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A Delphi Study of the Potential Influence of Women in STEM Careers

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Abstract

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Abstract

American businesses are working with educational institutions to attract women into technical and scientific professions. However, less than one quarter of the people working in science, technology, engineering, and mathematics (STEM) are women. The educational system as-a-pipeline model is not supplying business with skilled workers, specifically female STEM employees. Organizational change must occur and this process begins with the organization's leadership. Guided by the the conceptual frameworks of Kotter & Rathgeber and Kouzes & Posner, this Delphi study asked 54 female professionals, in various locations across the United States, about what influenced them in their education and career choices. Responses were collected from an internet survey and the emergent themes were deduced by graphical means using word clouds and word counts. The evaluation indicated that early interests in science were generated through networking experiences that occurred both in and out of the educational environment. Pro-male bias and lack of encouragement 'influenced the women's decision making while studying and working. To obtain the female professionals they need for the future, business leaders need to fund research, and provide internships, networking, and shadowing opportunities with current professionals. Leaders and managers also need to provide unbiased and supportive educational and workplace environments where women study and work. These social and organizational changes will allow women to become the needed workers for American businesses to maintain a technological presence in the world marketplace.

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Chapter 1: Introduction to the Study

When school-aged girls, 6 through 18 years of age, have a choice about what to study, their selection of Science, Technology, Engineering, and Mathematics (STEM) course selection falls behind other courses (National Science Foundation, 2008; U.S. Census Bureau, 2010; U.S. Department of Education, 2010). The process continues throughout the education system up to and including graduate level study. Existing data show the participation of female students in the STEM fields throughout the educational system from kindergarten through graduate school. A compilation of studies have presented inconsistent and often conflicting results about why they leave (Ceci & Williams, 2007, 2010, 2011; Hewlett, 2007; Xie & Shauman, 2003). An exodus does continue once females begin careers in the STEM areas with as many as 60% of women having nonlinear careers (Hewlett, 2007, 1). This exodus leaves high-tech companies with an observable lack of females in STEM positions (U.S. Census Bureau, 2010).

In this research I sought to delineate what it is that is different about the female professionals who leave the STEM fields, as well as to define those things that drive the women that do stay. In particular those that can be transferred, trained, or at a minimum, understood so that future students might benefit. While women comprise more than 20% of engineering school graduates, only 11% of practicing engineers are women (Fouad & Singh, 2011). The Project on Women Engineers' Retention (POWER) was designed to understand factors related to women engineers' career decisions and results indicated that the workplace climate was a strong factor in decisions not to enter STEM fields after college or to leave the profession after short careers (Hewlett, 2007).

Background

Quantitative studies and years of data collection by such organizations as the National Science Foundation and the Society of Women Engineers provide a wide body of knowledge of the numbers of degrees earned, by gender, by year, and number of students taking the various forms of engineering and scientific coursework in high schools and universities. These data indicated that while females have caught up to males in the numbers of degrees earned, they still lag behind in employment and earnings (U.S. Census Bureau, 2009). What is not clear is why they lag behind. Dugan, Fath, Howes, Lavelle, & Polanin (2013) found that despite decades of research on how to increase the educational persistence and career success of women in STEM fields, significant gaps still exist (p.17). This implies that there are various reasons why women choose to study STEM and why they stay or leave. It is far more complicated than just observing the numbers of women at various stages of the educational and work life journey.

Data, such as published in 2007 by the U.S. Department of Education, showed that the numbers of high school students electing STEM courses has been increasing. However, female engineers continue to drift away from the field as they progress through the educational system and into the workforce (Ceci & Williams, 2007, 2010, 2011; Dugan, et. al., 2013; Hewlett, 2007; Xie & Shauman, 2003). The U.S. Census Bureau summary of occupation by sex for the civilian employed population 16 years and over, indicated that males dominate the non-healthcare STEM occupations (U.S. Census Bureau, 2010).

The U. S. Census summary (2009) of Educational Attainment in the United States in the years 2006 through 2008 indicated that females exceeded males in earned bachelor and advanced degrees and that those professionals aged 45 and older comprise a significant segment of STEM educated people. This is representative of the population of women professionals who was polled to find their success recommendations for the younger people following them into the STEM fields. The respondent's age profile was 20 women ages 30-44, 21 ages 45 to 60, and 7 were over the age of 60.

U.S. Census data (2009) indicated that the females and males graduating high school and obtaining degrees have been fairly even. The summary also makes clear that the pay levels disproportionately favored males as more females are at the poverty level than males for the same population slice. This was supported by the responses found in this research. This may be indicative of a societal predilection to reward males more than females in the STEM careers.

There is a need to understand the reasons that females lag behind males in STEM fields, both in their numbers and in their ability to support themselves and their families as shown in the census summary. Nearly a full percentage point more of females with bachelor degrees were at the poverty level than similarly educated males (U.S. Census Bureau, 2009). Also evident was that males earn more, on average, than their female contemporaries, nearly $20,000 more annually for similarly educated college graduates (U.S. Census Bureau, 2009).

Since 1966, significant change occurred for degrees earned in science and engineering fields from 1966 through 2006, approximately 25% of the degrees in 1966 were earned by women to over half of the degrees in 2006 that were earned by women (National Science Foundation, 2008). This change is significant and impressive except for the lack of data that show that these graduating women are finding employment in the STEM fields.

Research is needed to fill the gap in the research of why females study STEM topics in school, but do not work in the STEM fields after graduation. It is unclear from the data alone if females are not applying for the available job openings, they are not hired for the positions due to bias, lack of female mentors or sponsors, or other reasons yet to be determined.

Problem Statement

Men and women are currently graduating with technical degrees at similar rates. Businesses that employ the graduates with majors in the STEM fields are experiencing a lack of qualified applicants and there is a corresponding lack of employed females in these careers (U.S. Census Bureau, 2010). Stephens, Vice President, Human Resources at The Boeing Company and Chair of the Aerospace Industries Association Steering Committee, addressed the House Science and Technology Committee on this subject in February 2010.

Stephens (2010) asserted,

> We in the aerospace industry are concerned about the United States' ability to sustain its leadership role in technology and innovation. As the need for complex problem-solving accelerates globally, this country faces a competitive gap that we can close only if more of our young people pursue careers in STEM-related fields.

Unless we can close this gap, it will have grave implications for our nation's competitiveness, security, and defense industrial base (p. 1).

Boeing, among other companies, is working with universities and professional societies to entice students, particularly girls, into the STEM arena. Many websites, while purporting to interest girls, are often aimed at educational professionals to sell books and other educational materials.[1]

A few exceptions are the Zoom Public Broadcasting Service television show website, the Girl Scouts website that has focused sites for ages beginning at five, and the animation software offered by MIT that has nearly a million subscribers who have posted nearly 2 million projects.

Focus has tended to be on educational institutions and academic professionals, but current trends are branching into the workplace. On September 26, 2011 during the 12:45PM Conference Call with Tchen, Holdren, and Suresh, the White House and the National Science Foundation announced a new initiative. The NSF Career-Life Balance Initiative is a 10-year plan to provide greater work-related flexibility to women and men in research careers (The White House, 2011). During the speech following this announcement First Lady Obama said, "If we're going to out-innovate and out-educate the rest of the world, we've got to open doors for everyone. We need all hands on deck, and that means clearing hurdles for women and girls as they navigate careers in science, technology, engineering and math (The White House, 2011, p.1)".

I sought to describe both the reasons and the situations in society and businesses that fail to educate, attract and retain female professionals into the STEM fields of endeavor and subsequently provide STEM professionals to the technology-based businesses that need them. Most respondents indicated that they had interests in STEM fields from an early age. They mentioned an interest in space, animals, insects, and medicine. Most were encouraged and influenced by parents and family while a few mentioned teachers or professors that had a lasting influence on their study or career.

Purpose of the Study

The purpose of the study was to distill experiences, circumstances, beliefs, or values that have kept the subject female STEM professionals in their chosen field or have caused them to leave into recommendations that can translate into information for future stem professionals. Through analysis the responses of the studies participants were distilled to their essence as described in Chapter 4. These will be disseminated to help younger women to develop an interest in the sciences and subsequently fill open positions in the STEM fields. Additionally, this study will be submitted to management and leadership journals to influence the current leaders of businesses and educational facilities in their paradigm of how female scientists are seen and treated compared to their male counterparts. The current paradigm, as defined by the participants in this study, is indicative of a workplace and business practices that favor male applicants and workers.

Research Questions

1. Do current and former STEM professional women have experiences, circumstances, beliefs, values, or interests, in common that might be recognized and built on to encourage young students to follow in their footsteps into the STEM fields?

2. What are the emergent recommendations that can be used to attract females to choose STEM coursework and make STEM career choices?

It was anticipated that answers to those questions might emerge and they did as described in Chapter 4.

There are aspects of culture, society, and personal development that were explored in the Delphi study. The essence of these similarities and differences were evaluated by comparing the individual responses of all of the participants by using tag clouds and the find function resident in both Microsoft Word and Microsoft Excel. Tag clouds permitted seeing the similarities and counting the repetition of language used in the participant responses.

Theoretical Framework

Leaders in business, like Boeing's Stevens (2010) recognize the gap between their need for STEM professionals and the numbers of graduating students capable of assuming those positions and the numbers that actually apply for the open positions. What they do not seem to be recognizing is that this is a global social problem where leaders do not understand the structure of the student body or the leadership change required to change organizations to attract the needed technology workers (Metcalf, 2010). Much of the literature references a pipeline model of education where students go in one end, make choices within a course of study, and come out the other end with skills and a working knowledge in that selected field (Metcalf, 2010). "Within the study of recruitment and retention in science, technology, engineering, and mathematics (STEM), the value of context is often lost when the highly critiqued, yet pervasive, pipeline model discursively stands predominant as the interpretative framework (Metcalf, 2010, p. 2)."

There are a variety of ways that students make choices about what to study, different influences that guide those decisions, be it parents or teachers. In the opinion of Reed (2009) of Warwick, R.I. in his correspondence to *Aviation Week & Space Technology* he stated, "The career choices of today's students are economic decisions; they select career fields that they believe will provide them the plentiful and secure employment opportunities" (p. 8). The women's responses mentioned money and security in addition to interests and proficiency that guided their STEM selections. Pay levels, while not a key focus of taking interesting courses and career steps, appears to be a significant aspect of the choices made by the responding women.

Current business and governmental leaders must change not only their conceptual model of how people move through the educational system, but also how students make the choices that will lead them to a career as they emerge as a fully educated person that will be attracted to working in a technology-based company. It seems that choices may be influenced by economics as Reed (2009) said. In addition, the influence of early childhood family and friends, society and the location where a student enters the world of learning and the interactions students have had with workers in those technology-based industries also had impact. Leaders may be able to influence people to make STEM career choices. Effort has been expended to influence teachers and educational leaders rather than providing an environment where students can interact to be exposed to STEM career workers (The White House, 2011). Perhaps there is more of a similarity to the leaderless networks of ants and bees than to a confined pipe that guides one along a given path.

In a hierarchical network, all directives and decisions must pass through the chain of command. In a leaderless social network, tasks are accomplished by those with that skill and as nonskilled members interact with skilled members, they may adapt that skill as their own (Gordon, 1999).

"When individuals discover a common interest or passion, they organize themselves and figure out how to make things happen (Wheatley, 2006, p. 170)". It is the emergent characteristics of self-organized and leaderless networks that hold the power for change.

Barabasi (2002) called these networks a web without a spider. "In the absence of a spider, there is not meticulous design behind these networks, either. Real networks are self-organized. They offer a vivid example of how the independent actions of millions of nodes and links lead to spectacular emergent behavior (Barabasi, 2002, p. 221)." If education as a network can be defined, capable of spectacular emergent behaviors, then change that might meet the needs of business with educated STEM professionals could be created.

If education is a network instead of the common notion of a pipeline, this model could be manipulated by creating and encouraging individual behavior and by creating nodes and links where people in the network can find others to interact with that would encourage interest in STEM.

The pervasiveness of social networks like Facebook and counting friends, and using Twitter to be connected to anyone or everyone has an interesting impact on our individual behaviors, including our choices for education and career. "Seeing ourselves as a part of a super organism allows us to understand our actions, choices, and experiences in a new light (Christakis & Fowler, 2009, p. xii)." People do what their friends, neighbors, acquaintances, and other influential people do. If it is not popular in a young person's sphere of interaction to take a STEM course, then they will not be taken.

This study contributes to the management field of organizational change by making business and political leaders aware of how students make their decisions about what to take in school and where to seek employment. These are based on networking experiences and interactions with professionals and information about STEM studies and careers (Gordon, 1999; Wheatley, 2006) and not economic thoughts about pay scale as Reed (2009) proposed. This notion was supported by the participants in the study. They remarked about interests from an early age that encouraged STEM study.

Managers and leaders need to recognize the network organization of students within the educational system and create interaction nodes within that network where students can find opportunities to interact with STEM professionals on a meaningful basis. I found that the research participants were not influenced by a unique science project or a singular experience with a parent's work environment or science fair or bring your child to work efforts. In my experience, these events often find the children being isolated in a cafeteria or conference room and shown movies while they enjoy pizza or hot dog lunches and not an interaction opportunity with either the workers or the work.

If the 8-step model for change defined by Kotter and Rathgeber (2005) is used with the information garnered in this research, organizational change could begin. The strength of the network model is its non-reliance on the instigation by a leader. If an organization is to accomplish change, it must create the environment for change, and have a plan for accomplishing change (Senge, 1999). A model for positive change is also offered by Leban and Stone (2008, p. 21). These models can be adapted or adopted to create meaningful change in the way leaders interact with potential employees.

A leader must work within a planning framework with their personal vision for the future and then communicate that vision to the organization, be it an entire company or a local department. Wherever the change is going to be taking place, leaders first duty is to prepare the environment and then to develop the creative tension to motivate people to want to change (Leban & Stone, 2008).

