should be self-selected and have a strong desire to take on this type of role. Another possibility was to make mentorship a part of any job description for transparency. Secondly, people who served as mentors should be given incentives for serving in this capacity, and it was proposed that this could be financial or another type of professional benefit. Mentors should have a network that supports them, and there should be some sort of evaluation to ensure that they are adding value to their mentee’s experience. Lastly, organizations should consider a horizontal model of mentorship, meaning that peers can support each other in a more formal capacity.

Finally, the group shifted their focus to the question, “how might we normalize conversations and make sure there is better female representation in STEM in the media?” The creation of this final Concept Poster required the researcher to create a narrative that describes the ideal future for female representation in STEM in the media.

Conclusion

Both the literature review and research of this study point to measures being taken to support women in STEM, yet there is still work to be done. The research garnered many helpful ideas and solutions to the issue of women leaving STEM, but there were limits to the study itself. With a sample size of only 24 women (n = 24), there were gaps in experiences being shared. Due to the small number of women interviewed, and the small number of industries represented, the solutions that were developed in this research cannot be considered a fully comprehensive list. In the future, a larger number of women from more varied industries should be invited to contribute their insights to additional research on the topic of women in STEM.

While many initiatives are happening in specific industries and organizations of STEM, substantial change will not occur until there is a wide-spread and systematic overhaul. Governmental, educational, and professional organizations are all responsible for promoting and rewarding inclusivity and diversity in STEM. General Electric was one of the major corporations cited in the literature review that had programs to support women in STEM. Its Woman's Network program provided professional development and other opportunities to 70,000 participants worldwide and has allocated over $1 million in scholarship funds to support and retain female professional talent (GE, 2020). The research conducted for this study found that professional development and networking were both important for women looking to become leaders in STEM fields.

Governmentally, subsidies and other programs must be developed to support parents and other caregivers who want to remain in the workforce. Prohibiting discrimination is one way that the government can help women in STEM, but there could be mandates that actively drive

women into STEM-related fields. There should also be legislation that requires equal representation of women in STEM in the media, including a media campaign that shows women in leadership positions. The G20 was a global organization that was cited in the literature review and had programs to help girls and women strengthen their voices within their communities (OECD, 2013). Having a platform such as the G20 is one important way that women's voices can be elevated in STEM, and such initiatives should be broadened to national and local governing bodies.

All levels of education must continue to strive for diverse student and faculty populations. Women who were interviewed for this study had varied experiences with mentorship at the undergraduate level. The women who did have an influential mentor found that they had more doors opened to them because of the professional connections a mentor provided. Women should also be given equal opportunities to be hired as interns and as fellows, be given research grants, and be considered for teaching assistant positions.

Finally, individual organizations in all fields of STEM must create systems that support and promote women in STEM. All STEM professions should be committed to hiring qualified women and encouraging them to leadership positions whenever it is appropriate to do so. They should also have support from their peers once they have been hired. In the article from *Harvard Business Review* by Laura Sherbin, having another woman to support a fellow female in the workplace can have mutual benefits for both parties. First, there would be advocacy for the woman being supported. This advocacy may look different depending on the situation but could include help with workplace issues or when mistakes happen, or as an advocate for job promotions. Secondly, the woman who offered her support would be seen as someone who could

find and support new talent for a company (Sherbin, 2018). Additionally, women should be paid equally and should be eligible for raises and promotions.

There is much to do for women in STEM, but there has also been significant progress made in many areas. The research conducted serves to not only come up with new solutions for women in STEM but should also serve as confirmation that there are organizations and individuals committed to the retention of women in STEM fields.

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Appendices

Appendix A- Concept Map Procedure

Materials: Zoom conference room with whiteboard capabilities

Time: 30- 45 minutes

Number of Participants: ~5 middle and high school educators

Directions:

- Participants will be asked to think about STEM. Guiding questions include:
    - What qualities do successful STEM students possess?
    - What types of careers do you associate with STEM beyond the obvious mathematician, scientist, or engineer?
    - What types of classes would students need to take to enter these types of careers?
- Participants will reflect on these questions and may decide to include more questions that help them to reflect on STEM and STEM students.
- The facilitator will document the ideas of the group using the whiteboard feature of Zoom. They will color-code each question for ease of reading the information.
- When all of the participants have contributed to the Concept Map, participants will organize their ideas.
- Ultimately, participants should be aiming to identify careers most associated with STEM, as well as any qualities that would lead a person to STEM-related majors or careers.
- This information will be used to identify interview candidates in a variety of fields.

Appendix B - Interview Questions

Interview Questions – Groups 1 and 3

1. Please state your title.
2. Are you married, single, or divorced?
3. Do you have any children? If so, hold old, are they?
4. What is your level of education?
5. What were your parent's levels of education?
6. What were your parent's career paths?
7. Where did you attend college, and what did you major in?
8. What were your career aspirations when you were a student?
9. Did you have any pivotal experiences (positive or negative) that determined your career choice? This can be any time between birth to now.
10. When you entered the workforce, what types of jobs or career paths were you pursuing?
11. What led you to the position that you currently hold?
12. Did you have any mentors, teachers, or professors who encouraged your pursuits in STEM? Please explain your answer.
13. Did you find it difficult to pursue a STEM career path? Please explain your answer.
14. Have you found it difficult to remain in a STEM field? Please explain your answer.

Interview Questions – Group #2

1. Please state your title.
2. Are you married, single, or divorced?

3. Do you have any children? If so, hold old, are they?
4. What is your level of education?
5. What were your parent's levels of education?
6. What were your parent's career paths?
7. Where did you attend college, and what did you major in?
8. What were your career aspirations when you were a student?
9. Did you have any formative experiences that determined your career choice?
10. What led you to the position that you currently hold?
11. When you entered the workforce, what types of jobs or career paths were you pursuing?
12. Did you find it difficult to pursue a STEM career path? Please explain your answer.
13. Have you found it difficult to remain in a STEM field? Please explain your answer.

Appendix C - Experience Diagrams Procedure

The researcher will conduct the experience diagram exercise during the interviews. The experience diagrams will be created as a way to visualize each woman's experience in the field of STEM. The experience diagram will be organized linearly, with information documented chronologically based on the interviewee's responses to the questions being asked. The experience diagram will focus on three different areas- bright spots, pain points, and opportunities from each woman's experience in STEM. Organizing the information in this manner will allow the researcher to identify different opportunities for innovation in the areas of marketing, recruitment, or retention in STEM-related career fields.

Appendix D – Experience Diagrams (Original Worksheets)

	Early Years	High School	Undergraduate	Graduate
	Parents Both MDs	New Jersey	Colby College, Psychology	UNH Master's in Clinical Nurse Leadership
Bright Spot				
Pain Points		Not a high achieving school	Serious Head Injury Prevents Julie from completing coursework to be a Neuro Biology Major. Drops down to Psychology because it is fewer credits	"I almost don't want to tell people that I want to be an Nurse Practioner (NP), get pushback" "I'd say it's hard to advocate"
Opportunities		Peers seeing Julie as the go-to for help Really incredible biology teacher, easy to grasp concepts, liked and was good at it		

	Early Years	High School	Undergraduate	Graduate - UConn	Clinical Work	Beacon Health Options - Case Manager	Regional Network Manager - Beacon Health Options	Health Data Viz
	Parents Both had Bachelor's Degrees. Mom artist, graphic design		Bucknell University, Psychology and English	Went straight into Master's program from undergraduate - Family and Marriage Psychology		Admin Service Org for Connecticu	Became Regional Network Manager working with hospitals, required to speak on data and strategize.	
Bright Spot	Always someone who was really good at math	Like biology, tthought I might be biological researcher, Took all the AP classes in High School, Straight As in Math	Really great professors, english teachers, indepedent study with great female professor	Stipend to this program	Worked with kids and families in their homes doing behavioral health, had a private practice for 1 year	Working directly with patients, had a more holistic view of their care. I had been a producer of data, now on the receiving end of this information.	Managing data for any authorized care. Led team on learning and implementing Tableau (data vizualization software) Led to professional growth	
Pain Points			Hated Chemistry	Less evidence based	Not always quantifiable	Didn't realize that the quality department was already doing this work	Our data was not easy to decipher	
Opportunities	Wanted to be a vet, liked anatomy, didn't like the idea of working with people but liked animals	Always someone who was really good at math	Psychology degree later in my senior year did an independent study who I admired.	Needed more education before going into an actual career	4 years of direct care. Loved, but was intense/draining. Didn't have a lot left over emotionally for husband. Didn't think she could do it forever. This was before children	Curiosity	Using artisitc abilities, saw opportunity to visually display information. Became data visualization expert. During this time worked with a new VP of analytics, she fantastic. Took me under her wing. Didn't report to this person, but she took her under wing. Advocated, wanted to improve analytics, eventually was able to create new role. So smart, strong, but also very maternal. Another boss so encouraging and promoting of my goals	Kept in touch because working with Health Data Viz was a pivotal moment. Changed life and perspective on things.