While a search on Yahoo.com will generate hundreds of images for change models, it is the concept of the audience and the model for interaction with potential employees that are at the heart of the leadership vision. Whether the leaders use a systems approach as defined by Senge (1999) or network approach as defined by Wheatley (2007) or the connections defined as networks, crowds, or markets of Easley and Kleinberg (2010), what is significant is that the model for the audience will strongly influence the decisions of the leader of how to influence the members of the potential employee pool.

Kouzes and Posner (2007) took a survey across countries in all six continents to determine what followers felt were the key characteristics of the leaders that they most admired. The survey was taken for each revision of the book and all were similar in the top four selected characteristics; honesty, forward-looking focus, inspiring, and competency.

Leaders who are honest, forward-looking, inspiring, and competent may make the changes necessary to train, hire, and retain the STEM professionals that will be needed to continue technology-based manufacturing. If they are to be competent, then information must be given to them to allow their forward-thinking skill to perform. It was the goal to define and to provide some of that needed information to those leaders. A theoretical change in the model of how STEM professionals are created needs to be updated from the antiquated and illogical pipeline model. Leaders in business and education need to update their paradigm to the model that students are a self-organized network that seeks to learn and apply STEM knowledge. Leaders must realize that they need to focus their change efforts on the perceptions of the members of the student network to change their perceptions of STEM coursework, careers, and the stereotypes for the people and environments associated with the STEM fields outside of medicine.

Since the students behave as a leaderless network that is reliant on their networking and their emotional response to the stimuli received, the current leaders must understand how to influence leaderless networks. Wheatley (2007) stated that:

> People often comment that the new leadership models derived from living systems and complexity science couldn't possibly work in "the real world". I assume they are referring to their organization or government, which they experience as a predesigned bureaucracy, governed by policies and laws, where

> people are expected to do what they're told and wait for instructions. This "real world" of mechanistic organizations craves efficiency and obedience. It relies on standard operating procedures for every situation, even when chaos erupts and things are out of control. This is not the real world. This world is a man-made, dangerous fiction that destroys our capacity to deal well with what's really going on. The *real* real world, not this fake one, demands that we learn to cope with chaos, that we know how to evoke human ingenuity and skills, that we adopt strategies and behaviors that lead to order, not to more chaos. (p. 1)

This consideration provided insight for interpretation of the information from the study participants about how they would change leadership, education, and interactions to influence the future STEM workforce.

Business leaders also need to redefine their industry and a company's real need for these professionals. The February 5, 2015 search of The Boeing Company employment website gave a result of less than 1000 open engineering and scientific professional positions available company-wide. With over 400,000 STEM graduates per year in the United States (National Science Foundation, 2008) companies, like The Boeing Company, that compete for the best scientific minds may either be misstating the future need or making politically beneficial statements. It would not be unheard of that companies who frequently ask congress for funding include such issues and concerns in their presentations as was done in the previously cited speech to Congress by Boeing Vice-president Stevens (2010).

Nature of the Study

While current thinking uses the analogy of a pipeline where students enter one end and where some leak out along the way does not seem logical. If one can leak, it seems logical that one might also be able to rejoin or that one might not leak and become stuck in the pipeline. (Metcalf, 2011) Logic conveys that it is not closed and linear, but a more open and circuitous route that leads people through education and then to a career (Hewlett, 2007). The research was structured such that the actual paths taken by both those that studied STEM and those that have careers in STEM fields could be delineated, understood, and passed on to others.

The inquiries to the Delphi group included a demographic survey, included by Survey Monkey, which surveyed about age group, education, geographical location, and household income. The interpretation of the responses to each Delphi study question was focused on identifying those synergies and similarities between the participants using tag clouds, Figures 1 through 6. Emergent characteristics were ascertained to determine the recommendations for influencing young people to enter STEM fields for study and the development of a lifetime career. These recommendations will influence future students so they might adopt or adapt similar paths into STEM careers.

Definitions

Credibility: The credibility criteria involve establishing that the results of qualitative research are credible or believable from the perspective of the participants (Trochim & Donnelly, 1999, p.149)

Dependability: The idea of dependability emphasizes the need for the researcher to account for the ever changing context within which the research occurs (Trochim & Donnelly, 1999, p.149).

Network: A pattern of interconnections among a set of things (Easley & Kleinberg, 2010, p.1).

Social network: An organized set that consists of two kinds of elements: human beings and the connections between them (Christakis & Fowler, 2009, p.13).

Transferability – Transferability refers to the degree to which the result of quantitative research can be generalized or transferred to other contexts or settings (Trochim & Donnelly, 1999, p.149).

Assumptions

Based on the review of the available literature, popular opinion, and personal experience there appears to be a universal assumption that the educational system can be perceived as a linear pipe and that students, primarily females, leave the pipeline of STEM studies beginning around age 12 and continuing through their professional careers (Ceci & Williams 2007, 2010, 2011; Xie & Shauman, 2003). While the current model of education is a pipeline where people move through based on teacher influence (Metcalf, 2010), as anticipated, contributors supported the research premise that students behave as members of a leaderless network that is influenced more by societal, familial, and interpersonal influential factors (Wheatley, 2006; Wheatley 2007).

A second assumption was that after employment females appear to leave due to so-called female issues like motherhood, caretaker roles, and lack of talent in traditionally male positions (Hewlett, 2007). A third assumption was that in middle and high school it is not popular for girls to take STEM classes or participate in activities like the science club or the computer club. At the college level, similar issues seem to be assumed in addition to a fourth assumption that there exists a societal bias that women do not do well in the STEM classes because of some innate disability to understand them (Allen, 2011). The data showed that women do not hold STEM career positions in the same ratios that they graduate from college (United States Census Bureau, 2010). The fifth assumption brought forward was that they do not apply for jobs in their major fields or that they marry and do not pursue a career at all (Hewlett, 2007). A sixth assumption was that those women who do get hired in their major field often leave after employment as they get pregnant and leave due to familial pressures and do not return after the children are older (Hewlett, 2007).

I made a seventh assumption that societal and business biases and prejudices are the actual reasons that women are underrepresented in the STEM fields outside of the medical fields. In particular, female STEM professionals face these issues from an early age by being told that girls do not do such things (Allen, 2011). By asking professionals that have been either successful the indicators emerged. The emergent characteristics that these women selected courses and careers based on proficiency and interest can be used to inform additional research and to influence the educational system, society, and governmental and business organizations. These data may inform young people, particularly women, of how they can anticipate an enjoyable study of STEM classes and a career free of prejudice and restrictions.

In her study of how ants learn the jobs of the ant society, Gordon (1999) explained that ants learn by interaction with other ants that have a different job within the society. In this way, each ant learns to imitate each job and thus move into the next strata of labor. This information led to a ninth assumption that people may choose educational interests and careers based on a similar leaderless network; on happenstance interactions and encounters with people or information about various STEM fields of endeavor. In contrast, they could be discouraged by negative interactions or encounters with cultural biases and prejudices (Allen, 2011). These ideas were supported by statements made by the participants in this study. They were influenced by parents, parents friends, and chance encounters with people that influenced their decision-making about study and careers.

Scope and Limitations

The participants in this Delphi study were limited by virtue of the selection process that focused on women with over 10 years of experience in a STEM career or those that had a STEM degree.

The second limitation was the use of the Delphi method, by virtue of its small sample size, restricted the information gathered to the experiences and knowledge of those qualified participants. While it was assumed that the participants are typical of the larger population of workers, they may not be. I found similarities or links between the participants that might have value to young people seeking information and encouragement to study and work in the STEM fields. While the research group was small, a third limitation may be that there was so much variation and diversity among the participants that no significant recommendations could be discerned from the discussions. People from the Survey Monkey audience that met the research criteria introduced an additional limitation where the responses of the participants may limit the creation of generalized results that may be applicable to a larger population.

This research reflected my own experiences as both a student in STEM and as a professional in a STEM field. "Qualitative methodology recognizes that the subjectivity of the researcher is intimately involved in scientific research. Subjectivity guides everything from the choice of topic that one studies, to formulating hypotheses, to selecting methodologies, and interpreting data," (Ratner, 2002, p.1). Limiting the influence of the researcher occurred by utilizing standardized methods for data collection, review, and summation. To remedy this fifth limitation, tag clouds were used to visualize the counts of words included in the responses from each contributor and the participant group as a whole. Another limitation was that the people engaged may not have similarities or synergies. The selection by years of experience and STEM degree bounded the research by defining a scope of similar years within American educational and work systems.

Significance of the Study

This examination will add to the literature that recognizes the strengths and key characteristics of living female scientists, technicians, engineers, and mathematicians. It fills a gap in the literature by delineating experiences and other influences that led these scientists to move through their primary education and university studies and into the professional work environment. This information will aid society by providing new perspectives on how students make decisions about their coursework and career planning, and when they join the workforce as they support technology-based businesses through selecting careers in STEM fields. This information will influence leaders within both the educational system and businesses that utilize STEM educated professionals. Understanding what guides the decision-making processes of current STEM professionals may allow leaders to make the changes necessary to support the development of new STEM professionals and maintain and retain current professionals.

The professional development experienced by group members might have an application to young people who are in the educational system and are seeking reasons or encouragement to study STEM coursework. The positive social change that might result would allow women to participate more fully in STEM careers. Their influence could lead to imaginative and innovative changes in technology-based products, processes, and improve the quality of work life created with the insight and different approaches that women might bring to the technical design and development community.

Summary

I elicited, associated, and defined the commonalities and recommendations from the Delphi study contributors. Their experiences and recommendations might influence the inclusion of women in science, technology, engineering, and mathematics and benefit businesses by providing needed professionals.

While researchers have mentioned the shortages of technical workers (Stephens, 2010), the focus appears to be on educational solutions and recommendations. Programs exist in companies like The Boeing Company that are meant to influence young people to take science and math at school, but most often the programs are aimed at the teachers and education professionals. This orientation seems to be a result of the current model for the educational system as a pipeline. Students enter, are educated by teachers led by educational professionals, and then emerge as fully educated individuals ready to engage the world by joining the workforce in a capacity that will benefit both the company they join and society as a whole. The pipeline model is pervasive in the literature; both education-based and business-based journals reiterate this model (Metcalf, 2010). The women in this study indicated that networking opportunities with STEM workers and teachers impacted their decision-making. Chapter 2 is an exploration of the current literature on educational models and gender bias in education, the workplace, and society. Governmental influences, programs, and funded research topics are also included.

Chapter 2: Literature Review

Introduction

Females in the areas of business have been of interest since 1923 when the Equal Rights Amendment was introduced and education was emphasized when Title IX was enacted in 1972 (Cho & Kramer, 2013). Research of the literature available initially focused on educational studies that were funded by universities in reaction to Title IX. Further investigations used keyword searches such as gender equity in education and business environs, the concepts of social networks, leaderless networking, and systems thinking. The pipeline model for education repeatedly occurred while researching other topics. It became evident that there is a lack of studies of other models for providing STEM professionals to business, both regarding women in STEM education and the shortage of female STEM professionals in technology-based businesses.

As stated by the participants in this study, bias in education from educators, administrations, and institutions, societal bias against women in technical fields and gender inequities in the workplace are still occurring. These are key indicators of educational, workplace, and social conditions that influenced decision-making; both the decision-making of the women seeking STEM education and employment and of the leaders and managers that might teach, hire or manage them.

Literature Search Strategy

Key research phrases were used to search the databases offered by the Walden library. These included the *educational pipeline, gender equality in STEM, gender equality at work, gender equity in education, systems thinking, networks, social networks,* *leaderless networks, leadership, human development, psychogenic disorders, organizational development, decision-making,* and *gender bias.*

The review of literature related to the research questions took shape under a few key topical searches. The data domain of STEM careers and education led the research to an education database search for gender bias in the classroom, gender differences in faculty and the attainment of faculty tenure. In the management databases, the search focused on such key topics as female retention rates, female engineers, and females in engineering and the sciences.

Various national, state, and local government agencies have assigned committees and focus groups to look at aspects of the female technical worker in the United States; among those are the University of Maryland study funded by the National Science Foundation on Enhancing the careers of females in the chemical industry in the United States and the National Academy of Engineering website Engineer Girl and the Adventures of Josie True website (http://www.josietrue.com/) from the National Science Foundation, Program for Gender Equity and The Girl Scouts of the USA study, Generation STEM: What girls say about science, technology, engineering and math.

In addition, the research questions led to questions about how many people graduate with STEM degrees, how well are they paid, is there equity in pay and the employment statistics between males and females in the STEM fields. Investigations in government databases such as the United States Census Bureau and the National Science Foundation revealed data on such conditions and events.

Examination of the literature of leadership in the STEM fields led to information on networks and on societal connections made through available social networks (Barabasi, 2002; Christakis & Fowler, 2010; Gordon, 1999; Wheatley 2006; Wheatley, 2007). These networks are leaderless and difficult to analyze beyond observation. The notion that social networks are the instigating models for how people learn and acquire information and influence their choices in life, including those in their educational career, indicate that the leaderless network is a preferred model for education in the United States in lieu of the prevalent pipeline model that influenced the research questions.

Organization was done using the Microsoft Excel facility to sort and to classify the books and articles. Table 1 is an example of this process.

Table 1

Literature Review Sorting in Microsoft Excel

Authors	Citation	Theoretical Framework
Al-Sanad, H. A., & Koushki, P. A. (2001). In Pursuit of Excellence and Gender Equality: Engineering Education at Kuwait University. *Journal of Engineering Education*, *90*(2), 253-259.	(Al-Sanad & Koushki, 2001)	Gender Equity in Education
ASHRAE Journal (Ed.). "Why aren't more women going into engineering?" *ASHRAE Journal*, November 2006: 7-8.	*(ASHRAE Journal*, November 2006)	Gender Equity in Education
Atwater, J. & Pitman, P. (2006). Facilitating systems thinking in business classes, *Decision Sciences Journal of Innovative Education,* 4 (2) 273-292.	(Atwater & Pitman, 2006)	System Thinking
Bain, C. D., & Rice, M. L. (2006). The Influence of Gender on Attitudes, Perceptions, and Uses of Technology. *Journal of Research On Technology In Education*, *39*(2), 119-132.	(Bain & Rice, 2006)	Gender Equality
Baker, J. (2002) Psychogenic voice disorders—heroes or hysterics? A brief overview with questions and discussion. *Log Phon Vocol 27* 84-91.	(Baker, 2002)	Psychogenic disorders
Bastalich, W., Franzway, S., Gill, J., Mills, J., & Sharp, R. (2007) *Australian Feminist Studies*, 22(54), 385-400.	(Bastalich et al., 2007)	Gender Equality
Benschop, Y. & Brouns, M. (2003) Crumbling ivory towers: Academic organizing and its gender effects, *Gender, Work, and Organization* *10*(2), 194-212.	(Benschop & Brouns, 2003)	Gender Equality at work

The Education Pipeline

As Erikson stated (1997), the life cycle cannot be separated from the social context within which it occurs. The stages of life often find people unprepared and they adopt a blameful attitude or self-deprivation to explain it.

Sheehy (2006) wrote:

> The years between 18 and 50 are the center of life, the unfolding of maximum opportunity and capacity. But without any guide to the inner changes on the way to full adulthood, we are swimming blind. When we don't 'fit in,' we are likely to think of our behavior as evidence of our inadequacies, rather than as a valid stage unfolding in a sequence of growth, something we all accept when applied to childhood. It is even easier to blame our periods of disequilibrium on the closest person or institution, our mother, our marriage, our work, the nuclear family, the system. We seize the cop-out (p.16).

These formative years when females are making decisions about what to study or where to work, the personal perception of fitting in with others and what girls are good at is based on our sphere of interactions. Choices are made based on our networking with the people in our sphere of influence (Gordon, 1999; Wheatley, 2006) not necessarily by teachers and others in our educational pipeline.

The idea of the educational pipeline fits our needs as we transition into adulthood from childhood, blaming the system or others because STEM courses are too hard to understand. The notion of the pipeline allows social and psychological biases to exist and perpetuates the notion that specific classes or types of people, in particular females, are not good at STEM coursework. Even the businesses looking for STEM professionals believe that the educational pipeline will produce educated professionals to fulfill the available jobs since they provide courses for teachers and professors instead of students.

There are few, if any, studies that show that teachers have failed to instill interest in the STEM fields in the students or that schools have not provided courses that capture the interest of students in STEM (Metcalf, 2010). I agree with this statement as I could find no recent studies about teacher impact on girls or schools impacting the selection of courses in STEM. There is data from the Department of Education (2007) and the United States Census Bureau (2009, 2010) that show that the courses are being taken and that girls are graduating but neither their decision-making processes or personal influences have been studied. This study did ask the participants about their influences, encouraging and discouraging aspects of their decision-making that led them into STEM careers. The participants support the idea that networking experiences impacted their decisions.

If business and educational leaders learn to see the educational system as a network of students linked by common interests and abilities, they might be able to provide circumstances where students can interact with STEM professionals and learn about the jobs they perform (Gordon, 1999). Once students are seen as a self-organizing network, the job of identifying the current emotional interests, the social interests, and network biases can be started and results found used to establish STEM awareness and STEM appreciation within the network (Metcalf, 2010).

A study performed by the Institute for Higher Education Policy, IHEP, uses the notion of a long-held model of the technology-based educational system, namely the

STEM pipeline, even while proposing a new model for individual facilities of higher learning to prepare students for STEM careers. "In 2006, the National Science Foundation (NSF) began funding the Model Replication Institutions (MRI) program, which sought to improve the quality, availability, and diversity of science, technology, engineering, and mathematics (STEM) education"(IHEP, 2009, p.1).

The pervasiveness of this model was indicated in Yahoo search results for STEM pipeline where 6,750,000 results were returned when searching for information about the STEM pipeline. Limitations exist within the literature for the pipeline model of education and training of STEM students as Xie and Shauman (2003) observed:

> First, the pipeline model does not capture the complexity of the educational and career processes of becoming a scientist. It refers to a unidirectional, orderly, and rigid, series of stages, and it equates non-compliance with the normative career trajectory as "leaking' or 'dropping out' of the pipeline…
>
> Second, in the pipeline framework, persistence across different stages of the educational and career trajectory is assumed to represent progress along the science pipeline. In other words, the pipeline model is a developmental framework in which the successful completion of all stages within an ideal time schedule means a positive outcome.
>
> Third, other life events that coincide and interact with the science career trajectory are absent from the pipeline conceptualization. (pp.8-9)

Life is not as linear or as timely as the pipeline model would have us think. Women have gained parity with men in the acquisition of STEM degrees at all levels (U.S. Census

Bureau, 2010). While the reality of such a nonlinear process seems almost intuitive and plausible, females gaining numbers in the STEM fields led to speculation and conclusions based on longitudinal studies such as that undertaken by Vogt, Hocevar, and Hagadorn (2007) when they determined that “Besides solid academic preparation, healthy self-confidence, and lack of ambiguity about their choice of major, other explanations cited for this reversal in previous trends are strong family support and females’ high expectations for success” (p.1).

While the data are clear that female students are graduating, the pipeline leakages at that stage have been evident in the employments rates of female engineers (U.S. Census, 2009). The rising number of women engineering students doesn't necessarily equate to an increase in those taking up the profession for a living. Researchers in the U.K. found that women students had identified engineering degrees as a good basis for a variety of career paths (Thilmany, 2007, p.10).

It would follow then that a similar finding may exist in other countries that are experiencing a similar rise in the educational selection of engineering as a university major. Machine Design (2009) “only 1 in 10 male engineers leave the field by the time they hit 30, but about 1 in 4 women leave engineering after getting their degree” (Machine Design, 2009, p.30). The numbers are available, but the reasons for women leaving are not intimated.

Xie and Shauman (2003) made an effort to modify the pipeline theory with a modification they called the Life Perspective model. “In a nutshell the life course perspective posits that the significant life events and transitions in an individual’s life are age-dependent, inter-related, and contingent on (but not determined by) earlier experiences and societal forces" (Xie & Shauman, 2003, p.12).

A study performed by the Girl Scouts found that girls who are interested in STEM have been exposed to a variety of opportunities and support systems. The study results show that it is important for girls to have exposure to the possibilities that STEM studies and careers can offer (Girls Scouts of the United States, 2012, p. 26).

As the women in this study also reported, early influences were important to their decision-making process to elect STEM courses in school and continue into a STEM related career. "We need to show girls that women in science and manufacturing are not weird or asocial; they are successful and charismatic. If she can see it, she can be it" (Wange, 2014, 34).

Bias in Education

"Linda Rosen, chief executive officer of Change the Equation, a nonprofit formed to engage girls and minority students in STEM fields said, 'As early as second grade, girls are more likely than boys to say that math isn't for them' even though achievement tests show no differences (HR Magazine, 2011, p.31)." If the tests show no differences, why is there a societal bias that says there is a difference? Studies have been performed looking at the differences in the cognitive strength of the genders. From Piaget's (1920's) study of boys at school and Gilligan's (1982) study of females to the compilation of longitudinal studies edited by Ceci and Williams (2007) the data substantiate that males and females approach life and its circumstances with differences, but that cognitive ability in science and the arts is not different. Ceci and Williams

(2007, p.89) showed that even students identified as mathematically precocious in a 20 year study showed similar differences in the outcome with more males achieving higher degrees in the STEM fields and females more in the health and life sciences and slightly higher percentage earning degrees overall.

Gilligan (1982) elucidated the differences in male and female thinking as one's self relates to others within the construct of psychological and sociological stress. One can then postulate that those types of circumstances then instigate the different experiences in school, from kindergarten through university studies. The speaking patterns and self-awareness issues of trainers, teachers, and professors must have an impact on the student's ability to conceive a theory and thus learn the topic at hand. With the clear dominance of male instructors in engineering and the lack of female role models (Wolcott, 2001) it is unclear that the continued departure of females from the STEM degree programs and careers is entirely an educational issue but may be a communication issue. Wolf and Powell found that "changing the name of the speaker from James to Julie or Mark to Mary did not influence how the transcript was perceived. These findings suggest that even though engineering men were biased against female-typical speech acts, this bias was a function of the discourse itself and not whether it was spoken by a man or a woman" (2009, p.11). Communication is the basis for our educational system, a teacher speaks and students listen. If the gender of both the speaker and the listener can influence the messages being transmitted, then future curriculum needs to address this inherent bias. If research questions, methods, criteria of success, and styles of teaching are male-defined, then the knowledge itself reflects bias towards a male cognitive style in its practices, theories, and ways of teaching (Mills & Ayre, 2003, p.204).

Morganson., Jones, & Major (2010) recommended that girls “make special efforts to form study groups with peers, build relationships with other students, use teaching assistants and professors for support, join STEM-specific girls' and women's organizations, and engage in professional networking” (p. 176). While it may be helpful to the girls themselves to build networking support groups, only the interactions that happen with STEM professionals could add to their knowledge of what STEM work entails for women that make those choices. There exists an inherent bias for males in STEM fields, both the curriculum and ensuing careers ignore the psychological and sociological aspects of communication that Gilligan (1982) and Mills and Ayre (2003) noted are missing in communication and in the evaluation of both cognitive and career suitability for females.

Perhaps we need to create or recognize a ‘tipping point’ as defined by Gladwell (2000) for the phenomena of word of mouth that mark everyday life and to think of them as epidemics. Ideas and products and messages and behaviors spread just like viruses do (Gladwell, 2000, p.7). Students might be influenced to study STEM if they knew what people involved currently or formerly in STEM know. This Delphi technique will seek to provide answers to the questions, 1. Do current STEM professional women have characteristics, circumstances, beliefs, values, or interests, in common that might be recognized and built on to encourage young students to follow in their footsteps into the

STEM fields? and 2. What are the emergent recommendations that can be used to attract females to choose STEM coursework and make STEM career choices?

The women in this Delphi discussion corroborated the Deemer et. al. (2014) findings that women, especially those in STEM classes, experience more bias in classroom environments than the male students (p.151). Women seem to be victims of bias, even themselves buying into the stereotypes, but also driven by an additional societal aspect that is different than their male counterparts. Ma, 2011, found that women value social improvement activities more than men do and that they have a corresponding lower self-assessment of their math abilities.

Both factors are negatively associated with completing the pathway to attaining STEM degrees (Ma, 2011, p.1186).

Similarly, Title IX issues and those influenced by the Carl D. Perkins Act of 1984 created focus on gender issues in the educational arena (Toglia, 2013; Walters & McNeely, 2010). Studies linked to institutions of higher learning have addressed such Title IX issues as recruitment and hiring, compensation, pregnancy and dependent care, work environment, and sexual harassment (Walters & McNeely, 2010, p.322). Unfortunately this focus has also provided institutions with target numbers that appear to influence hiring as observed by McNeely and Vlaicu (2010) in their study of the hiring practices across 107 major U.S. universities.

They observed:

> institutions seem to reduce their efforts to identify and hire qualified female faculty once they have reached a certain number that “looks good,” based on

> some institutional target quotas. As our data show, *universities with lower initial numbers of women had much higher gains than their peers, but the upward trend in hiring starts to flatten out once the percentage of newly hired women reaches a number that could be considered "average" among this peer group*. (p. 791)

So while Title IX and the current efforts of Congress to consider the Equal Pay Act and other amendments to the Fair Labor Standards Act to aid the employment of women and the equity in the workplace, these efforts often lead to quotas and targets that tend to reduce women to gender counts rather than rely on their abilities and potential contributions.

Gender Inequities in the Workplace

Businesses that have stated a lack of qualified candidates for highly technical and scientific positions still tend to be male-dominated as stated by the respondents in this study and that is supported by employment data (U.S. Census Bureau, 2010). Looking at female performance in both education and in engineering work environments, Joshi (2014) found that the gender composition of the teams where women work influenced productivity. Teams that were made of primarily of women outperformed teams that were more gender balanced. "These findings support the argument that the level of gender integration in any given discipline can shape the salience of gender as a basis for status differences or role expectations among men and women in science and engineering" (Joshi, 2014, p.228).

Joshi's research seems to indicate that an increase of women within these technical environments might help to improve overall productivity, reduce bias and improve morale.

While their study was performed in Australia, the themes argued by Bastalich et al. (2007) might apply to other cultures as well, in particular those with similar histories and cultural traditions such as the United States and the United Kingdom. Their research found that, although women engineers cite the lack of family-friendly workplaces as the most likely reason they would leave the profession, very few reported this as the reason they had left the profession, and it was rarely cited as a cause of discomfort in the workplace (Bastalich et. al., 2007, p. 386-387).

A study of females and males in engineering workspaces was conducted by Wendy Faulkner in three workplaces, one in the United States and two in the United Kingdom. Faulkner (2009) observed a number of gender exclusive dynamics and practices within engineering workplace cultures:

1. Fraternal markers of familiarity and bonding
2. The generic "he"
3. Conversation dominated by men's interests
4. Offensive humour and sanctions against challenging this
5. Heteronormative and sexualised culture
6. Pressures to conform to particular masculinities
7. Organisationally powerful networks of men. (p. 15)

Similar responses were offered by the participants in this examination of STEM professionals. The importance of increasing the numbers of women in STEM education, business, and making female leaders more visible within society as a whole cannot be understated.

As Purcell (2012) said:

> Attracting more women to and retaining them in STEM careers will help tremendously to improve diversity, maximize creativity, and boost competitiveness. Women bring a different perspective to the workplace and can help breed creativity in scientific fields that can only expand as broadly as the minds that work within them. The number of women employed in STEM fields has increased over the past few decades, but not at rates that will soon eliminate the male domination in those fields. Gender bias on the job is still prevalent in the workforce, although not in the same overt ways it was in the past. To limit gender biases, employers need to monitor their hiring practices, their work environments, and the ways in which they might be hindering gender diversity. (p. 32)

The women in this study reported similar types of thinking in their responses. The participants indicated that they were still a minority in their fields and that expectations of their male colleagues were different than what was required of them.