Category #2	Early Years	High School	Undergraduate	Private Practice	Oncology	Worked with Consulting Group	Consulting
			Business Operations, Colby Sawyer College	Worked for private practice for approximately 25 years	Spent entire career in the field of Oncology (Division Director for the American Society of Clinical Oncology), Analysis and Consulting Services		Retired from oncology but consulting.
Bright Spots	Mom was a nurse, wanted to be a nurse	Wanted to teach foreign languages	Worked at Parkland hospital in the summers	Grew up with that practice, worked with oncologist for many years; getting involved with other oncology managers		Financial and data analysis for oncology groups nation wide	Work is with practicing oncology groups
Pain Points		Dissuaded because at the time there were 1000s of candidates for teaching positions				Company sold twice during her time there. Don't want to build products just to have companies be sold. Really small consulting firm, made me nervous	Coronavirus has basically stopped business
Opportunities		Had enjoyed volunteering at hospitals as a candy striper - decided did not want to be a nurse but stay in healthcare	Medical transcription, whatever they needed. That helped clinch that I wanted to stay in healthcare field	When original doc left, had the ability to become leader in the practice.	Fell into a job by answering an ad. Very new speciality at the time she joined group. Volunteer work with another group led her to consulting	Really small consulting firm, made me nervous	Connections with oncology group made it possible to branch off into her own consulting business

	Early Years	High School	Undergraduate	Graduate	Post Graduate - Harvard	Post-Graduate UMass Worcester	Oncology @ UMass	Business Owner	Data Manager for Cardiac Surgery @ Leahy Medical	Codman Center
	Came from a very blue collar home. Mom only went through 8th grade, raised on a farm, oldest of 9. Dad only one of eleven siblings who graduated high school.		Bachelor's Degree, University of Rochester, Neuroscience	N/A	First job out of college was at the Harvard School of Public Health	"Having a family was a major goal for me" Also knew I had to keep working.				
Bright Spot	As early as middle school was interested in science, parents were very supportive of learning, make sure that we're at least high school educated. Mother told her children that they could do anything they put their mind to.	Math and science -- not hard to study, wanted to learn more and more	Entered undeclared but was attracted to biological science, built her own program (neuroscience), "wanted to study things that greatly interested me"	N/A	Fascinating position, development work. Meeting people in NYC, writing proposals, etc. Researching and assimilating data was really strong, really expanded my ability to manage large amounts of data. I knew I wasn't going to stay, good interim. Decided to marry husband around this time...working well in my life, felt good		Female boss, supportive of working mother. Set up a crib for her first child to come into work with her.	Raising three kids, started working for husband's practice. Building management, billing, etc.	Still don't know to this day why I was hired, knew nothing about surgery but I was published	
Pain Points			Received a grant to attend U. of Rochester, but was one of only one or two women to receive it. "This is how it is" Let down advisor, thought she'd get her PhD but it didn't fit with her personal life. Coming to realization that I don't need to have a man in my life right away but it's my goal, maybe not jump in advanced studies	N/A					Only wanted to show data that was complimentary to this hospital, marketing would take that information. Any data that was unfavorable must have been incorrect. Arrogance, looking for jobs elsewhere. Dismissive of my opinions	Told that she couldn't move up because she didn't have a Master's degree. Want to spend $ to get a few letter behind her name when she already knew a lot of the content. Took at out 2 1/2 years to convince management that she could progress
Opportunities	Went on a field trip to a lab, sparked interest, sister was first RN in the state of Massachusetts	Not heading toward any particular vocation or career	Female advisor strongly encouraged her, undergraduate research was published gave her a "leg-up," credibility with male colleagues	N/A	The role was a "pivot" from previous experience. Researching and assimilating data	Husband a physician, worked in his office for a period of time while raising family	Led her down the quality path that she ended up on	Surprise baby #4!	Codman center looking for data manager	
			There wasn't the same level of awareness of gender discrepancies back then as there is now							
			"It just never seemed to bother me"							
			More about Power. Did people in power happen to be in power? Yes.							

	Early Years	High School	Army	-	Undergraduate/Temp Company as part of Mass General	Graduate/ Supervisor of Material Transport	Operations Manager, Scheduling/Film Manager Department of Radiology	Director of Clinical Support Services at MGH, Department of Radiology
	Both parents high school graduates			15 years	Business Management at Emmanuel College, Materials Management at MGH	Suffolk, Health Care Business Management		"If you told me 28 years later I would still be at Mass General, I wouldn't have believed you"
Bright Spot	Wanted to be a vet from the time she can remember	Enrolled in a work program, school for 4 hours and then work for 4 hours. Worked well for her. Changed major and thought process from vet - secretarial. Easy, available.	Scored really well on army test	Purchased manufacturing lines that had patents.	Good opportunity to dabble, see what groups were like. 3 different assignments. Materials management, had experience so they thought it would be a good fit. Loved people and loved the group. Boss happened to be a woman. All other directors/managers male, she was younger than all of them. 1st real female STEM Mentor.	Loved working with entry level folks, people who's first language wasn't english. Fulfilling. Felt like I could be an advocate. Solidified I could be a manager, leader of people. Boss who was in the army, "by the books," clear expectations, no weird mind games, straightforward helping me gain confidence. Let me fail on my face but didn't beat me up over it	"What the hell -- what do I have to lose?" Denise was very good to me, gave me a lot of opportunities. She was promoted. "H-, you're taking the real!"	Scope grew when mentor got promoted
Pain Points		No interest in school. Dissuaded from being a vet, program scared the heck out of me. Talking about the math and education, 8 year's. Wasn't fond of school to begin with.	Settled. Could've done more.	After 15 years my brain started to die	Early 80s, male dominated world. Don't know if it was intentional.	"I don't know anything about managing people"	"women are just bitches, guys can do the same thing and are brilliant"	Partner got really sick, wasn't trying to change career. Barbara being groomed for position, took her way out of comfort zone to prepare for the transition. That was 10 years ago. Denise, mentor, really pushed "Women are just bitches -- guys can do the same thing and are brilliant" Male dominated world
Opportunities		Signed up for the delay entry program for the army 6 months before I graduated, wanted to get out of Peabody, MA		What about working in hospitals? That's when the whole path shifted. Big, a lot of opportunities.	Working in secretarial position, loved working with people. Loved indirect healthcare	Timing was everything - just received Bachelor's which allowed her to apply to the position	"You don't need to know everything" Scope got bigger	

	Early Years	High School	Undergraduate	Pharmaceutical Company	Graduate	Colorado State Department	Health Data Viz
	Both parents have Bachelor's degrees	Colorado	University of Colorado at Boulder, Bachelor of Arts in Biochemistry	Worked there while she was pursuing graduate school. 2 years	Master's of Public Health with emphasis in epedimiology and biostastics at Oregon Health and Science University	Moved from Oregon back to Denver.	Consultant
Bright Spot	Wanted to be a vet, astronaut, optometrist - "I don't have to figure it out yet"	Mentor - high school chemistry teacher, thought she might want to be a chemistry teacher		She hated the internship but they loved her.	Grad school program, clinical research, national research. Internship during graduate school. Loved the work. High level data	Do something more applied, got connected with group at CO State Deparment. Across whole state department	Works with one token male
Pain Points	"They sort of floundered through life." Parents did not have one straight career path. Dad "serial entrepreneur" **Instability**		In terms of being a vet, optometrist, etc. realized she didn't like biology. Had an internship in pharma HATED IT. Huge university, never really had a mentor there. Can't devote life to animals when there are humans with worse healthcare	Took a job there even though she hated the internship. Conservative in decision making, **scared and overwhelmed.**	Felt disconnected from community. Didn't really understand job, boss was least linear person		
Opportunities	Middle school- always strong in math. Had a math teacher she really liked	Two really strong chemistry teachers, one male and one female. Turned me on to chemistry, eventually would major in it	Sister who is 6 years older went into Public Health - she also wanted to be in public health. Public health is very woman heavy		Didn't want to be a NP or doctor - **wanted to have a bigger impact**	Started working in the Department of Public health, building connections. Community health assessment, collecting data about needs ot community. Purchased Tableau, fell in love, brought Health Data Viz in. I said, I want to work for them! 2 years later, work for HDV	A lot of data analysts are good at data but not good at sharing that data. I felt like I was the bridge

	Early Years	High School	Undergraduate	Graduate	General Engineer at SUBMEPP (Submarine Maintenance Engineering, Planning and Procurement) an activity of NAVSEA located on the Portsmouth Naval Shipyard (PNS)
			Industrial and Manufacturing Engineering at Penn State	Engineer Management	Began working at Naval Shipyard in 2013
Bright Spot	Wanted to be an interior designer		Thought that architectural engineering, close to interior design		Career path is rewarding, what you worked so hard for. Working in a Lego Robotics where they have ratio requirements , feels valued in her job
Pain Point		Worked summers at BAE, didn't enjoy, not many women enjoy math and science, a lot of work required and may have missed out on some normal college experiences	Didn't get into the program for architectural engineering, lack of support for women, few or no role models, campus was so large. Difficult to pursue Engineering		One of only a few women working on her site, over 200 people working there (esimate 10 other women, 31ish and younger)
Opportunities		Taking a vocational engineering class, one of two girls in the program			"We need more women and teachers in STEM"