Societal Gender Bias

Societal biases can be observed in education, business and everyday life circumstances. In particular, bias toward females in perceived male positions can be devastating to the people, the institutions, and the economies involved.

Polkowska (2013) observed:

> Lack of familiarity encourages the lumping together of unknown individuals. One of the strongest stereotypes related to female entrepreneurs is that they need 'special support.' For example, one of the European Commission reports on female entrepreneurship reads: Women frequently lack the necessary confidence and skills to successfully start and run a business (Young Entrepreneurs, Women Entrepreneurs, Co-Entrepreneurs and Ethnic Minority Entrepreneurs in the European Union and Central and Eastern Europe 2000; Green Paper – Entrepreneurship in Europe 2003). The stereotypes about women entrepreneurs translate into their personalized evaluation by potential partners. Therefore, it is so difficult for women to break out of the cage of mistrust created by prejudices. (p. 158-159)

Will recruiting solve the issues or must there be additional efforts to make people aware of behaviors that support old biases, traditions and stereotypes to remedy the lack of females in the STEM fields? Society as a whole is complicated by the mix of two genders across various cultures and traditional backgrounds.

A study by Myers (2007 performed with her students seems to indicate that biases favoring males in our culture run deep and will be difficult to change. The field study of wait times in Boston-area coffee shops suggests that female customers wait an average of 20 seconds longer for their orders than do male customers even when controlling for gender differences in the orders (Myers, 2007, p.49). While it is possible that the Myers study has found that societal bias is at the root of some service behaviors, this research found that an ingrained bias toward males also exists in education and workplace situations. The participants also provided insight into other phenomena that might be influencing the observed lack of women.

Mel Shiavelli (2012), president and CEO of Harrisburg University of Science and Technology, the only STEM-focused comprehensive university between Philadelphia and Pittsburgh, wondered about the reluctance of women to enter the STEM fields even though women in STEM tend to make more money than women in other fields. While various theories have emerged to explain the observable lack of women in STEM courses of study and workplaces, a reoccurring one is the lack of female role models in industry. (p. 18)

Drury, Siy, & Cheryan, (2011) similarly found that role models of both genders are equally effective in bringing more women into STEM. Using both male and female role models can in some ways be seen as a more inclusive approach and by moving some of the responsibility for recruitment of women onto men; we can ease the pressure on women (Drury, Siy, & Cheryan, 2011, pp. 267-268). The findings of this Delphi research also support that mentoring, role models, and professional interactions are important to developing both interest and motivation to pursue STEM careers.

It also appears that women have difficulty networking within the male dominated STEM fields. Polkowska (2013) stressed that women have less access to key resources because they are women. While networking is necessary to seek funding opportunities; exclusion from the organization’s informal networks and channels of communication creates a lack of understanding of organizational policies and limits females the means of approaching potential mentors or sponsors (Polkowska, 2013, p. 159).

The data show that women are graduating with STEM degrees (U.S. Census Bureau, 2009) but that they remain under represented in STEM fields of endeavor (U.S. Census Bureau, 2010). Glass, Sassler, Levitte, & Michelmore (2013) reported that advanced training, increasing job tenure, job satisfaction, and aging do not deepen female worker commitment to STEM fields as they do for most other workers in other fields (p. 744).

Observing the workplace and making recommendations can be difficult without a formal method and criteria for evaluation. Cameron and Quinn (1999) in *Diagnosing and changing organizational culture: based on the competing values framework* provides both the method and a process for evaluation. The method takes into consideration that businesses often must shape their management paradigms, processes, and policies within an environment that has competing values such as balancing the profits against developing personnel. The women in this study indicated that a management paradigm shift is needed to eliminate the pro-male processes that are used in businesses.

Summary

The literature available about the education pipeline, women in STEM studies and careers, and the business issues of recruiting, hiring, and retaining females is vast and varied (Ceci & Williams, 2007, 2010, 2011; Drury et. al., 2011; Glass et. al., 2013; Hewlett, 2007; Ma, 2011; McNeely & Vlaicu, 2010; Morganson, et.al., 2010; Polkowska, 2013; Purcell, 2012; Schiavelli 2012; Wange, 2014; Xie & Shauman, 2003). Limiting the research to a few targeted keywords and phrases proved helpful in producing a focused library of references on these topics. It also highlighted that there exists a lack of studies about why females do not choose STEM education and why women are not present in significant numbers in STEM careers in business and in education and why they leave STEM careers.

Chapter 3 will summarize the numerous research methods that were investigated to find the method that might best give insight into the issues of the current model for the educational system and at the same time garner information from people that went through the system and emerged as a career technician or scientist. Quantitative methods are available that would count people in the various STEM fields and possibly show relationships between the fields and the people by comparing and contrasting their positions and degrees, but what was needed was a method to see why and how those workers got educated and got to their current positions. The women interviewed in this research were all volunteers available through the Survey Monkey audience that was accessed by a membership purchased through the website. Chapter 3 delineates the method and processes that facilitated this research.

Chapter 3: Research Method

The recommendations of women who studied STEM or were in STEM careers were collected using a Delphi technique. The Delphi method allows for the free exchange of information within a structured framework that permitted the focused analysis of information. Tag clouds and word counts were used to establish common themes.

Research Design and Rationale

Qualitative methods are numerous and vary in their scope and complexity. Data are available for the observed number of students in each of the STEM fields and career professionals in various STEM occupations. However, there seems to be little literature available on the theoretical reasons for why these outcomes have occurred. With this lack in mind, any positivist paradigm was rejected for subsequent research and only constructivist paradigm methods were reviewed. A grounded theory-based research was rejected as no theories appeared to be forthcoming on why there has been an exodus or why only a small percentage of STEM professionals are female. The Case study method did not seem appropriate as any one person's or group's experiences might not represent the majority of females in similar circumstances. Field research was also rejected for similar reasons; the person or group selected for observation might not be representative of all women that studied or worked in the fields of interest. Taking a look at the phenomenon of studying and staying in STEM seemed most appropriate. Investigating the differences and the similarities in a collective experience of why women selected STEM careers provides interesting and informative data.

While phenomenology could have been appropriate since it relies on the constructivist paradigm and the idea that the data reside within the combined knowledge of an expert group (Groenwald, 2004), subsequent research conducted by Graefe and Armstrong (2011) provided influence for the Delphi selection. They compared face to face meetings with nominal group technique, Delphi, and prediction markets. "The three structured approaches were more accurate than participants' prior individual estimates. Delphi was also more accurate than staticized groups. Nominal groups and prediction markets provided little additional value compared to a simple average of forecast (Graefe & Armstrong, 2011, p. 176)." The published comparisons Welsman (2010) made of various qualitative methods such as phenomenology, grounded theory, ethnography, case study, Phenomenography, hermeneutics, action research, and Delphi technique also influenced the final selection of the Delphi technique. The Delphi method was determined to be the best model for this research because of the structured data collection method, the relatively small sample needed, and the allowance for the free-flowing exchanges of information by the experts.

The research design was based on the typical Delphi design from Skulmoski et al. (2007, p.3) however aspects of the Delphi methods of Linstone & Turoff (1975) were also used. Informing the query design are the experiences and knowledge of the researcher and information garnered from the literature review. These provided background and illustrative examples that helped to formulate the research questions.

1. Do current and former STEM professional women have experiences, circumstances, beliefs, values, or interests, in common that might be

recognized and built on to encourage young students to follow in their footsteps into the STEM fields?

2. What are the emergent recommendations that can be used to attract females to choose STEM coursework and make STEM career choices?

The research design was to query current professionals from STEM fields to discern the encouraging and discouraging characteristics, circumstances, beliefs, or values that aided the decision-making aspects of their educational and professional lives. The purpose was to establish credibility that the combined experiences of these professionals are similar and may be defined. When disseminated they will inform leaders of the steps they might take to acquire professionals that will serve the needs of technology-based businesses in the United States and world-wide.

The context of the study was the female population of scientists, technicians, engineers, and mathematicians volunteering to participate in studies through the Survey Monkey parameter defined audience pool. The use of the tool to facilitate this research allowed the research to be limited the group to the desired audience within the United States, with the desired background and STEM experiences. The desired group size for the Delphi study was thirty women, but to ensure that a minimum of thirty acceptable responses were acquired, an audience of fifty was purchased.

The utilization of the Delphi technique as a data collection method provided the opportunity to analyze participant responses to formulate the emergent information. The transferable knowledge garnered will inform the business world of ideas for improvement in recruiting, hiring, and retention efforts of women STEM professionals.

The use of open-ended questions allowed for insight into the characteristics of women in STEM careers. The influences of cultural background, educational choices, familial circumstances, sponsorship and mentors, among other characteristics were evidenced in the responses. Their recommendations are summarized in Chapter 5 and highlight the emergent ideas and the divergent and synergistic thinking among the participants.

Table 2

Research Variables and Measurement

Question	Variable	Measure
Common characteristics	Encouraging and discouraging influences on coursework and career choices	Survey response tag cloud analysis
Common values and beliefs	Open-ended questions about influences	Survey response tag cloud analysis
Educational choices	STEM coursework	Survey response tag cloud analysis
Work experience	Demographic qualifying question requiring a STEM degree or 10 years of STEM career work	Count
Work culture	Experiences of bias	Survey response tag cloud analysis
Recommendations	Repetition in responses	Cloud analysis word count

Role of the Researcher

I had the role of observer and analyst. The participants came from the Survey Monkey audience pool where I am also a member of the pool. No additional relationships exist between the researcher and other members of the Survey Monkey audience or Survey Monkey support personnel. All information exchanges were confidential and known only to the Survey Monkey administrators.

Researcher bias was managed through the use of standardized questions and summary tools. In this way I was the programmer and sorter for the information. There was no researcher influence on how the questions were posed to the participants or in the summation of their results. All facilitation was conducted by Survey Monkey once the criteria for the audience were defined.

Ethical issues were minimized by doing the study with participants that were unknown to the researcher. This method also eliminated any conflict of interest issues or power differentials. I maintained the position of coordinator for data collection and summation of the reported responses.

Methodology

After reviewing various methods for collecting and sorting language data, such as surveys and interviews, the focused and interactive nature of the Delphi method led to the selection of that method for collecting data from a group of experts. The project plan was approved by the Institutional Review Board of Walden University and a study number of 11-11-13-0046913 was assigned to this research. The participant group was limited to women with a STEM degree or currently working in a STEM field at an American place of business. The participants were asked for ideas that might interest young people in studying and selecting careers in the STEM fields as well as a series of demographic questions to determine similarity or diversity.

Policy Delphi was first introduced in 1969 and reported on in 1970 (Turoff, 1970). It represented a significant departure from the understanding and application of the Delphi technique as practiced to that point in time, as a forecasting method. This research took a similar approach (Trochim & Donnelly, 2007, p.147) to the Policy Delphi method by utilizing a specific context. Selecting people from the Survey Monkey audience pool that met the research requirements created the specific context.

The examination was qualitative and focused on the credibility of the participants, the transferability of the found data and information, the dependability of the data, and the confirmability of the response variables (Trochim & Donnelly, 2007, p.149). The Delphi method was chosen in lieu of other qualitative predictive techniques based on available research (Graefe & Armstrong, 2011; Welsman, 2006).

This Delphi study included volunteers of eligible candidates from the Survey Monkey audience. To find commonalities in recommendations from the participants, the focused inquiries based on the research questions were defined and included in the survey.

The Delphi method is a focused communication between experts that occurs over time and across distances through a moderator that compiles and distributes the participant data for all to see, comment upon, and discuss. The term expert within the context of this Delphi study meant a STEM professional over 35 years of age and with either a STEM degree or career of a minimum of 10 years in a STEM field.

The classical Delphi method is characterized by the following four key features:

1. Anonymity of Delphi participants: allows the participants to express their opinions without undue social pressures to conform from others in the group. Decisions are evaluated on their merit, rather than who has proposed the idea.

2. Iteration: allows the participants to refine their views in light of the progress of the group's work from round to round.
3. Controlled feedback: informs the participants of the other participant's perspectives, and provides an opportunity for Delphi participants to clarify or change their views.
4. Statistical aggregation of group response: allows for a quantitative analysis and interpretation of data (Skulmoski, Hartman, & Krahn, 2007, p.3).

The research method incorporated a demographic survey that was designed to instigate discussion on key characteristics regarding familial, social, educational, and environmental influences.

Context and Sample

The Delphi study allowed determination of those characteristics, values, support, and a cultural environment that define a scientist. These data will be used to influence young people, educational professionals, and curriculum developers. The population from which the sample was drawn was female scientists, technicians, engineers, and mathematicians within the participant pool that had a STEM degree or a minimum of ten years of service in a STEM career. The participants were selected at random from those that responded in the affirmative. The 38 person participant sample was selected based on a screening question that disqualified women without the necessary credentials. The number of 38 participants is in keeping with typical Delphi studies as defined by Skulmoski, et.al. (2007).

All participants were qualified volunteers from the Survey Monkey audience. The open-ended questions were posted. All response information was summarized verbatim by Survey Monkey. The summation allowed for the analysis of word counts, the generation of tag clouds, and themes within the responses.

Study Participants

Participants were expert female scientists, technicians, engineers or mathematicians who were employed in an American-based business and a secondary group of those that were trained in STEM fields, but were either never employed in a STEM field or left before completing 10years of employment in that field.

The women included were qualified from a pool of candidates from the Survey Monkey participant audience. To increase the applicability of responses, the study was limited to American females. The research focused on the qualified participants and their personal descriptions of encouraging and discouraging factors of studying STEM or maintaining a STEM-based career.