	Early Years	High School	Undergraduate	Children's Hospital	Graduate School	Children's Hospital
	Wanted to be a pediatrician from day one		Tufts, Started as pre-med, transitioned into child development and psychology		Speech Pathology at Emerson College	
Bright Spot	Skipped a grade, school was always easy	"The girl who skipped a grade," didn't have to work that hard. Very math driven, on the math team, BFF with math teachers	Child development, psychology, and biopsych as a good fit. Pulled in traditional science but applied it in a way that was human focuses. Seminar on Autism senior year, professor stood out. Helped her pursue research position	Really loved the research process. Loved working with data, building a story out of it.	Supporting classmates, helping to explain the papers they were reading, what the statistics meant	Took job to fill vacancy but ended up loving the role. Married all of the things that she was looking for, data heavy and significant clinical component
Pain Points		Balance of artistic pursuits with more STEM focused courses	First year was very hard. Had to study for the first time in my life and wasn't used to that. Fell into the trap of thinking she was failing. B+ average was the end of the world. By the end of first semester she realized that a chemistry or math major was not for her. "Oh my god, what am I doing here, this is really hard." Clac III felt like it was way over her head. Difficulty asking for help, lack of mentors. Had a friend be told she should pursue a major other than pre-med, Jenna didn't ask for advice because she couldn't stand to hear those words herself. College internship working with students with disabilities. Supervisor said "we never say to kids that reading is hard, it's OK if you don't like to read" but we do that with math. **More willing to let women build a wall.**		"This doesn't feel as rigorous as I expected it to feel." Speech pathology predominently women (96-97%) there seems like there is a great **fear** of math in speech pathology. Frustrating, want to have evidence-based practice.	
Opportunities	Never felt like "you can't do this because you're a girl"	Deep interest in math and other STEM related topics	Learned valuable study skills that would serve her well in graduate school. Took a year off before graduate school to decide if med school was for her, this is how she ended up at Children's Hospital where she still works now.	One research paper made her realize that she wasn't interested in pursuing medicine	It was strange feeling like I didn't have to work hard.	Should focus more on statistics, skill people need. Versus trignometry

#3	Early Years	High School	Undergraduate	Pharmacy	Graduate	Info Tech Software	Working for herself	Clinical Pharmacist Consulting in Fraud, Waste, and Abuse at SAS
			Bachelor's Degree in Pharmacy from Dusquesne - 5 year program	Started in retail, transitioned to hospital	Master's in Health and Medical Informatics, Brandeis University	Transitioned into this during period when she was in graduate school	"Anything for a buck"	
Bright Spots	one of 7 girls, raised by a strong mother. Mother earned two Master's degrees	Higher level courses, skewed toward men. Two females in her physics class, spurred her. "I'm not leaving this" Fight that gender thing	Went in undecided thinking she would be a math major	Working in a hospital had more reasonable hours		Learning software because boss didn't want to.	Teaching in a graduate program	Feels that STEM is moving in a positive direction, just slower
Pain Points	Secretly wanted to be a doctor, never got affirmation that she was smart enough to do that	AP classes didn't exist.	Math, derivatives and Calculus II "humbled me"	Male dominated industry, retail pharmacy nightmare, pharmacists reach an earning cap at 28 y/o. Anecdote: "I was working in the pharmacy and this guy came in and said, 'I want to talk to the pharmacist.' When I said, 'speaking' he said, 'no, I want to talk to *that* guy.' He was a porter or something. 'Best of luck!" Husband was also a pharmacist, and when the time came for higher education **he** got the Master's degree. I became the supportive role, always worked.	Waited to earn a Master's degree until after children were in college	Lost job during this time, company sold to competitor	Hated other work doing consulting for local hospital system	
Opportunities	6 sisters were teachers - didn't like how much teachers made (financial). Being one of 6 girls means that the household jobs aren't divided along gender lines, they all pitched in	No mentors. Self-determination. The harder something is, the more I like it. "That looks too hard → I better try"	Found a book in the library. Went down the list of careers, "what's in healthcare, and who makes the most money?" "The harder it seems the more I want to try"	"STEM wasn't challenging, the environment of work was" Promotions, "feeling like you have to prove yourself"	Didn't have "letters" behind name to make her feel like software professional, that's why she went back to school	Started working with Health Data Viz on book. Female owned company	Taking care of sick mother, needed to be able to work from home	

#3	Early Years	High School	Undergradua	Beth Israel - taking Master's levels courses concurrently	Brigham and Women's	Joslin Clinic	Massachusetts Improvement program	VP of Clinical Innovation
			Kent State University, Bachelor's of Science in Nursing	Staff Nurse - General Surgery/ER Care	Outpatient care - women's abortion clinic	Director of Nursing		Azzarra - broke off from original job in the private sector
Bright Spots	Mother was a nurse			Because of how that system/program was set up (leaders in nursing) and believed that nurses should be Master's prepared, so within 2 years started taking Master's levels courses. Doing clinical advancement ladder, more admin focuses	Added on different responsibilities, breadth of experience. Nursing field is primarily women	Involved in IHI (Institute of Healthcare improvement, did a lot of workflow redesign, groundbreaking work on improving outpatient care	Developed care management program	Data analytics company, only women, under 30
Pain Points		Mother wanted me to be a social worker, but I didn't want to do that						Difficulty to remain in tech, more men than women. When I started at this company I was only the clinical person
Opportunities		Never one to say I want to be a nurse my whole life, never had that defining moment. Mom was a nurse so maybe it was the easier thing to do?		Really great professional mentor, getting your Master's didn't mean you have to leave patient care		This job came from layoffs, good opporunities		Helping people to marry real experience that clinician brings to data analytics is a challenge.
	When people say STEM, they mean "hardcore sciences"	"Care-related profession"						

	Early Years	High School	Undergraduate/ Grad School	Rockefeller University	Wilkinson Institute	Columbia Graduate School	Symposium (anecdote)	General Insights
	Dad - PhD in Engineering, Mother Master's. Both Engineers		Computer Engineering, LVOV, Western Ukraine. Enrolled in 1982, time of the Afghanistan war. Computer Engineering, Russian system of Education Master's combined 5 year program	One of the oldest research institutes in the country 93-2000	Wilkinson Institute, Kidney Research	Statistics		Changing, more and more prominent women in medical informatics world. Interesting that a lot of them started as nurses.
Bright Spots	Had an appendectomy as a little girl - fell in love with surgeon, dreamed of being a doctor. Professors in the family	Uncle tutored her in math and physics, was the best tutor. Phenomenal teachers in math and physics who were inspirational. Always good at math, going her advanced level tasks. Started very early for her	She remembered it being 50/50. Lucky to have people in my family who were very enthusiastic.	First loves phenomenal. Supportive men (still in touch, lives in US). Saw her affinity for Software Development. Highlighted her liking and affinity to programming, directed her to that sub-specialty. Mentoring and teaching. Agnostic to gender. Best two program men on his team were women **Worth board. A mentor and friend there, Feminist with a capital F**	First time at a much higher position, founder of their informatics team. Phenomenal mentors. Mentor, data-oriented, he encourage me to go get my second degree.		4 female leaders on the panel. Attendance was equal by men and women. Everyone extremely supportive. Excerpt of traits listed below.	Don't find it difficult to stay in the career because I really love what I'm doing. I think that I'm good at what I'm doing. Creative work, interesting people. Challenging and interesting problems, motivation. Remembering ultimately that it's done for the betterment of humanity.
Pain Points	A lot of discrimination (Jewish, Soviet Union)	Facing the reality of the difficulty of enrolling in medical school, or even if I did I would end up in remote village in Siberia	A well known problem, chauvinism, vast majority of professors men. In computer science there were no women at all. Down greeted class, said one lady who is not admitted and her mom approached and said she was dreaming about computer engineering. He said a woman? Bullshit.	The only pregnant woman at the conference. Most of the women were content managers, not engineers.	Huge Apple conference in SF, enormous line to men's room and nobody in line for ladies room. Gender discrepancy at conference		Question - women leaders, necessary trends in character. Often times it's aggressiveness, testosterone equivalent qualities. Lack of consideration, lack of empathy. On the other hand, there are women who play "girlish" role, flirty. It's a defensive mechanism to survive discrimination. Encountered women who were harder to work with because of the trends listed.	Making it in STEM is difficult. Women vs. men twice as talented, two times the hard work, perseverance in the face of ambiguity. There is discrimination in pay, condescending approach is prevalent. "Even among the most refined men who considered themselves feminists" Michael on many research collabs with men and ever and over again the statements that I have made confirm the experience. Not only a women but an immigrant as well
Opportunities	Grew up in a family of scientists and engineers, family had connections	Family pragmatic – suggested computer engineering	Most boys were drafted during the war, so the breakdown boasts a different and majority of grads became women. Taking programming languages created their love, programming is an item I liked drawing computer schemes.	Job gave her connections. Lifelong connections				Motivation - husband had cancer and lived with it for a long time, practical information. Husband was a patient at the hospital she works at now