Selection Criteria

The participants were qualified by being female and responding affirmatively to one of the qualifying questions. Question 1 of the survey was a multiple choice question where respondents were required to select one of the following answers; 1. I am a female with a degree in science, technology, engineering or math, 2. I am a female with 10 years in a STEM field, or 3. This survey does not apply to me. If the respondent checked answer 3 the survey was aborted and the respondent disqualified within Survey Monkey.

Allowing Survey Monkey to sort the volunteers in this way allowed for diversity of career focus, technical disciplines, ages, and locations within America among the group. The selection optimized the diversity of the participants and garnered variety in the responses. The volunteer group consisted of women in a variety of STEM fields and geographical locations as summarized in Chapter 4.

Confidentiality of the participants was maintained by obtaining only coded results from Survey Monkey. The volunteer's personal information is maintained by Survey Monkey but is not shared with researchers using the site.

Data Collection and Analysis

The data was collected on Survey Monkey using the qualification sorting question ensuring that participants met the research criteria. Their identity was coded to the researcher so all information remained confidential. All published information and data will remain anonymous. Both the identity of participants and the identity of the researcher remain undisclosed.

The data was collected according to the question and put into a unique word document by each question with a participant code assigned for future sorting (Auer-Srnka & Koeszegi, 2007, Muskat et.al. 2012, Welsman, 2006)). A tag cloud for the top 20 to 30 words per question was used to identify the key themes for each question and all data collectively, Figures 1 through 6. A tag cloud generator available on the website wordle.net was used to generate the clouds. A typical tag cloud is where the most often repeated words are larger. The tag cloud generator allowed for the selection of the number of words to be displayed and for the sublimation of common articles and conjunctions. This method aided the interpretation of commonalities and synergies among the responses. The data was analyzed to find common themes and significant variation across the participants. Significant word counts will be analyzed using Cronbach's alpha or similar statistic to determine the statistical significance of the variation.

Instrumentation and Materials

The survey was developed through an iterative process with subject matter experts from Walden University and a survey coordinator from Survey Monkey. The Survey Monkey process summarizes all collected data and presents it in various forms for analysis such as comma delineated, *.pdf, and Microsoft Excel formats.

Data Summation

Data were compiled into a Microsoft Excel program so that the participant responses could be used to generate a tag cloud for each question and aggregate response. Word counts were generated in Microsoft Word and used to calculate average, standard deviation, and other appropriate statistics for subsequent analysis of the response characteristics.

Issues of Trustworthiness

Table 3 Criteria for judging research quality from a more qualitative perspective, relates the typical criteria for qualitative research to similar ideologies for quantitative research (Trochim & Donnelly, 1999, p.149).

Table 3

Criteria for Judging Research Quality from a More Qualitative Perspective

Traditional Criteria for judging quantitative research	Alternative Criteria for judging qualitative research
Internal validity	Credibility
External validity	Transferability
Reliability	Dependability
Objectivity	Confirmability

The alternative criteria for qualitative research scenarios were met by using Survey Monkey. The internal facilities within the survey process that was used to collect the data by using the qualification process, the coding of the participant identities, the sorting by location, and the logging of responses by individual ensure credibility, transferability, dependability and confirmability.

Ethical Treatment of Participants

The participants remained anonymous from each other and the researcher. Participant computer identities and their American locations are documented in the responses. Ethical treatment was accomplished through the use of a coding system elsewhere described. Each respondent's information was eliminated from the documented responses since they may inadvertently include some information that could lead to their identity.

Dissemination of Findings

The final results are summarized in a combination of Microsoft Word, Excel and PowerPoint reports. Due to the nature of the selection of participants through the Survey Monkey audience facility, no dissemination of findings other than this dissertation will be performed. A publishable version will be made available to various management journals for consideration.

Summary

The Delphi study engaged women with experience in both STEM educational and workplace environments. They were selected from the Survey Monkey audience pool of available scientists aged 35 or older with applicable education and work experiences. While the facilitator managed the questioning of the participants, the influence provided by the women was maximized using standardized research questions and summarizing techniques for the accumulated data.

All of the participants were ensured anonymity and ethical treatment. The group members were assured that trustworthy information was collected by the process. All data, including summaries and exclusions, were included so that trustworthy ideas and recommendations resulted.

I found ideas and messages that might create a tipping point (Gladwell, 2000) and that may capture the attention of leaders and students and influence participation in STEM. Just as the NASA Mohawk guy, Bobak Ferdowski, captured the attention of people during the Mars exploration in September 2012 (Hsu, 2012, 1). It is interesting to note that in the third paragraph of the same article, the vice president and general manager of Lockheed Martin, Mark Valerio, is cited as saying, “Many young scientists and engineers are leaving as we’re downsizing and moving to production. Many young employees want to marry and start a family and we can’t tell them they’ll have a job in the next three years” (Hsu, 2012, p.1).

The companies that need to attract and maintain these young people to work future programs will have to find creative solutions to meet that need. Can leaders connect with Mohawk guy? It was the goal of this research to find some tipping points, some ideas, some traditions or paradigms that might influence both the leaders and students to provide STEM professionals to benefit society in the future.

The need of business leaders to employ qualified STEM professionals is clearly stated. The current pipeline model reinforces the notion that education professionals have failed to train the teachers that could produce those needed STEM career professionals (Mills & Ayre, 2003). A leaderless network model might better simulate how students select their own path through the educational system (Christakis & Fowler, 2010; Gordon, 1999; Wheatley, 2006; Wheatley, 2007).

The summary of results, Chapter 4, indicates that the women in this study have histories and experiences that support the need for changes in both the educational model of STEM studies and the business paradigm that continues to allow gender bias within workplaces.

Chapter 4: Results

A survey of six questions was used to collect responses from a pool of 54 women currently in STEM positions. The survey was posted on Survey Monkey to facilitate the data collection and the women were volunteers from the Survey Monkey audience. Responses were downloaded as a results file and were analyzed by creating tag clouds and by review of recurring themes to generate a collective response to each of the study questions.

This research was performed to find out if women with experience in STEM studies or work had similar encouraging and discouraging experiences and to collect their ideas about getting young people interested in science, technology, engineering, and mathematics.

The survey Questions 2 through 5 addressed the primary research question "Do current and former STEM professional women have experiences, circumstances, beliefs, values, or interests, in common that might be recognized and built on to encourage young students to follow in their footsteps into the STEM fields?" Even a cursory look at the tag clouds indicates that the women were not only interested in science and math, but love it. The responders chose STEM topics encouraged by experiences with animals, insects, rocks, and the like as influenced by their parents and teachers. Career choices were influenced by high pay, intellectual challenge, personal interests and the potential benefit to society and humanity. These women were encouraged by professors and teachers, parents, spouses, family members and female role models. Discouragement was experienced in schools and workplaces as favoritism and sexism; indicated by unequal pay, unbalanced hours worked, unequal expectations, and the resultant negative impact on work-life balance.

Questions 6 and 7 addressed the second research question, "What are the emergent recommendations that can be used to attract females to choose STEM coursework and make STEM career choices?" The women responded that education and businesses should make more face-to-face and hands-on experiences available in schools and workplaces through internships and sponsored events so that young people can get a better idea of what STEM professionals do. The experiences should be real and they should be a fun introduction to the many aspects of the tasks that STEM professionals perform on a daily basis.

Research Process

The research was originally planned to use the Walden University participant pool which proved unsuccessful in generating a significant audience. The research was eventually conducted on the Survey Monkey website. The web-based survey provided the ability to reach an audience that met the research specific criteria by using a screening question prior to the study questions. Questions were presented to the potential participants by Survey Monkey as the research survey SDelphi. The survey was developed with assistance from survey coordinators that are accessible through Survey Monkey when a membership is purchased.

Initially, it was attempted to confine the participants to those in the Walden University participant pool but, after two months that process only provided a single qualified response. Since the Walden University IRB had approved the inclusion of participants not from the Walden Pool, an audience was purchased using the Survey Monkey feature for finding an audience that qualifies for a defined research process.

The research process counts both rejected and productive responses from the participants. Fifty results were requested so that the needed 8 to 15 responses might be assured. The project ran between: 01/12/2014 and 01/14/2014. On January 19, 2014, the documented project parameters for the SDelphi research were: Completes: 9 on January 12 and 45 on January 14, Abandon Rate: 7%, Country: United states, Employment Status: Employed full-time, Age: 32 - 100+, Gender: Female, Job Function: analyst, engineering, information technology, manufacturing, quality assurance, research, science, and Education: two-year college degree, four-year college degree, or graduate degree.

The survey was opened initially without the screening question and the Survey Monkey administrator stopped the process so that revisions could be made. During that initial period, 8 positive responses were collected. The added qualification question, Question 1, was a multiple choice question where respondents were required to select one of the following answers:

1. I am a female with a degree in science, technology, engineering or math
2. I am a female with 10 years in a STEM field
3. This survey does not apply to me.

If the respondent checked Answer 3 the survey was aborted and the respondent disqualified. The question generated responses of 21 people who answered that they had a STEM degree, 5 people answered that they worked in a STEM field for more than 10 years, and 19 people were disqualified.

If the respondent was qualified by either education or employment, then the following open-ended questions were presented; however, not every respondent answered every question.

2. What influenced your curriculum choices?
3. What influenced your career choices?
4. What were the encouraging factors that influenced your choices?
5. What were the discouraging factors that influenced your choices?
6. What would you recommend to generate an interest in young people to study math and science?
7. What would you recommend to businesses to generate interest in STEM careers?

Demographic questions that were added by Survey Monkey as part of their standard survey parameters are included in the results of this research. The respondents were varied in age, income, education, and household income as well as geographical areas but all within the United States.

Evidence of Quality

Quality was maintained by using the research audience facility of Survey Monkey where 50 potential responses were collected. Using Survey Monkey ensured that anonymity was maintained and the criteria for participation were met prior to the questions being presented. The survey process maintains the identity of each respondent by their computer address and email and guarantees that each respondent has only a single entry. All data were downloaded as either an adobe pdf file or a Microsoft excel file. All responses were saved verbatim and logged by date and time of response. The process for presenting the research questions, screening potential participants and coding their identities, verifying their location and logging the verbatim responses ensured the credibility, transferability, dependability, and the confirmability of the data.

Responses

Demographic responses included the gender, age, income, education, and geographic area information for all of the participants in the study. All participants were from the United States. The data are presented in Appendix A.

Data Analysis

The responses to each question were summarized using a tag cloud so that the most used words significant to each question could be seen and analyzed for impact on the research questions. The tag clouds for each question are Figures 1 through 6.

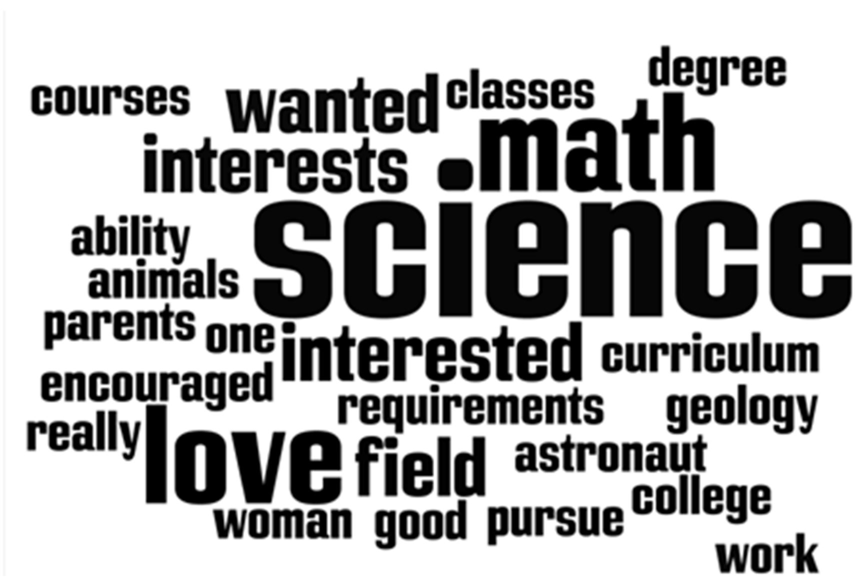

Figure 1. Tag cloud for Question 2 about influences on curriculum.

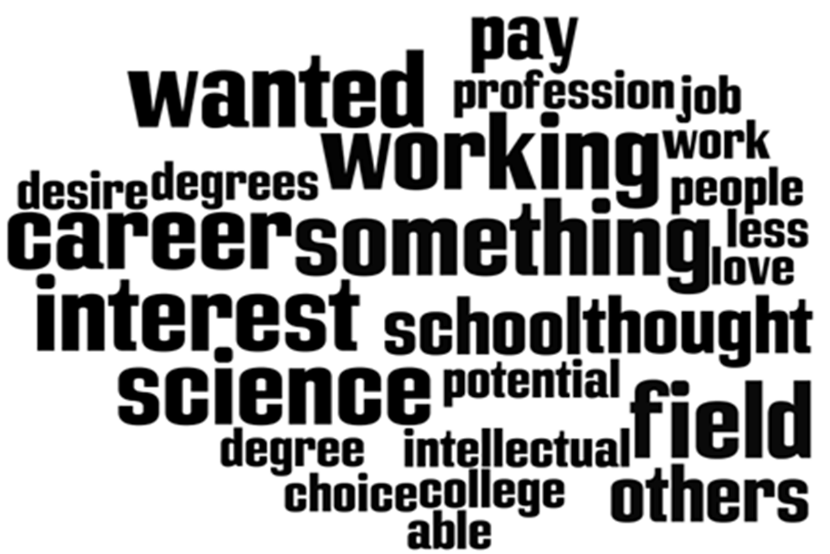

Figure 2. Tag cloud for Question 3 about influences on career choices.