	Early Years	High School	Undegraduate	Graduate	PhD	Workforce
			University of Central Florida, Industrial Engineering	Pennsylvania State University - Master's in Industrial Engineering		Human Systems Engineer
Bright Spots	Wanted to be a brain surgeon, news anchor, and then wanted to be a Mechanical Engineer so she could design roller coasters!	HS - Autocad Program.	Freshman year was tasked with finding a mentor, targeted female professors, wanted their perspective. Guidance from other women in STEM.		Funding became available to continue PhD, stayed. Just because you have PhD doesn't mean you have to go into academia	Strong network led her to finding her current position
Pain Points		Program was "for boys"	Experience of professors teaching to the book but not having experience with practical application	Internship during graduate school: told directly that she checked off the minority box because she was a woman.	Academia "rife" with gender inequality. More difficult for women to be published, including in double-blind studies.	"manspaining," interrupting, belitting, lack of attribution
Opportunities		Took it partially to prove she could, partially to meet boys (HS brain). Enjoyed exploring engineering and design concepts, turned out she was good at it and understood the concepts better than most in the class	Surprised by the representation at UCF in Industrial Engineering. POC, genders and backgrounds varied. Department offered healthy and unique mix of people	In some ways, recognition that women don't have the same opportunities worked in her favor	Having a PhD meant she could pursue career opportunities but also transition more easily into academia is she so chose	Challenging but not necessarily driving me away. Don't know if anyother inudstry would serve me any better or worse

Group #2	Early Years	High School	Undergraduate	Registered Client Associate,
			University of Pittsburg,Started as business major, shifted to Communication and Rhetoric	Licenses. Two exams, you don't actually have to have a college degree to take them.
Bright Spots	Convinced I was going to be a pediatrician. Liked working with kids			Once you're licensed, you're good to go. Arguably the most successful person at her branch (a female) does not have a degree. Manager saw her potential
Pain Points	Turns out, she doesn't like the medical field. "White coat syndrome"	Wasn't a great student. Lack of teachers that were mentors. Can remember the teachers that discouraged her more than the ones that encouraged her	Student Athlete - athletics can damper focus on academics. Definitely didn't get as much out of education as she could have.	#Metoo movement drastically affects the work environment. Lack of diversity, "typical to what you might think in a big bank or investment opportunity." Old school. Don't get the impression that these is a push to change things, realistically it's a battle." Male dominated industry, women only make up 15%
Opportunities		Parents and coaches mentors. Mom was a hardass	A lot of the skills translate into her current role. Relationship building. Senior year panic, "I don't care what kind of job I get, just want a job." Didn't necessarily pick finance, just picked jobs I felt qualified for" "I'm really going to have to nail this"	"Tell me I can't and I'll do it anyway"

	Early Years	High School	Undergraduate/Graduate	Oracle	Start-up	Start-up Sold to Amazon	State Department
	Dad - Professor at BU, EDD, Teachs K-12 STEM Educators	Norwood, MA	5 year program, Massachusetts Institute of Technology (MIT) Computer Science, Masters of Engineering in Computer Science	Nashua, NH	Cybersecurity, Cambridge, MA		Program Officer, Department of State Office of Cooperative Threat Reduction, Bureau of International Security
Bright Spot	Dad was encouraging, signed up for lots of STEM related-camps	Good grades, set me up well. Liked STEM subjects in school. Computer science fun, and part of the appeal was that there were very few girls and liked the feeling of being able to keep up with the guys. Jr. Year went to a camp "Women in Technology." Overachiever in HS.	Funding available for Master's, make it pretty easy to pursue if you're a student in MIT. Logical thing to do. Loved the academic setting and challenge. In a sorority in college, lots of women to look up to. Demographics of MIT are balanced.		More meaningful work, more people her age and closer to the actual product		Utilizing more skills such as speaking and writing, building and maintaining relationships. Creativity and decision making.
Pain Point		Wished she was given more direction. She was focused on school in the moment, but didn't really know what she wanted to do. Not many mentors in HS	No strong mentor in undergraduate - did work with one woman for undergraduate and graduate thesis, and she was a good role model. Some one-off interactions like guys taking over projects, but not systematic	Not as much diversity once you've entered the industry. **microaggressions.** Pretty obscure, low level work, boring. "Old men" Manager great guy, in his 60s, didn't have modern understanding of the job field	More to offer than just coding. Didn't feel like she was good at coding. **Lack of confidence. "raging quietly off-line to my friends"** Personality not entirely suited to start-ups, "fads"	Had worked there for 3 years, when Amazon bought the company she was put in an entry level position, despite the fact that she was in the industry for 6-7 years, Master's from MIT. Male co-workers with similar credentials or less experience were put into higher roles. Her performance reviews all said "speak up, be more confident" There wasn't a trajectory for her, especially after she got bumped down to entry level position	Still doesn't feel like she speaks up or is confident.
Opportunities	Supportive family, exposure to STEM from a young age, extracurriculars	Pursued computer science because she thought she could get a good job	Computer science can be applied to any problem set or field, that aspect feels like you can go into any field you want	Had done an internship at Oracle, they gave her a job offer without putting through the process. Interviews - trick questions, code on the spot, write code on the board.		Felt like she had more to offer. Analogy: if you're a runner and you're not fast, what's the point? But if you're a soccer player, you may not be fast but you have other skills	"I don't want to be a statistic." Industry is hard but she doesn't know if she can attribute that difficulty to her gender. Getting scientists into government, bring more science experience into federal government

#1	Early Years	High School	Undergraduate	DC Urban Ins	Graduate	Post-Graduat	Managing Director, Health Content
			French and Economics @ Simmons College		University of Chicago	Market reserach	Information Science and Data Management
Bright Spots			Economics, analytics math classes. Really liked statistics	Creating econometric model of Japan	Econo-analysis - getting pleasure out of knowing more, ego boost	Thought she would work in marketing until she was introduced to information science.	Meritocracy
Pain Points	Father died at a young age, rasied in single parent home		OMG Linear Algebra! Didn't take it. Professor in college suggested she get a degree in statistics, but it didn't click with the way it was taught. Didn't have great role models				Terminology is a barrier to entry. Used to intimidate (at least initially)
Opportunities			Math for economics - didn't listen when someone said it's hard. During undergraduate worked with an Economics professor at Harvard, connections	Working on a mainframe, Pre-PC		Working with the first interactive search engine	

#2	Early Years	High School	Undergraduate	Graduate	Department of Health	CEO, Communicate Health
			Hampshire College	California School of Intergral Studies, Intergral Medicine		Communication company that oversees data and design
Bright Spot	She always knew she wanted to lead build something, make a change		Non-traditional grading	Looks at different ways of healing, different ways of health and wellness from different cultures		Research, design
Pain Point				Lack of mentorship	Had a boss that overall presented as a nice guy but was sexist. Not very forthcoming with acknowledging work. Grew to dislike him over the 9 years she worked	Lack of mentorship. When they started the company small business bureau were not responsive to her seeking mentorship. "You'll see how hard it is to be a woman in business" They'll assume you're the secretary, not the boss. When she wanted to integrate tech, people said "how can you do tech without a tech team" You have to know tech. Male tech people were doubutful. You'll never do this
Opportunities	Wanted to be the President of the U.S. when she was little - now, the CEO of a company		Writing and porfolio work, more focused on giving written feedback. Easy transition into graduate work, public health focus	policy work played well into integrative health	Experience made her decide that she didn't want to work for people like that, she knew she wanted to do things differently	As one of three female principals CEO of her company she can run the company the way she wants, not just like a male-run company. Environment is healthy and supportive, inclusivity. She has the power to ensure that this is the type of company she runs. Thought that they had thought about bringing senior leadership, glad she didn't because she's learned so much. Situation is really unique. "No one at Communicate Health will make less than a man"

#2	Early Years	High School	Undergraduate	Hospital	UNH	Dartmouth	MGH	NSQIP	Principal, Health Data Viz
	Parents both educators		Colby Sawyer, Business Administration	Finance Department		Dartmouth Medical School			
Bright Spot	Always wanted to be in business, strong interest in art and design		Brother in computers, was very interested in computers. Dean, director of her program saw something in her, was her champion. Got job out of college from this connection		Was one of the first people in the program, started by the professor at Yale that was in the program she was really interested in	Niche program. Quit her job and was able to go full time. Amazing, learned things. Cutting edge, select program, well respected. Early admitee	Working with sugeons, they told her "you taught me things" lots of validation, opportunities. Saw a skill set that made sense to them. Always showed up and worked hard. Highly supportive, spoke well of me to other colleagues, got me in front of opportunities	Knew she was the smartest, hardest working person	Women-owned
Pain Point				Frustrated, wanted to spreak wings. No one wanted to hire her for high levels. "I think it's a mans world. NH is a funny place, wouldn't break through to get hired, not very progressive.	Had started MBA, Accounting degrees. Hated. The program she really wanted to enroll in was at Yale but she couldn't uproot family		Boys club."In front of a room of people he called me a bitch." Called a bitch more than once. Just because she knowledge and confidence, claimed her place in the room. Innapropriate, demoralizing. Wanted to start her own business, it wasn't that she lacked confidence but she wasn't ready or fully clear. Wasn't full ready to leave a paycheck. Breadwinner of family.	Sacrificed a ton of personal, family time. "If you don't own it, someone else can determine your fate." I was never ever going to be in that position again. Bad situation, CEO was an idiot	Really hard to start. There was Plan B. Started when daughter was in college, had some savings but she was the primary breadwinner. No other choice
Opportunities			Mentor always steered her toward opportunities	Even when I was working for other people, I always wanted to work for myself	Learned a ton, Singularly focused	Was teaching at the time, someone asked if she knew about the program. Ephiphany. She went on a three-day program. Knew it's where she needed to be	Saw a lot of people out on their own who she thought was idiotic, not very good at it.		Women are better at managing technical projects. Collaborative, Problem-Solving, Communication.