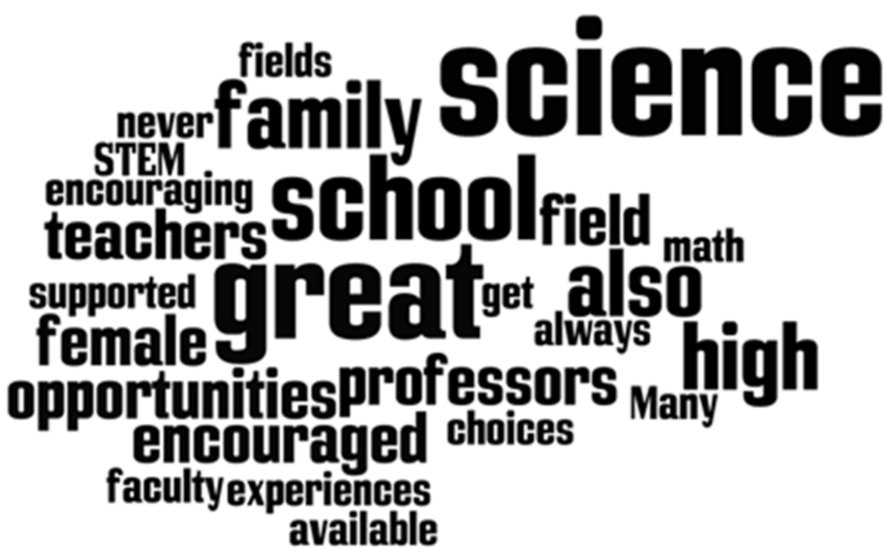

Figure 3. Tag cloud for Question 4 about encouraging factor.

Figure 4. Tag cloud for Question 5 about discouraging factors.

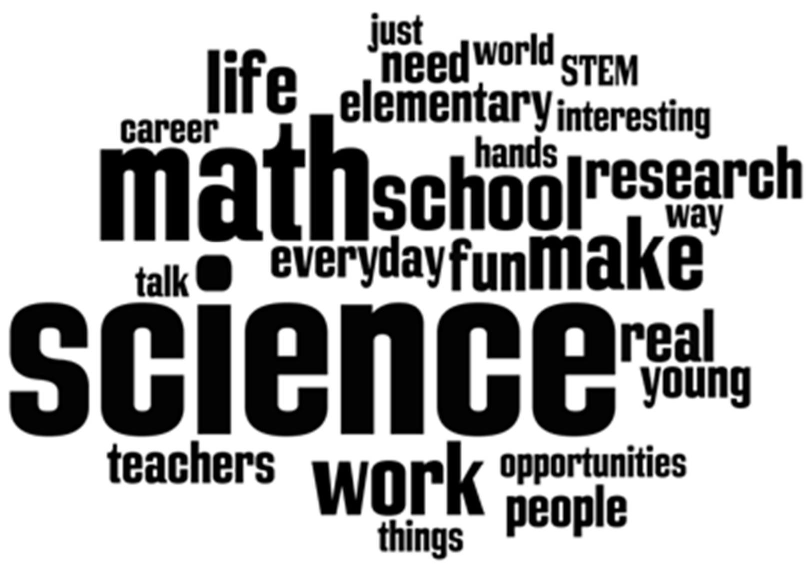

Figure 5. Tag cloud for Question 6 about generating interest of young people.

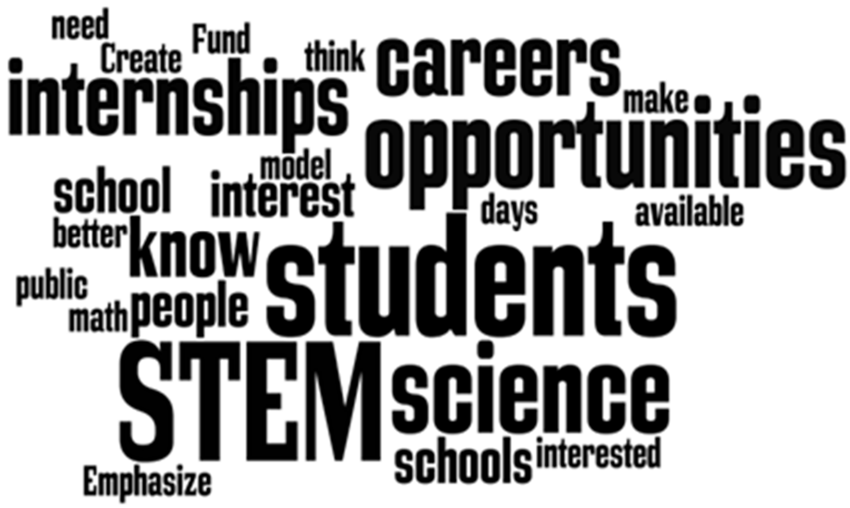

Figure 6. Tag cloud for Question 7 about recommendations to businesses.

The tag clouds give an indication about the focus of the responses. It appears to be a reasonable method for making conclusions about the focus of the study responders for each question and in particular the research question, Do STEM professional women have experiences, circumstances, beliefs, values, or interests, in common that might be recognized and built on to encourage young students to follow in their footsteps into the STEM fields? Looking at the keywords from each of the applicable tag clouds the participants loved science and made curriculum choices for courses in science that supported a significant interest that might lead to a career. A school with encouraging teachers and family with supportive members were encouraging factors for these women. Discouraging factors also included school where STEM courses were dominated by males and some professors and teachers either not supportive or demanded more of female students. Similarly in jobs the women found that men might have favored positions that had assistants, required less time, and that the men were paid more money.

The second research question was what are the emergent recommendations that can be used to attract females to choose STEM coursework and make STEM career choices? The tag clouds for survey questions 7 and 8 indicate that the women recommended that science and math experiences be made fun for the students as well as designed to show students that STEM can have an impact on life outside of school. The respondents suggested that the introduction to STEM occur in the elementary grades and that opportunities to interface with career STEM professionals be made available to students.

Similarly, the recommendations to business request that those student interactions be aided and funded so that employees have the opportunity to interface with students on a meaningful level. The study participants also recommended that businesses with an interest in employing STEM professionals should make funding available for internships and create opportunities for students and graduates to learn what careers are available and to have face-to-face experiences with current professionals.

While the survey collected data related to the two research questions, there were repeated words in the total data set that are indicative of trends. The word counts are a summary of all of the responses to all questions.

Table 4

Word Count Summary

Word	Count
science	45
school	33
interest, interested, interests	29
math	25
career	23
female, women	18
people	15
teach, teacher	14
opportunity, opportunities	13
support, supportive	12
love, loved	10
other, others	10
STEM	10
students	9
encourage, encouraged	8
like, liked	8
family	7
fun	7
challenge, challenging	7
internship	7
professor	7
money	6
parents	6
pay	5

These words indicate that the choices that were made by the participants were based on interest. While interest was generated by various conditions, people other than parents, and personal experiences, it seems clear that science played an important role early in the lives of these STEM professionals. Whether it was geology, insects, animals, or space that created the interest, these women chose to study STEM courses and selected careers based on those childhood interests.

Interpretation of Findings

The literature available about the education pipeline, women in STEM studies and careers, and the business issues of recruiting, hiring, and retaining females is vast and varied (Ceci & Williams, 2007, 2010, 2011; Hewlett, 2007; Xie & Shauman, 2003). The women in this study did not indicate a linear path for STEM study was offered or followed as predicted by the currently accepted pipeline model of education. The women also did not share that people within the educational hierarchy encouraged them to pursue their STEM interests.

The popular pipeline model, where students enter the education system and linearly progress through to graduation, places the focus of generating interests on the teachers and professors within the system (Metcalf, 2010, p. 2). This study indicated that while school influences are important, it appears the linear pipeline model and its associated managerial paradigm to look to educational organizations for trained professionals is not relevant. The responders to this study indicated that school was not always significant for generating their interest in STEM. The women in this study appeared to support the theory that interest is generated through networking and interacting with role models, who may or may not be a teacher. A few enlightening responses to the question about what encouraged these women to pursue STEM are:

- Participant 6 said "My teachers and professors shared their own research with us, and it opened my eyes to fields that I never even knew existed."
- Participant 12 said, "Role models, other women in science."

- Participant 15 said, "Many science classes including a trip class in high school, encouraging parents and teachers (although not all teachers), great education that provided many opportunities, great internship that led to employment."
- Participant 21 said, "Others in the same field."
- Participant 27 said, "Being around people who also thought STEM was cool. Jobs were available. Going to an engineering college. I was never told I couldn't do STEM (because I was a girl)."
- Participant 29 said, "Great undergrad experience, loved short-term teaching experiences in the classroom and the lab."

These examples indicate that direct experiences with the work, the people that do the work, and fun hands-on experiences supported and encouraged both their educational and career choices. The networking aspects of learning and experiencing are clear from the responses and indicate that the pipeline model is not reflective of the actual experiences of these women that passed through the American educational system and emerged as STEM professionals.

In addition to the need expressed for the availability of professional role models and mentors, the women also wrote about the bias that they experienced in both educational and professional environments. While bias and prejudice may be difficult to perceive, the women in this study showed that bias and prejudice do still exist. When asked what discouraged them in their pursuit of STEM education and work the women responded:

- Participant 1 said, “Blatant sexism in male researchers, cutthroat research environment, no work-life balance.”
- Participant 7 said, “STEM careers are still male dominant, men get paid better, they aren't asked to do things that women are asked to do (e.g. they are more likely to get an assistant while you are expected to handle your own assistant worthy responsibilities).”
- Participant 10 said, “Current position does not have opportunity for career growth.”
- Participant 12 said, “Not enough power in the hierarchy.”
- Participant 14 said, “Switched jobs after work was not challenging and encountered issues related to a male-dominated field.”
- Participant 15 said, “At the time I started any men in automotive were paid a higher wage than I got doing the same job. Long hours and sometimes extended hours and days off site.”
- Participant 16 said, “Some social pressure and lack of professional role models. Although there was one great female environmental studies professor in college she was only a visiting professor.”
- Participant 17 said, “Sometimes I felt like I didn't get the opportunity to show my abilities.”
- Participant 21 said, “I was always the only female in many classes and sometimes it seemed like the professors wanted me to fail and made me work harder.”

- Participant 25 said, “Being the only woman in a class or on the job site. Being told I was accepted into my college because there was a quota to be met for females. My suggestions and recommendations not being taken because I am a woman.”

Managers and educators need to be aware that these conditions exist and take measures to both expose the bias and then create the changes necessary to provide women STEM professionals with environments where they can both participate fully and feel comfortable doing so. Understanding the current societal bias and then causing change to remedy pro-male bias and prejudice in STEM will also provide positive role models and mentors that will encourage future students rather than as Respondent 22 experienced;

> Some of my mentors were not encouraging. In those cases, either seeking out other supportive people or ignoring the negative people proved to be useful. My field is male-dominated and probably always will be, so women have a tough time overcoming the inherent sexism.

My own experiences in both the educational and business environments were similar to those responders. In my career I had professors that made me feel that I did not belong and had a mathematics professor that gave me a C grade when I had earned and A because “there is no room in mathematics for women.” Professionally I often had to work longer hours, take more trips, and perform more menial tasks than my male colleagues. For three consecutive years I was not invited to department outings because the manager assumed that I did not play golf because I was a woman. Although I did then and still do play golf. He did not ask.

Implications for Social Change

The bias I experienced at work is also pervasive within society. Just the other day my 7 year old granddaughter observed a woman driving a semi-truck and she said, "Look, there is a girl driving a man's truck." I am not sure where she developed the paradigm that women do not drive large trucks other than she just hadn't seen one. Perhaps that is how society has developed the pro-male bias against female STEM professionals. They just haven't seen one.

Like some respondents, as a Mathematics and Physics double major I was often the only female in the class. In the 1970's when traveling for business as an aviation quality engineer, I often stayed in hotels that had female only floors and did not allow unescorted females to eat in their dining rooms. I was unable to entertain male peers when they traveled to my hometown because of the societal bias that this was inappropriate behavior. It seems that these extremes have been somewhat abated, but these women indicated that the pro-male bias in STEM education and business still exists and is prevalent. A networking cooperative educational and business system that has opportunities for girls to learn and have fun experiencing directly with STEM, conditions for them to discuss STEM topics with professionals working in various STEM fields, and funded internships where they can learn directly about job tasks is imperative. The girls, the organizations, and society as a whole will benefit.

Understanding what guided the decision-making processes of current STEM professionals will allow leaders to make changes in their paradigm about how STEM professionals are produced through the educational system. The women suggested change to support the development of new STEM professionals by providing networking and experiential learning opportunities. To maintain employment levels and retain current female professionals, they suggested that managers identify and remedy social and professional bias that favors the male.

These women are making contributions to society because of the choices they made early in their lives. Their responses clearly show that while a love of science was a key interest, the focus was often on social impact as they said:

- I liked the intellectual challenge of research, and wanted to be able to contribute to better outcomes for individuals with disabilities
- Wanted to do something that would help others
- My desire to work in a field that had direct benefit for people
- I wanted to work on science in a social context so I took positions working on HIV antivirals and now do basic science in a health disparities focused institution.
- The career was interesting to me. It was challenging. I was doing something useful, solving problems. I have a salary that I can support my family with.

Business and educational leaders must be aware of what drove the decisions for STEM study and career selections of these participating women and the prejudices and societal biases that hindered them. Their experiences and recommendations can cause change if leaders and managers can hear them, respond, and change the management paradigms that are affecting decision-making regarding the training, hiring, and retention of female STEM professionals.

Chapter 5: Summary, Conclusions, and Recommendations

Summary

The women in this study were from various locations and different industries and organizations that employ STEM professionals. They have brought to light divergent thinking that is in conflict with the pipeline theory of education that is supported by current literature. The women indicated that their decisions to take STEM coursework and later to develop a career path within STEM had more to do with early influences of parents, teachers, and interactions with people and hands-on science experiences. These data support the need for a paradigm shift within management about the nature of how STEM professionals evolve from students to degreed professionals. It is clear that the pipeline model where students begin a path to a STEM career in early elementary school and the female students leak out of the pipeline is obsolete and not representative of reality. A networking model better reflects reality.