	Early Years	High School	Undergraduate	Graduate	Practice	Chief Medical Officer	Consulting	Cigna
			Brown - phiosophical anthropology	Tufts, MD	Practiced medicine for 25 years	UMass Worcester		Marketing Medical Executive and Sr. Director
Bright Spots		math teacher major influence	mentor in college ran human studies - professors, doctors be geared toward	Female hematologist - Jane DeForge. 35% women - vanguard			Consulting, hated the travel. Mother of 5.	Allowed more family time
Pain Points	Everyone but parents were discouraging		Discouraged every step of the way	5 women, 105 people. Not easy to get into STEM	Pushed aside, sexist jokes, harrassment			
Opportunities	Mother had worked in an OB/GYN office		Knew she wanted to be a doctor, so she majored in humanities		Always interested in healthcare quality			Lives in a multigeneration al home

#3	Early Years	High School	Undergrad	Division of Military Trauma	NASA Ames	Graduate	Fellowship in California	Baylor	Opportunity to move into tech
	Dad - army, West Point, two Master's in Engineering, Med School after that		Santa Clara University, Biology	Injury Epedimiologist, undergraduate research	Interned in college, got a job with them after college	MSPH, University of Colorado	Injury Prevention	Systems Analyst, Healthcare Analyst and Coder	
Bright Spots			Liked the lab and thought it was fun. Teachers a mix of male and female. Role models around. Biology professors that were women	Not a math person, liked working with data. Liked the problem solving aspect.	Studying bone loss during space flight -- fun. At this point Dad became encouraging	Supportive female professor got her through tough year in Arizona	Fellowship turned into a permanent position. Built programming. Some women in leadership.		
Pain Points	Father was not encouraging with engineering - gender biases coming from the army. Grew up with Dad who was in med school -- different view, didn't want to be a doctor. Wasn't a student	Grew up with Dad who was in med school -- different view, didn't want to be a doctor	More men in chemistry and physics.		Couldn't work in lab full-time due to rat allergy	Started at University of Arizona, program was just an OK fit "Don't move for a boy"	Mostly women -- could it be because it paid less? Terrible money. Most of her bosses men. Health educators women, the "touchy-feely" side	Didn't like management. Didn't want to work with HR. Baylor/Dallas TX more conservative. Not oppressive but not many role models. Has a friend who was on a call, she said she was one of two "brownish people" and one of two women --> lack of diversity. As you go up in hierarchy, more men	Confidence shaken by this prospect. Gender? Brother given the same opportunity and he hac no problem taking the chance
Opportunities		Didn't know what I liked - process of elimination	Introduced to a woman who was in Public Health, still in health care but not an MD. "Goldilocks" school. Good size, connections, etc.	Liked study design, just came across the field working on a study of injuries of West Point cadets		Thought about getting a PhD, but not positive she wanted to.			
Doesn't take crap									

	Early Years	High School	Undergraduate	Graduate	PhD Program
			Environment and development	University of New Hampshire	McGill - Analyzing wildfires
Bright Spots				Women in Science Club - older graduate students giving her advice, helping her navigate	Ladies of Landsat- amazing way to meet women in the field from around the world. Highlighting women's work on their Twitter page, storytelling. In N. America field is men but it Europe it's female dominated
Pain Points		Interested in physics in high school but got way more encouragement to go into social sciences		Challenging, didn't click. Advisor pushing her away from hard science toward more social science. During her dissertation defense, asked her if she was moving to Canada to be a "stay at home wife"	90% of the field white and male
Opportunities		Mom encouraged her to pick major in environment because green jobs were popular	Science courses as apart of her studies, but also lots of economics courses		Networking with women

	Early Years	High School	New England Institute of Art	New Hampshire Technical Institute	Manchester Community College	University of Massachusetts Lowell	Transitioning from school to the workforce	Head Start
	Mother did not go past 8th grade, ended up getting GED when she was 7 or 8. Dad did some technical school, was a tradesman				Associated in Advanced Mathematics and Sciences	Bachelor's in Science in Pure Mathematics	Looking at careers in the public and private sector utilizing degree.	Home visitor
Bright Spots		Discovered that I wanted to be a teacher at this point		Took an advanced mathematics class - it was at this point she discovered intrinsic passion for math.	Great professors, encouraging. Female department chair, formed relationship. Being a woman in a position of power was something that was really inspiring. Didn't know it was something that I was necessarily missing	Applied mathematics, amazing professor	Having a gender neutral name may have helped her get a foot in the dorm with certain job opportunities.	Blending education into her work which was her ultimate goal
Pain Points		Dad diagnosed with cancer - without the support of teachers and Vice Principal don't know if she would have graduated. Highlighted the impact of teachers	Left after a year to re-evaluate			Hard to pursue STEM. Lots of sexism. Hard to overcome. Abundance of male faculty, 5 females. Females are lecturers vs. associates professors, terms track despite PhD. Meet all the same criteria as men. Male faculty, well-meaning or not, didn't contribute to me feeling like I could have success. Doubted me, didn't give me credit, trust, belief in skills. That mentality was passed on to male students. Jr./Sr. Classes. Number of women in STEM classes started to dwindle as coursework went on. By the end of college career it was not surprising when I was the only woman, or one of two women. "hard to feel like the odd-one-out" all the time. Fall Semester Sr. Year - applied mathematics. "Wow, you're the only woman left in this class!" Didn't necessarily feel welcome. Jarring. Hard to not have people to rely on. Incidences where I would do HW, male peers didn't believe she had the right answers.	Intimidating. The jobs that interested her she was not qualified for. Not interested in getting higher degrees. undergraduate was hard enough	Said she spefically didn't want to work with little kids - now she's working with very little kids
Opportunities	Never had a specific career in mind			Focused on elementary education until she realized that she wanted to work on content-specific and higher grades.		Having a gender neutral name may have helped her get a foot in the dorm with certain job opportunities.	Transitioning into something that she was still interested in but didn't stress and overwhelm her	

	Early Years	High School	College	Post-Graduate
	Both parents Bachelor's Degrees, both computer programmers		Bachelor's Degree Worcester Polytechnic Institute (WPI) -- Chemical Engineering	Consulting Assistant Project Engineer. Civil and Environmertal Firm
			Interned at wastewater treatment plant in college. Helped to get the job she is in now	First job out of college, been working there for 3 years
Bright Spots		Really liked chemistry, high school chemistry teacher "whipped us into shape because we were lazy" helped her through school applications even after she was done with class. She had a doctorate, smart and knowledgable going to school interviews (particularly one at WPI) there was a professor who said this is everything you can do with chemical engineering. The possibilities were vast.	When you tell people you're getting a degree in chemical engineering, people gasp. Vanity thing, but it kept her going. Her year at WPI was about 60/40 and that was a big deal that year. Chemical engineering 50/50 split which was rare	Not difficult to stay in STEM. Like working in STEM, liked going to school for it, I do like what I do. I guess it's hard to pinpoint if any major thing would happen that would have her fully leave field vs. leave her job
Pain Points		Didn't like doing labs, really hated physics so that killed NASA idea	"You're only here for the numbers" You didn't deserve your spot in the program. Only one undergraduate professor was a woman. **Discouraging.**	You got a job first over (X) because they need to fill their quota. All clients men, one female client. Going out into the field to deal with all these men, hard to be taken seriously, it's hard to be taken seriously in the field and then you bring the complaint back to the office and you're telling this to a man. Annoyance and discomfort because no one is there who has been through that. Initially very encouraged because they had a lot of women, but then as I've been there longer that they hire a lot of women in lower roles, only a few in the higher roles so obviously they leave because it's not. sustainable for them. She can see that if she stays in company to point where she has kids or wants another degree, no support system. Things like we have women, 25-35, you know one of them will want a kid at some point. They get pregnant and panic, no breastpumping room. No good systems in place for these women
Opportunities	Watching Jeopardy College Tournament as a little girl, all the winners were male. Watched one episode where the winner was a female who worked for NASA. Made her want to work for NASA	Pivoted to Chemistry from NASA aspirations	I thought if I was just a pure chemistry major I'd just be doing lab experiments	All over the place because I wanted a job. Main goal was to work in environmental field in some way. Gives her the chance to try her hand at lots of different types of projects and decide what she likes best
	"If she can do it, I want to do it"			

Appendix E - Personas Procedure

The researcher will develop the Persona after the interviews. The Personas will summarize the experiences of the women who were interviewed to identify trends and themes. These Personas will be presented to the thesis committee and will be a launching point for the Statement Starter activity that the group will conduct.