The primary research question was "Do current and former STEM professional women have experiences, circumstances, beliefs, values, or interests, in common that might be recognized and built on to encourage young students to follow in their footsteps into the STEM fields?" It seems that they do. According to the women from the study, they developed interest in STEM fields early in their lifetime supported by parents, teachers, and other significant interactions that caused them to develop an interest in a scientific field through positive interactions with these role models. Whether experiences with a parent that was an astronaut with scientific interests and scientist friends or a teacher that introduced one to geology and rocks, or insects, or loving animals, those early interactions were key to sparking the interest in STEM studies.

The women indicated a strong desire to help people and society and showed this through their ultimate work choices. They have succeeded (better than average salaries, respect, high self-esteem) in spite of hindrances within the STEM fields such as prejudicial behaviors and a bias favoring males as well as meeting the required personal sacrifices (long hours, travel away from family, no children).

The secondary research question was "What are the emergent recommendations that can be used to attract females to choose STEM coursework and make STEM career choices?" These women have recommended that girls be given the chance to interact with STEM professionals so they might learn about the work that STEM requires. They recommend networking opportunities for girls beginning early in their education. These would not be the typical "take your daughter to work" events where the girls are often set aside in a cafeteria with pizza and films, but a real interaction opportunity for the girls to learn hands-on. For university students they have recommended internships funded by businesses that need STEM professionals so that students might learn from hands-on experiences what STEM work requires and perhaps introduce additional aspects that may peak an interest for further study or for future career choices.

Significance of the Study

This Delphi discussion has added to the literature that recognizes the strengths and key characteristics of living female scientists, technicians, engineers, and mathematicians. This study has filled a gap in the literature by delineating experiences and other influences that led these female scientists to move through their primary and secondary education and university studies and into the professional work environment as scientists and technicians. The contributions of these women will be magnified by their participation in this study by the contribution to the body of literature supporting networking models such as those of Gordon (1999), Hewlett (2007), Institute of Higher Education Policy, (2009) Ma, (2011), Metcalf (2010), and Wheatley, 2006, 2007). They may also contribute to society by perhaps helping to influence the changes needed in the observed gender-biased leadership paradigm that favors males over females as described in the literature by Allen (2011), Bastilich et.al. (2007), Ceci & Williams, (2007, 2010, 2011), Colvan et. al. (2013), Committee on science, engineering, and public policy (2007), Dugan et. al. (2013), Faulkner (2009), Fouad & Singh (2009), Girl Scouts of the USA (2012), Glass et. al. (2013), Morganson et. al. (2011), Thilmany (2007), Toglia (2013), Walters & McNeely (2010), and Wolfe & Powell (2009).

Conclusions

The linear educational pipeline model needs to be abandoned in favor of the network model so that evaluation and evolution might occur (Metcalf, 2010). The women in this study have made it clear that networking and interactions with scientists and STEM professionals were more influential than teachers. Investigations of a new networking model consisting of interactions and experiences similar to that seen in Gordon (1999) and Wheatley (2006, 2007) will need to be made from the perspectives of students, teachers, and STEM professionals so that their interactions with both the informational focus and methods can be determined. Business leaders need to adopt the network model so that internships, in-house training, hiring practices, and employee support mechanisms can enhance both the educational and societal preparation of potential new employees.

From their study of over 14,000 female university students Dugan, et. al. (2013) concluded that despite decades of research on how to increase the educational persistence and career success of women in STEM fields, significant gaps still exist (p.17). Leaders in the STEM fields in our schools, universities and business organizations need to be aware that females continue to experience prejudice and take steps to minimize or eliminate the bias for men that exist in organizations and within society as a whole. The processes used for admitting and training female STEM university students and the hiring and maintaining women in business need revision.

Respondent 1 summed it up this way:

> I think the research environment is going to have to change a lot. The way things are now, you have to be completely antisocial, hyper-focused on your career, and willing to give up having any kind of normal life to want to be a research scientist. Never mind that even if you "make it" it is only after years of low-paid postdoctoral fellowships---who wants to have your first "real job" in your 40's?

Recommendations for Action

As these women stated, educational and business institutions and society need to find ways to allow STEM professionals to interact with girls early. Teachers need to be provided with training and support on how to guide hands-on discovery, experimentation, and training and how to arrange for interactions with STEM professionals. Businesses and universities must also provide funding to STEM students through their financial support to provide internships, mentoring, and networking to develop the STEM female professionals of the future.

Once women can contribute fully and female voices heard within American organizations, the impact of women on STEM might be felt. Then society as a whole will benefit. Businesses will have additional people in the pool for future employees. Educational organizations will have the opportunity to train the future teachers, scientists, technicians, engineers, and mathematicians.

If people are aware of behaviors that support the traditional model of education as a pipeline and those that support the biased traditions and stereotypes of females within STEM, it could lead to a remedy for the lack of females in the STEM fields (Metcalf, 2010, p. 2). The women in this study indicated that they took courses that interested them and that the interest was generated by experiences and interactions with people in STEM work and hands-on experimenting (Gordon, 1999; Wheatley, 2006).

Participant 24 seemed to summarize it best when she said:

> We have to teach these topics in the most interesting (i.e. NOT just from books) ways we can from the beginning of their school lives and we have to have

> competent, interested, engaged teachers. We also need local, state and Federal governments that all agree that we need to support STEM education, or it will disappear in the US. It is not enough to tell teachers to do a better job at getting students interested in STEM; they need to know what to do and how to accomplish the task.

Participant 7 agreed and said:

> Encourage as much "wow" science WITHOUT book work intensive curricula through elementary school and ease into the didactics, make it realistic and true to life. Make science experiments something that they can do with real life materials and doing real life activities. Once they understand these fun general things then you can turn them on to the more abstract.

Adopting this approach implies that schools will need to engage local scientists and other STEM professionals to aid with the real life experiences. In accord, those local businesses will need to encourage their STEM professionals to get involved with the educational system as role models and mentors and by providing funding.

The model of education needs to be revised from a linear pipeline model to the more complex, but more representative, network model. As children, people learn what they experience; people cannot read as youngsters so they learn from the people with whom they interact (Metcalf, 2010). They collect bugs with Grandpa, bake with Mom, dig rocks with Grandma, or their Dad was an astronaut, these interactions then became meaningful in later choices for study at school and for careers. The network design will allow for the definition of experience nodes that when supported by business and political leaders will facilitate the interactions of students with current and former professionals. To encourage these recommended changes, dissemination of the information learned in this study will occur through professional journals and professional seminars and conferences where management and teaching are the main focus.

Recommendations for Further Study

Closer examination needs to be conducted about the methods and materials used for influencing students to take STEM courses as well as for the development of competent and engaging teachers and professors. Since networking with STEM professionals appears to be the most compelling instigation for the respondents, it follows that a study of the impact of a networking educational environment that includes hands-on experiences, real life interaction with current STEM professionals and experimentation with scientific discovery needs to be conducted.

A study of how business decisions are made for hiring and maintaining STEM professionals, in particular, the hiring and maintaining of female professionals, needs to be performed. Once known how these decisions are made, a determination can be made on how to influence them so that female students and professionals can have equal opportunities to participate in STEM education and the associated STEM careers.

Reflections

I am sad that a well-respected organization such as the National Science Foundation found it appropriate to fund leadership training for female tenured faculty in American universities (O'Bannon, Garavalia, Renz & McCarther, 2010) so that they would be prepared to be promoted. It appears that the underlying paradigm is that men are somehow predisposed to know how to lead but women must be trained to fulfill that role. Perhaps this reflects our societal paradigm as well. The United States is far behind other countries in female leaders. We have never had a female president, female governors are a rarity and while the 2015 Congress is seating more women than previous sessions, it is far from 50%.

Being the lone female in university classes or the only female professional in the department or told that my hiring was to meet a quota were personal experiences that were shared by some of the participants. It is a personal hope that future female scientists, engineers, technicians, and mathematicians will experience different conditions in a workplace where they can hold a professional position that benefits society. They should experience a workplace where they are able to have female colleagues, work without fear or extraordinary expectations, free of bias and prejudice, and where they can enjoy the work that they have come to love since childhood, and where female voices may be heard.

86% of professional STEM women say they lack mentors and many plan to leave their current occupation within a year (Hersman, 2014). This reality is not only a comment on the conditions in our society, but on the lack of determination or abilities of current STEM women to somehow create growth opportunities for those following in their footsteps. Perhaps with issues such as Respondent 7 reported, “STEM careers are still male dominant, men get paid better, they aren't asked to do things that women are asked to do (e.g. they are more likely to get an assistant while you are expected to handle your own assistant worthy responsibilities)” and as Respondent 15 says, “At the time I started any men in automotive were paid a higher wage than I got doing the same job. Long hours and sometimes extended hours and days off site", women STEM professionals may be just too busy, too pressured, too tired, etc. to act as mentors and leaders for younger women. It may be that the organizations where they work do not allow them opportunities for such interactions. It may be that the societal bias toward men in STEM careers is too hard to overcome.

If 58% of current graduate degrees are held by women (Hersman, 2014) why would universities feel compelled to train their tenured female faculty in leadership so they could be promoted (O'Bannan et. al., 2013)? Why do technology-based businesses like The Boeing Company say they can't find qualified candidates (Stephens, 2010)? Where are the future female STEM professionals for American business now? Are they in schools in India and Pakistan, maybe China and progressive schools in Europe? There are significant numbers of female STEM students in American schools (U.S. Census Bureau, 2009) and the data showed that American universities are granting STEM degrees to females in greater numbers than ever before (U.S. Census Bureau, 2009). According to Google Trends, the inquiries about engineering work have been increasing since 2004, however, those internet inquiries about engineering positions are coming from other countries like India, South Africa, Pakistan, and Zimbabwe.

The interest may be increasing, but it appears that STEM positions are hard to find, especially for women candidates. The need for STEM professionals as stated by such professionals as Stephens (2010) from The Boeing Company before Congress has been inflated. It seems well known that STEM graduates are having a hard time finding employment and that they are often underemployed as a result. The figures for women especially indicate that many even with a STEM degree are working below the poverty line (U.S. Census Bureau, 2010).

American girls need to have opportunities to learn STEM topics not only watching while the boys are enjoying robot contests and programming graphics to create videos and games. Many of the programs that attempt to interest girls in STEM are visits with Mom or Dad at work, advertising for books or teachers, or small workshops with limited funds and scope and not with the interest of girls as the focus at all. Girls need to have interaction with women role models. Businesses, as well as schools and universities, need to create these opportunities for girls so that youngsters can see that women can be happy in STEM careers beyond medicine.

As Hersman (2014) encouraged women to leave an inheritance by having a vision for women in STEM and find a way to make it a reality by helping other women and girls to participate in STEM (p.151). Hersman's vision supports the vision of the women who participated in this study and the paradigm shift they recommend to move educators and leaders to support networking. The pervasive pipeline model needs to be abandoned. Women and girls need to be encouraged, but also given mentors, funded internships, and networking opportunities to see STEM first-hand, hands-on, and with professionals of both genders. The female professionals need to be encouraged and given similar opportunities to interact with each other and with those coming behind them. Society needs to be supportive of females in STEM and other non-traditional roles. We need to stop saying "I saw a woman today" doing something traditionally male like driving a truck and say instead, “I helped a girl experience science or technology or engineering or math today.”

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Endnote

Some representative sites are:

- Http://girlsangle.com
- Http://pbskids.org/scigirls/
- Http://Pbskids.Org/Zoom/Index.html
- Http://school.discoveryeducation.com/students/
- Http://Scratch.Mit.Edu/
- Http://www.aiaa.org/index.cfm is the home page, kid's activities and information is found at Http://www.Aiaa.Org/Content.Cfm?Pageid=473
- Http://www.alice.org/
- Http://engineergirl.org
- Http://www.gemsclub.org
- Http://www.girlsgotech.org
- Http://www.Girlscouts.Org/For_Girls
- Http://www.josietrue.com/
- Http://www.mathdoesntsuck.com
- Http://www.omsi.edu/tech/
- Http://www.sallyridescience.com
- Http://www.scienceclubforgirls.org
- Http://www.siemensscienceday.com/
- Http://spaceplace.nasa.gov/

Appendix A: Study Responses

Responses to questions 1 through 5

Q1 Select the option that qualifies you for this survey

Answered: 40 Skipped: 9

Answer Choices	Responses	
I am a female with a degree in a science, technology, engineering or math field	47.50%	19
I am a female that has worked for more than 10 years as a STEM professional	12.50%	5
This survey does not apply to me	40%	16

Q2 What influenced your curriculum choices?

Answered: 31 Skipped: 18

#	**Responses**
1	I am good at math and science and was heavily recruited into research.
2	my degree requirements and interests (for electives)
3	Program requirements - the main factor in determining which courses I took
4	My love of math and learning more....
5	Always wanted to learn more about plants and animals
6	The availability of courses that fit my schedule, and how many classes I could juggle per semester
7	I loved animals and wanted to be a veterinarian so I actually backed into it. I didn't get into vet school but started to love the science.
8	wanted a job that had the potential for good pay
9	Money and Security
10	Academic ally challenging
11	My curriculum was influenced most by the subjects that I was interested in.
12	My abilities and academic success.
13	knowledge base needs
14	I studied what interested me the most.
15	Love of the outdoors and science, great professors, ability to have a career in my field, lots of travel
16	Interest and ability to understand the curriculum

17	Do not have a degree in my field but did go back and take classes related to my field
18	When I was young I was a girl scout and I liked environmental science.
19	In college "fell in love" with IT
20	a love for science and math
21	Demographics and state of the profession
22	I like figuring out how and why things work.
24	my interest in science and math
25	My natural talents in math and problem solving, along with parents who encouraged me to do what I enjoyed.
28	I am assuming you mean why I majored in what I did at college. I had been interested in geology since I was 5 years old. My parents encouraged me to pursue my interests. I thought geology would be fun, and it is.
29	My interests.
30	Parents: one scientist, one science teacher, so always expected that I would find science interesting and useful, and I did!
31	Father was a NASA Physicist, had Mercury and Gemini astronauts over at the house all the time. Majored in Mechanical Engineering towards becoming the first woman astronaut. Only got as far as doing Top Secret missile defense work! LOL. I have serious motion sickness, throw up on rollercoasters anyways. Never became a woman astronaut but that was my Father's vision for me, not mine. It would've been different obviously if that was my true passion.

Q3 What influenced your career choices?

Answered: 30 Skipped: 19

#	Responses
1	I liked the intellectual challenge of research, and wanted to be able to contribute to better outcomes for individuals with disabilities.
2	I am working in the field of my degree
3	I decided at age 10 I was going to be a marine scientist
4	My career choice was made when I was very young while in high school
5	Wanted to do something that would help others
6	My desire to work in a field that had direct benefit for people
7	I wanted to work on science in a social context so I took positions working on HIV antivirals and now do basic science in a health disparities focused institution.
8	wanted a career with the potential for good pay
9	Money and security
10	pay rate & flexibility
11	My interest in the field and my academic success in it.
12	My interest in science.
13	practical application of creativity
14	The economy and pay.
15	Job availability in my degree, location, potential satisfaction in my job in enjoyment and helping others by using my degrees
16	Career opportunities in my area
17	Started working in Quality and stayed in it I always enjoyed statistics in school
18	Intellectual challenges but also something where I could interact with people as well as straight science.
19	My ambition
20	a wanting to share my knowledge with others
21	Demographics and state of the profession
22	A company that funded degrees in the field is what tipped the scale for me.
23	My original career choice was influenced by my High School Biology teacher and then from my college professors.
24	Personal interest in the subject matter was my main influence. Having a supportive spouse.
25	This survey does not apply to me.
26	na
27	The career was interesting to me. It was challenging. I was doing something useful, solving problems. I have a salary that I can support my family with.
28	My interests.
29	Loved my undergraduate experience at a small undergraduate college and wanted that as my job. Less happy in the lab full time at research-intensive schools in grad school and postdoc .

30	Never thought I had a gender. I just considered myself as a human being. If so, then I probably would've thought less of myself and less of my capabilities. Thank GAWD never thought I couldn't do anything unless it was something I had no interest in doing to begin with.

Q4 What were the encouraging factors that influenced your choices?

Answered: 30 Skipped: 19

#	Responses
1	Good female science faculty mentor.
2	I took honors science and math courses in junior and senior high school. My father was technically-minded.
3	Supportive & encouraging family members
4	The available choices I had at that present time, given my school, my race and my gender.
5	My high school counselor and projected job opportunities
6	My teachers and professors shared their own research with us, and it opened my eyes to fields that I never even knew existed
7	I had some faculty at the PhD level who were very supportive of me and my work.
8	science and math were easy for me
9	supporting children
10	pay rate
11	I was doing well in those subjects and others in my family both male and female were involved in scientific fields
12	Role models, other women in science.
13	rewarding, monetary gain of reasonable level, interesting, complex thinking
14	Quality of company, benefits, compensation.
15	Many science classes including a trip class in high school, encouraging parents and teachers (although not all teachers), great education that provided many opportunities, great internship that led to employment
16	Personal goal and family
17	Interesting field with a great deal of challenge.
18	I went to Oberlin College where there was lots of support for women in science. I also had a great high school physics teacher who was a woman.
19	Support from my family and trust in my capabilities
20	self-motivation
21	Others in the same field
22	I had great professors who encouraged female students to pursue the path despite it being heavily populated by men.
23	Just a love of the topic and a positive outlook on jobs.
24	Having (mostly male) mentors who also supported my choices and encouraged

	me to try when I felt like I might be failing. The ability to get funding opportunities because I am a woman.
25	This survey does not apply to me.
26	na
27	Being around people who also thought STEM was cool. Jobs were available. Going to an engineering college. I was never told I couldn't do STEM (because I was a girl).
28	I was good at science, and my parents encouraged me.
29	Great undergrad experience, loved short-term teaching experiences in the classroom and the lab
30	I think I always liked to learn. That's always been stimulating for me - natural curiosity and knowing how to get the information about it.

Q5 What were the discouraging factors that influenced your choices?

Answered: 28 Skipped: 21

#	**Responses**
1	Blatant sexism in male researchers, cutthroat research environment, no work-life balance.
2	none
3	No one discouraged me
4	The available choices I had at that present time, given my school, my race and my gender.
5	Having to move away from my home town and family
6	The cost of continuing on in my education. Graduate school or medical school just seemed cost prohibitive
7	STEM careers are still male dominant, men get paid better, they aren't asked to do things that women are asked to do (e.g. they are more likely to get an assistant while you are expected to handle your own assistant worthy responsibilities).
8	not really anything
9	difficulty of class, changing career
10	current position does not have opportunity for career growth
11	I can't think of any discouraging factors.
12	not enough power in the hierarchy
13	Commuting distance.
14	Switched jobs after work was not challenging and encountered issues related to a male-dominated field.
15	At the time I started any men in automotive were paid a higher wage than I got doing the same job. Long hours and sometimes extended hours and days off site.
16	Some social pressure and lack of professional role models. Although there was

	one great female environmental studies professor in college she was only a visiting professor.
17	Sometimes i felt like i didn't get the opportunity to show my abilities.
18	family
19	amount of work
20	Math is not my strongest subject. That can be intimidating.
21	I was always the only female in many classes and sometimes it seemed like the professors wanted me to fail and made me work harder
22	Some of my mentors were not encouraging. In those cases, either seeking out other supportive people or ignoring the negative people proved to be useful. My field is male dominated and probably always will be, so women have a tough time overcoming the inherent sexism.
23	This survey does not apply to me.
24	na
25	Being the only woman in a class or on the job site. Being told I was accepted into my college because there was a quota to be met for females. My suggestions and recommendations not being taken because I am a woman.
26	None.
27	Unhappy grad school experience (highly critical advisor)
28	There's always pebbles and roadblocks along the way of life's journey. Sometimes I'd foolishly allowed myself to accept somebody's negative judgment about me as the truth. Bottom-line: Can't let the Turkeys get you down because they will win if you do. Nobody wins actually when this happens.

Responses to questions 6 and 7

Q6 What would you recommend to generate an interest in young people to study math and science?

Answered: 30 Skipped: 19

#	**Responses**
1	I think the research environment is going to have to change a lot. The way things are now, you have to be completely antisocial, hyper focused on your career, and willing to give up having any kind of normal life to want to be a research scientist. Never mind that even if you "make it" it is only after years of low-paid postdoctoral fellowships---who wants to have your first "real job" in your 40's?
2	You really DO actually use what you learn in school later in life!
3	Kids need to know that math & science is rewarding. People in education are grossly underpaid compared to private industry.
4	Math is money.......
5	Starts getting young people involved in the math and sciences as soon as possible and cultivate a love for the area and a hunger for learning.
6	Give them lots of opportunities for hands on experiences. My 4th grade science teacher is the person who really sparked an interest in experimental work for me.

7 Encourage as much "wow" science WITHOUT book work intensive curricula through elementary school and ease into the didactics. Also it is important to have math and science be relevant to everyday events, for example, I was asked one time to go to a low income public elementary school in Lansing MI to talk about my work which was, at that time, looking at an anti-cancer vaccine for chickens. One little boy came in late he had just helped deliver his own baby brother at home. it was much more interesting than my talk. then we started talking about the other kids families and kids wanted to talk about diabetes and all kinds of things. So that is what we did.

8 make it realistic and true to life. Make science experiments something that they can do with real life materials and doing real life activities. Once they understand these fun general things then you can turn them on to the more abstract

9 Feeling more comfortable with math and science. Making it more relevant to everyday

10 Always exciting and new, you'll never get bored

11 That they get involved in the participation part of science and math. In math young people should be shown how it can help them make better decision and solve real world problems.

12 Seeing more role models, understanding how math and science studies and explains the real world.

13 make it fun and show them that there are a multitude of ways a career can go rather than what the normative messages say, which tend to promote "pure" math and scientific research as theoretic al, non-people, uncreative

14 I try to make it fun.

15 Provide real-world examples that apply to their everyday lives, hands-on and outdoor learning, shadowing and mentoring opportunities, more structure in elementary and middle school science classes to study more areas on science

16 Participating in work days for students rather than have just parents taking their children to work

17 Requirements

18 Make sure there are female science teachers in high school.

19 More hands on experiments

20 math and science classrooms with tons of hands on activities

21 Be prepared to work hard

22 Above all set them up for success. Make the environment safe and encouraging and make it fun.

23 Look at their everyday life and how everything in it is science and math in one way or another.

24 We have to teach these topics in the most interesting (i.e. NOT just from books) ways we can from the beginning of their school lives and we have to have competent, interested, engaged teachers. We also need local, state and Federal governments that all agree that we need to support STEM education, or it will disappear in the US.

25	This survey does not apply to me.
26	na
27	Tell them about all the fun, interesting, useful jobs they could do with a STEM job. Tell them math and science aren't as hard as people say they are.
28	Start them young (elementary school) with science as a way to learn about the world.
29	More outreach by scientists to help K-12 teachers incorporate more hands-on, inquiry based activities in the classroom. Science isn't about textbooks, but many K-12 teachers aren't comfortable enough with STEM content to use better methods.
30	Holding a ton of math and science conferences for girls! They need to know these career paths are attainable for themselves too by seeing examples in the "living flesh".

Q7 What would you recommend to businesses to generate an interest in STEM careers?
Answered: 30 Skipped: 19

#	**Responses**
1	I don't think it is businesses' job to generate interest in STEM careers. People don't go into STEM careers because STEM careers are not appealing. I am working outside a STEM field---only part of my STEM degree I use is the occasional statistic s.
2	Consider week-long mini internships with junior and senior high school students
3	More outreach at the pre-school & primary level to pique their interest so they'll keep wanting to learn
4	The world is an open book, you have to want to explore and take chances.
5	Offer more internships and opportunities for youth to explore career opportunities at an earlier age.
6	Invest money in recruiting outstanding math and science teachers at all grade levels in public schools. Fund scholarships for students who are interested in pursuing careers in STEM, especially for those who fall into the financial aid cracks.
7	Support science camps, after school science programs etc. The one I worked on in Michigan was run by the amazing Dr. Diana Martinez. After school science fun, bring a parent, snacks were provided (low income families, the kids were clamoring for fresh fruits etc. they would ask to take some home to their siblings). That is the kind of thing that makes and keeps them interested. put off the memorization and didactics as long as possible.
8	get your employees involved in the schools with a mentor or role model program
9	Sharing the different careers available
10	outreach more to elementary, middle and high schools career days
11	Businesses should open their doors and have young people see how science and math are used daily to perform work and to build and manufacture things.

12 Career days where students can see real people with STEM careers.
13 let people know about all the options as noted in response above
14 Making internships/independent study opportunities available to students.
15 Internships and showing opportunities, speaking to classes
16 yes
17 Create better work environments. Create a more positive workplace. Look to Google as a model of great workplaces.
18 I think right now they're doing pretty well. Biotech and tech companies is where the money and the buzz is.
19 I don't know
20 publicity
21 I don’t know
22 Fund programs that encourage students (not just the A students, generate interest and engagement among those who need the challenge and have not been encouraged yet).
23 Provide internships and opportunities for observation of the business. Show how the products make life better
24 Money MUST be put into real R&D, not just lip service for it. If you want educated, competent problem solvers, you need to grow them and then employ them.
25 This survey does not apply to me.
26 na
27 I don't know a good answer to this question.
28 Support graduate fellowships and internships.
29 Advertise jobs with specific qualifications! Reach out to college students EARLY in training to make clear what they are looking for in employees. Emphasize critical thinking skills learned in STEM fields as applicable to a huge variety of jobs. Emphasize social, collegial nature of science to combat image of solitary, lonely lab workers.
30 The problem requires a wider perspective on the matter. It's a culture shift that needs to be brought about, but the things I'm doing in St. Kitts can be done ANYWHERE.

Demographic Responses

Q8 Gender

Answered: 49 Skipped: 0

Answer Choices	Responses
Male	0
Female	49

Q9 Age

Answered: 49 Skipped: 0

Answer Choices	Responses
< 18	0
18-29	0
30-44	20
45-60	22
> 60	7

Q10 Household Income

Answered: 49 Skipped: 0

Answer Choices	Responses
$0 - $24,999	2
$25,000 - $49,999	4
$50,000 - $99,999	16
$100,000 - $149,999	7
$150,000+	20

Q11 Education

Answered: 49 Skipped: 0

Answer Choices	Responses
Less than high school degree	0
High school degree	0
Some college	3
Associate or bachelor degree	23
Graduate degree	23

Q12 Location (Census Region)

Answered: 48 Skipped: 1

Answer Choices	Responses
New England	11
Middle Atlantic	3
East North Central	4
West North Central	7
South Atlantic	8
East South Central	3
West South Central	3
Mountain	3
Pacific	6

Curriculum Vitae

Sharyn Elizabeth Mlinar, B.S., M.S., Ph.D

Professional Experience

The Boeing Company, 2004 – 2014, Associate Technical Fellow, Statistics

The Boeing Company, 1988 – 2004, Senior Quality Engineer

Lord Corporation, Engineered Plastics Division, Aurora, Ohio, 1986-1988, Division Manager, Quality Assurance and Purchasing

The Ridge Tool Company, Elyria, Ohio 1982-1986, Statistical Quality Engineer

TRW, Inc., 1976 – 1982, Euclid, Ohio, Quality Engineer and Sales Engineer

Education

Bachelor of Science Mathematics, Physics, Cleveland State University (1976)

Master of Science Quality Assurance, California State University at Dominguez Hills (2004)

Doctor of Philosophy, Applied Management and Decision Science, Walden University (2015)