Appendix F - Personas Results

Jamie, 32, Chemical Engineer
Introvert

High School

- In high school, Jamie loved being in classes that were "for the boys." She liked to prove that she could do it

College

- Jamie attended an undergraduate institution where both male and females were represented in the faculty population
- She had a female mentor
- She was a member of a sorority in college and felt a lot of support amongst her peers
- Her university has a strong alumni association and has connected her to professional networks

Professional Life

- She deals with micro-aggressions in the office, including "mansplaining," interrupting, belittling, and lack of attribution.
- She is challenged by engineering, but she does not know if the challenges she is facing is unique to her industry or if she would encounter these challenges in another field

Challenges/Frustrations

- Jamie had a very positive undergraduate experience but has not had the same experience in her industry.
- She has very few female colleagues to support her when she is dealing with sexism and discrimination in the workplace.

They said 'you're only here for diversity quota.'

Rebecca, 25,
Industrial Engineer
Extrovert

Early Years

- Rebecca grew up in a household with at least one parent who worked in a STEM-related field.
- Rebecca was often the only girl in her higher-level math and science courses in high school and college.

College

- In college, Rebecca did not feel like she was reflected in the greater engineering population. She had very few female professors or mentors to look up to. Even well-intentioned male professors made her feel like the odd-one-out in class.
- Rebecca's male classmates in college were often demeaning. They would ask her for help on the homework but would then question her answers, even if she knew she had them all right.
- When she interned at different organizations in college she found the awareness of gender discrepancies actually worked in her favor, although she didn't like the feeling of "checking a box."

Professional Life

- Despite being only one of the few women in her office, she feels more valued in the workplace that she did at school.

Challenges/Frustrations

- Rebecca is frustrated that many of her opportunities have been given to her because she is a women rather than her merits.
- Rebecca dealt with the challenge of being the only female in many of her classes, and the pressue it put on her.

“They'll assume you're the secretary, not the boss.”

Mary, 60,
Healthcare Company CEO
Extrovert

About Mary

- Mary co-owns and operates a healthcare consulting business with two other women.
- Prior to starting her own company she dealt with sexism in the workplace, including being overlooked for higher management positions and offensive name-calling.
- Due to her experience working for someone else, Mary decided she wanted to be her own boss.
- As the CEO, Mary is in charge of hiring practices, insuring inclusivity and diversity in her company.
- Even as the CEO, Mary has been in situations where people assume her male employees are her boss.

Challenges/Frustrations

- It frustrates Mary that she continues to deal with sexism even as the owner of her own company.
- Her situation is unique and therefore she does not have many peers who are in a similar position as her.

Alison, 37
Healthcare Data Analyst
Introvert

Early Years and High School

- Alison expressed a deep interest and aptitude for math from a young age
- In high school she had encouraging math and science teachers. She got straight As and was in AP level classes.
- Initially Alison thought that she wanted to be a vet, but she realized that there are humans who have worse healthcare than animals
- This made her think that she wanted to be a MD,

College

- In college she realized she hated biology and began to pivot to Public Health. This would allow her to have the bigger impact that she was seeking.
- Alison received a Bachelor's of Arts, but knew that she wanted to be in a healthcare-related profession.

Professional Life

- Alison has strong professional networks that allow her to grow her career. and to tackle projects that she's interested and passionate about.
- She started working with a large organization to help them visualize their data, became passionate about the work.
- Now she works at a female-owned company.

Challenges/Frustrations

- Allison has had many positive experiences in her professional life, and wants to continue working in a female-led environment.

Having a family was a major goal for me, but I had to keep working.

Eleanor, 50
Healthcare Administrator, Nursing
Extrovert

Early Years

- Eleanor had many role models in nursing growing up, so naturally she gravitated toward a career in that field.

Professional Life

- Eleanor found work in hospitals that supported women and their professional growth.
- One hospital she worked in had a program specifically for people who wanted to work and get a Master's degree.
- She had the ability to work and raise a family. She even had a boss who made it possible for her to bring a child to work.
- Because Eleanor worked in healthcare, she never felt that gender was a factor in her ability to advance professionally.

Challenges/Frustration

- Eleanor has been fortunate in her professional career to have supervisors that have supported her career and her aspirations to be a mother.
- Childcare did become an issue once her children got older and she could no longer bring them to work with her. She has to rely on family and expensive daycare to continue working.

I don't need a bunch of letters behind my name when I already know a lot of the content.

Bethany, 52
Pharmaceutical Consultant
Extrovert

College

- Bethany has a 5-year degree in pharmacy which is the same degree that her husband has.
- When she and her husband started a family, they decided that it would be he who earned a higher degree.

Professional Life

- Bethany continued to work, but it wasn't until her children were grown and out of the house that she decided to look into higher education.
- Bethany continues to work in the field and works to prove to management that she is qualified for a higher job despite having no Master's degree. She not want to commit time and money to a degree when she already feels like an expert in her field.

Challenges/Frustrations

- Bethany's frustration lies in the fact that she considers herself an expert in her field, but is not able to move up in her organization because she does not have an advanced degree.

"I didn't listen when people said math was too hard."

Susan, 40
Information Technology
Introvert

Early Years and High School

- Susan grew up with strong STEM advocates both at home and at school.
- In high school she liked and was good at math, especially statistics
- She got an ego-boost out of knowing more than her peers.

Professional Life

- Susan believes that there is meritocracy in the field of Information Technology.
- She does admit that there are a few barriers for women, including a lack of female role models in the undergraduate setting and terminology that can be intimidating.
- Susan had a male boss that she said was "gender-agnostic" and who encouraged her to pursue a Master's degree.

Challenges/Frustrations

- Susan believes that her field can be intimidating to young women. She wants to remove barriers that would deter women from pursuing Information Technology.

"I have never questioned my passion for architecture. It may not always be my job but it will always be my profession."

Lydia, 39
Architect
Extrovert

Education/Personal Life

- Lydia immigrated to the United States with her family in high school.
- Both of her parents and many of her family members hold advanced degrees in STEM-related fields. She received encouragement and mentorship from within her family.

Professional Life

- Lydia now works in architecture, which is a male-dominated industry.
- She has had many experiences where she is the only woman in the room, and in some cases she is the only mother.
- She has had to advocate for a wellness room at her workplace so that she and other mothers can pump in privacy.
- Lydia feels that she has experienced discrimination in pay and that other women have left the field of architecture for that very reason.
- Many industry events are mostly male. She has created friendships with other women at these events, and they laugh to themselves when there's a long line to the men's bathroom. Usually it is the other way around!
- Lydia feels that there is a lack of mentorship and leadership development in architecture.
- The reason she stays is because she is passionate about the work. She finds the work to be challenging and creative, and she gets to work with interesting people.
- Lydia now works on smaller consulting projects where she has more flexibility to be with her children and still have a career.

Challenges/Frustrations

- Lydia is frustrated by many aspects of the field of architecture, mostly as it relates to corporate culture.
- Becoming a parent in architecture is especially difficult. Even men who want to take paternity leave have a difficulty getting it.
- The issues in Lydia's field are not exclusive to the United States - she has had issues working in other countries because of her gender.

Appendix G - Verbatim Procedure

The Experience Diagram will be used by the researcher to pinpoint specific quotes or anecdotes that cannot be generalized into a Persona. They will then be written up in a narrative. The goal of the Verbatim section of this paper is to highlight the unique and individual experiences that women have faced during their professional or educational careers in STEM. This information will be used along with Personas to create Statement Starters with the research committee.

Appendix H - Statement Starter Procedure

Materials: Zoom conference room with whiteboard capabilities, Statement Starter Supplemental Packet, PowerPoint presentation

Time: 45 minutes – 1 hour

Number of Participants: 4, committee members and researcher

Directions:

- The research will begin by sharing the Experience Diagrams, Persona Profiles, and Verbatim to the group.
- The group will discuss the findings and begin brainstorming “how might we” statements.
- The researcher on the Zoom whiteboard will record the statements.
- Once the group feels that they have done a sufficient job of brainstorming, they will organize their findings.
- These statements will be shared with the group of women who will participate in the Big Concepts Poster.

Appendix I - Concept Poster Procedure

Materials: Zoom conference room with whiteboard capabilities, Thesis PowerPoint

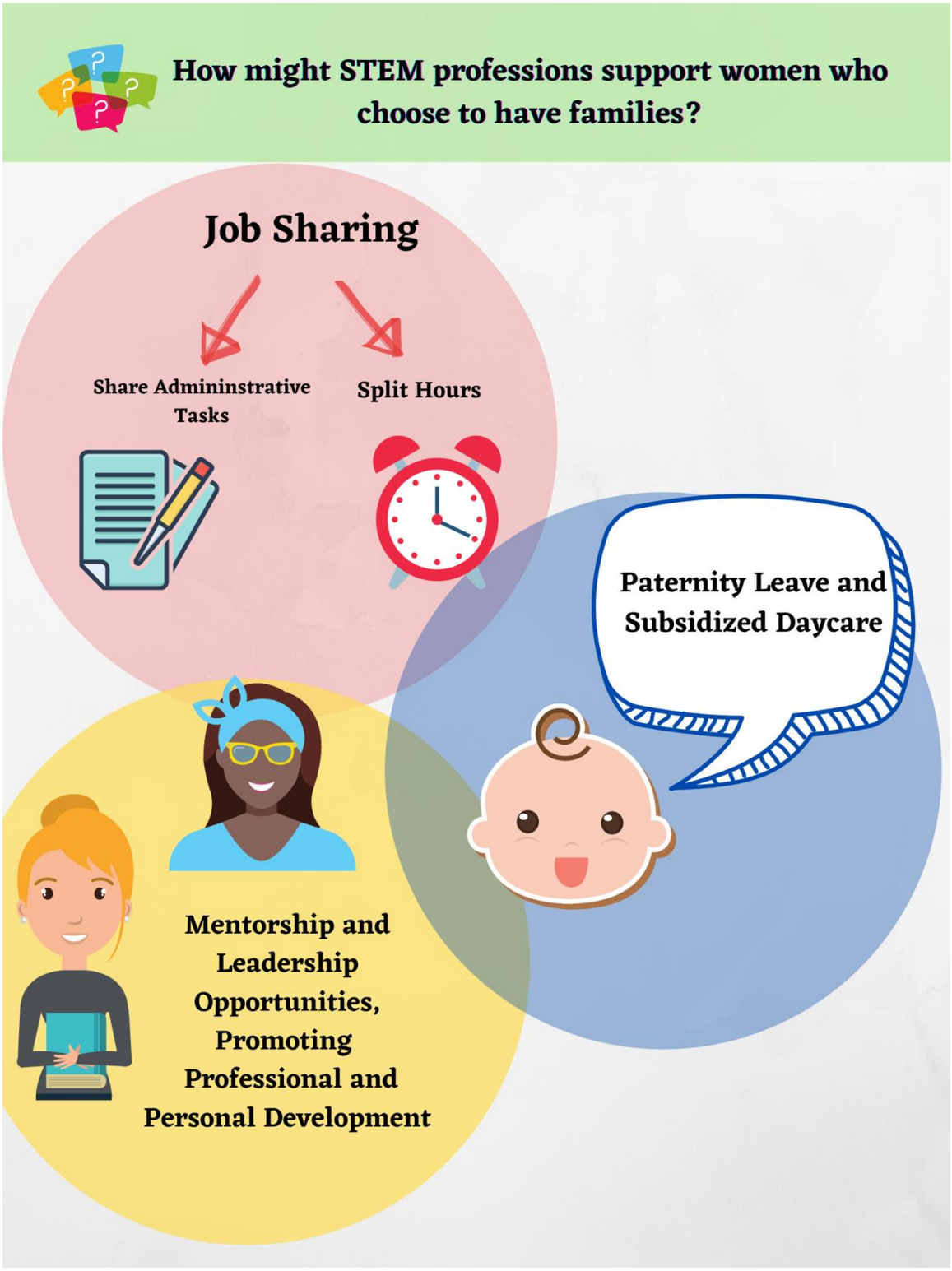
Time: 45 minutes – 1 hour

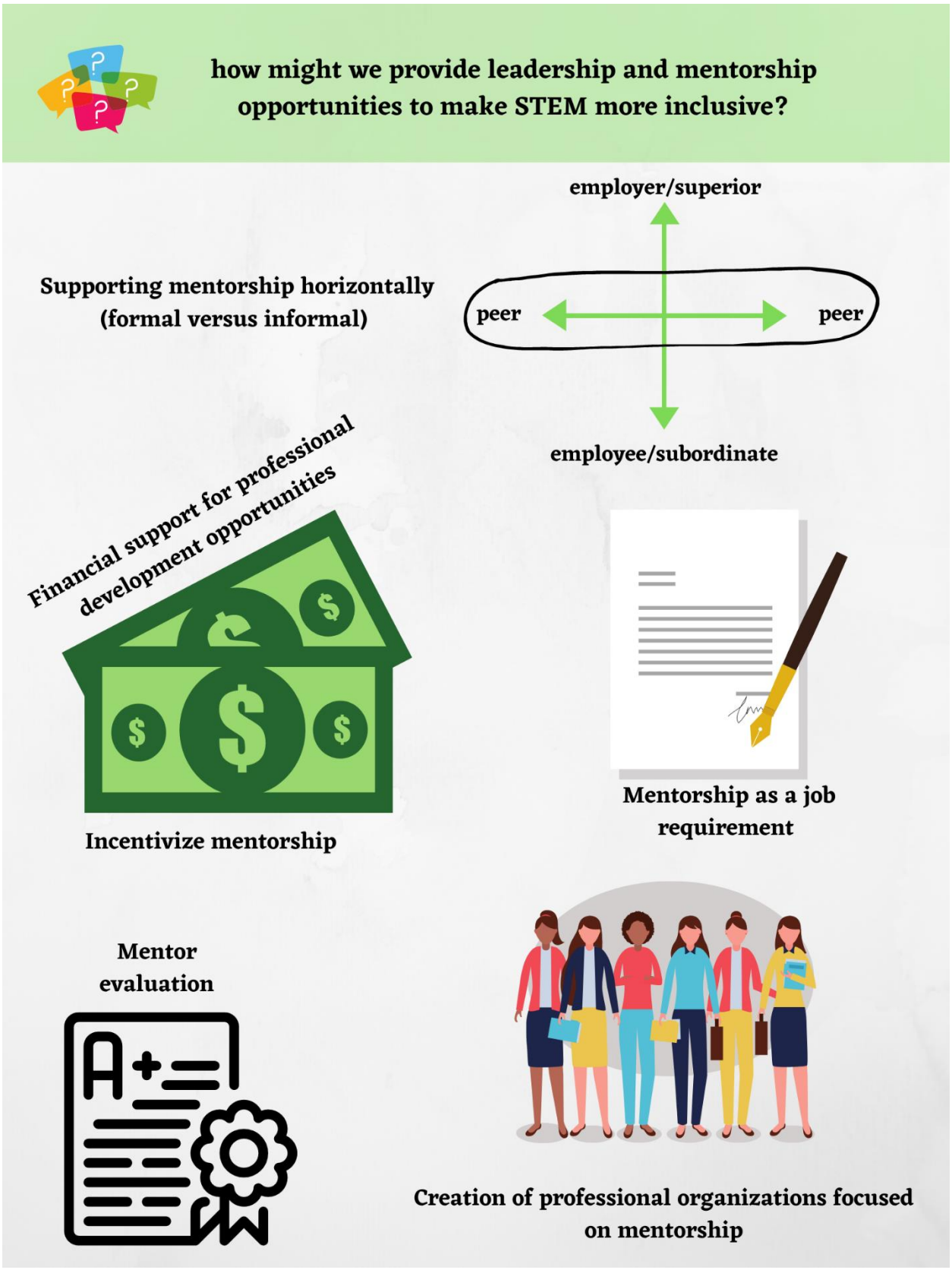
Number of Participants:

Directions:

- The researcher will begin by sharing a summary of the research findings.
- The researcher will then focus the group's attention on the Statement Starters developed by the research committee.
- The participants in the Big Concept Poster activity will vote on the top three Statement Starters that they wish to explore more thoroughly.
- For each Statement Starter, the women will brainstorm various solutions to the questions they are exploring in depth. They will encourage them to explore all possible answers. They should not worry about time, money, or other resources at this point.
- As the women are sharing ideas, a scribe will be recording their answers in the sketch form.

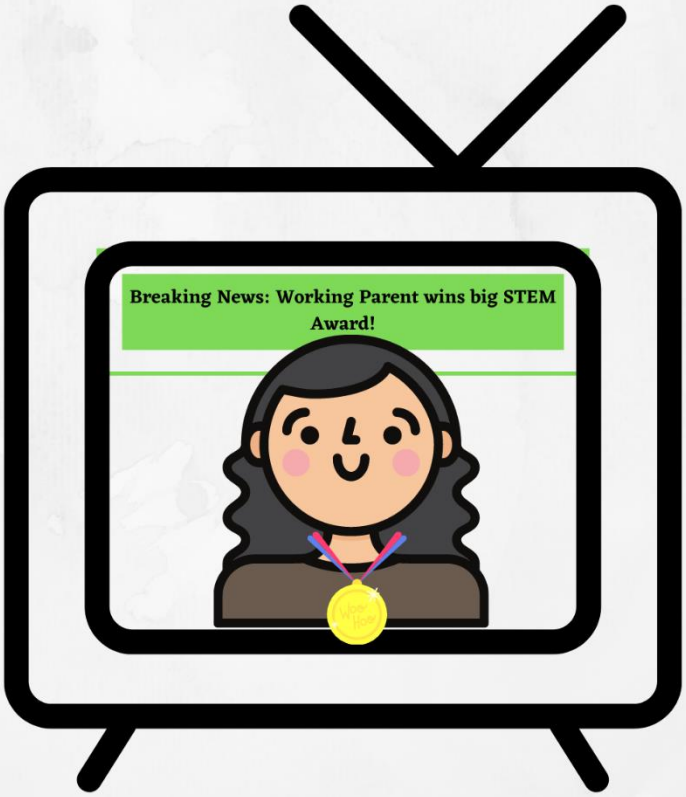
Big Concepts Posters




how might we provide leadership and mentorship opportunities to make STEM more inclusive?
employer/superior
Supporting mentorship horizontally (formal versus informal)
peer
peer
employee/subordinate
Financial support for professional development opportunities
Incentivize mentorship
Mentorship as a job requirement
Mentor evaluation
Creation of professional organizations focused on mentorship

How might we normalize inclusive conversations and make sure women have better representation in the media?

The year is 2021, and there is now a mandate for equal representation of women and men in STEM. This applies to award nominations, TV representation, and social media.



There is a TV campaign titled, "Women in STEM" that raises awareness about women in various STEM-related fields. There is a special focus on working parents.

Appendix J - Consent Forms

RADFORD UNIVERSITY

Informed Consent

Title of Research: The Training and Retention of Women in STEM-related fields
Researcher(s):

Dr. Joan Dickinson
Mrs. Anne Rowell Clark

The purpose of this study is to examine the factors that determine whether women will stay in science, technology, engineering, and math (STEM) related careers. While there is research on discrepancies between the number of men and women entering STEM related majors and career paths, there are not as many studies that examine why these discrepancies exist and what is being done to eliminate them. The purpose of this study is to use Design Thinking strategies to explore women's experiences as students and in STEM related fields, and to determine the factors that either keep them in STEM or drive them away.

We ask you to be in a research study designed to: examine the factors that determine whether women will stay in science, technology, engineering, and math (STEM) related careers. While there is research on discrepancies between the number of men and women entering STEM related majors and career paths, there are not as many studies that examine why these discrepancies exist and what is being done to eliminate them. The purpose of this study is to use Design Thinking strategies to explore women's experiences as students and in STEM related fields, and to determine the factors that either keep them in STEM or drive them away. If you decide to be in the study, you will be asked to participate in an interview either in person or via Skype. You will be asked a series of questions regarding your educational experience in STEM related fields and/or their career path in a STEM field. These interviews should last approximately 20-30 minutes. The researchers may determine that additional information is needed and ask to schedule a follow up call, which would last no longer than 15-20 minutes. Video/audio recording will be utilized for this study. Approximately 7-10 people from a group of educators will be asked to participate in the study.

You are being invited to participate in a research study of women in STEM-related fields. You were selected as a possible participant because of your experience as a student and/or professional in a STEM-related major or a in a STEM-related career field.

This study has no more risk than you may find in daily life. However, recounting past or present student experiences could evoke emotions and reactions. Participants may decide to withdraw from the study at any time without penalty.

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This study has no more risk than you may find in daily life. However, recounting past or present student experiences could evoke emotions and reactions. Participants may decide to withdraw from the study at any time without penalty.

There is no compensation from being in this study.

There are no direct benefits to you for being in the study.

You can choose not to be in this study. If you decide to be in this study, you may choose not to answer certain questions or not to be in certain parts of this study.

If you decide to be in this study, what you tell us will be kept private unless required by law to tell. If we present or publish the results of this study, your name will not be linked in any way to what we present. The data collected in this study are anonymous. This means that not even the research team can match you to your data.

We will collect your information through audio recordings. This information will be stored on a secure computer and will only be accessible by the researchers. Audio recordings will be collected during this study and used in order for the researchers to listen back to interviews after they have been conducted. The recordings will be transcribed and then deleted from the iPhone they will be recorded on. They will remain on a secure computer for the duration of the study. After that point, the recordings will be stored on a private server for a minimum of three years and then deleted. The recordings will not be shared with the general public or other researchers. You *do not* have to agree to be recorded in order to participate in the main part of this study. If you give the research team permission to quote you directly, the researchers will give you a pseudonym and will generalize your quote to remove any information that could be personally identifying.

If at any time you want to stop being in this study, you may stop being in the study without penalty or loss of benefits by contacting: Dr. Joan Dickinson, jidickins@radford.edu, (540) 831-6164, or Anne Rowell Clark, arowell1@radford.edu.

If you have questions now about this study, ask before you sign this form.

If you have any questions later, you may talk with Dr. Joan Dickinson.

If this study raised some issues that you would like to discuss with a professional, you may contact Dr. Joan Dickinson.

This study was approved by the Radford University Committee for the Review of Human Subjects Research. If you have questions or concerns about your rights as a research subject or have complaints about this study, you should contact Dean Orion Rogers, Institutional Officer for Research, Artis College of Science and Technology, Radford University, jorogers@radford.edu, 1-540-831-5958.

It is your choice whether or not to be in this study. What you choose will not affect any current or future relationship with Radford University.

If all of your questions have been answered and you would like to take part in this study, then please sign below.

_____	_____	_____
Signature	Printed Name(s)	Date

I/We have explained the study to the person signing above, have allowed an opportunity for questions, and have answered all of his/her questions. I/We believe that the subject understands this information.

_____	_____	_____
Signature of Researcher	Printed Name	Date
_____	_____	_____
Signature of Researcher	Printed Name	Date

Note: A signed copy of this form will be provided for your records.

Use when direct quotes or audio/video may be used

I do □ or do not □ give my permission to the investigators to quote me directly in their research.

The investigators may □ or may not □ digitally record this interview.

Participant Name (printed): _____

Signature: _____ Date: _____

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_____	_____	_____
Signature of Researcher	Printed Name	Date
_____	_____	_____
Signature of Researcher	Printed Name	Date

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Participant Name (printed): _____

Signature: _____ Date: _____

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Researcher(s): Dr. Joan Dickinson, Mrs. Anne Rowell Clark

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We ask you to be in a research study designed to examine the factors that determine whether women will stay in science, technology, engineering, and math (STEM) related careers. While there is research on discrepancies between the number of men and women entering STEM related majors and career paths, there are not as many studies that examine why these discrepancies exist and what is being done to eliminate them. The purpose of this study is to use Design Thinking strategies to explore women's experiences as students and in STEM related fields, and to determine the factors that either keep them in STEM or drive them away. If you decide to be in the study, you will be asked to participate in a Concept Mapping activity. In this activity, a group of educators will be asked to identify different aspects of a STEM education, including skills that are acquired in a STEM class, majors that are associated with STEM-careers, and future careers of a STEM learner. This activity will take place in-person at Cardigan Mountain School or online depending on the availability of participants. This activity will take around one hour to conduct. Approximately 7-10 educators will be asked to participate in this activity.

You are being invited to participate in a research study of women in STEM-related fields. You were selected as a possible participant because of your experience as an educator in a STEM-related major or a in a STEM-related career field.

This study has no more risk than you may find in daily life. However, recounting past or present student experiences could evoke emotions and reactions. Participants may decide to withdraw from the study at any time without penalty.

There is no compensation from being in this study.

There are no direct benefits to you for being in the study.

You can choose not to be in this study. If you decide to be in this study, you may choose not to answer certain questions or not to be in certain parts of this study.

If you decide to be in this study, what you tell us will be kept private unless required by law to tell. If we present or publish the results of this study, your name will not be linked in any way to what we present. The data collected in this study are anonymous. This means that not even the research team can match you to your data.

We will collect your information through audio recordings. This information will be stored on a secure computer and will only be accessible by the researchers. Audio recordings will be collected during this study and used in order for the researchers to listen back to interviews after they have been conducted. The recordings will be transcribed and then deleted from the iPhone the will be recorded on. They will remain on a secure computer for the duration of the study. After that point, they will be stored on a secure server for a minimum of three years and then deleted. The recordings will not be shared with the general public or other researchers. You *do not* have to agree to be recorded in order to participate in the main part of this study.
If you give the research team permission to quote you directly, the researchers will give you a pseudonym and will generalize your quote to remove any information that could be personally identifying.

If at any time you want to stop being in this study, you may stop being in the study without penalty or loss of benefits by contacting: Dr. Joan Dickinson, jidickins@radford.edu, (540) 831 – 6164, or Anne Rowell Clark, arowell1@radford.edu.

If you have questions now about this study, ask before you sign this form.

If you have any questions later, you may talk with Dr. Joan Dickinson.

If this study raised some issues that you would like to discuss with a professional, you may contact Dr. Joan Dickinson.

This study was approved by the Radford University Committee for the Review of Human Subjects Research. If you have questions or concerns about your rights as a research subject or have complaints about this study, you should contact Dean Orion Rogers, Institutional Officer for Research, Artis College of Science and Technology, Radford University, jorogers@radford.edu, 1-540-831-5958.

It is your choice whether or not to be in this study. What you choose will not affect any current or future relationship with Radford University.

If all of your questions have been answered and you would like to take part in this study, then please sign below.

_____	_____	_____
Signature	Printed Name(s)	Date

I/We have explained the study to the person signing above, have allowed an opportunity for questions, and have answered all of his/her questions. I/We believe that the subject understands this information.

_____	_____	_____
Signature of Researcher	Printed Name	Date
_____	_____	_____
Signature of Researcher	Printed Name	Date

Note: A signed copy of this form will be provided for your records.

Use when direct quotes or audio/video may be used

I do □ or do not □ give my permission to the investigators to quote me directly in their research.

The investigators may □ or may not □ digitally record this interview.

Participant Name (printed): _____

Signature: _____ Date: _____