Pilot Study: An Exploration of the Experiences that Influence Women's Interest, Pursuit, and Continued Involvement in STEM Careers

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Abstract

While longitudinal studies that examine the effects of personal and environmental factors on women's career motivation have been reported in the literature [1] [2], none have provided depth or breadth of biographical interviewing over the time span of the last two decades. Many intersecting variables have been identified by empirical research to account for women's continued underrepresentation in STEM careers, yet persistence, especially in computer science and engineering, remains an issue. Recent studies [3] [4] cite several contributing factors to the underrepresentation of women in the field and give special attention to women in STEM academic positions, with less focus on women in STEM careers broadly.

In this pilot study the experiences that encourage or discourage women's interest and persistence in STEM careers through a retrospective analysis of their K-16 and early career experiences are explored. The researchers use a grounded theory approach [5] [6] to interview women about their experiences and use these data to formulate theoretical propositions that extend or challenge what is presently known about factors influencing underrepresentation of women in STEM careers. The influences of family, culture, K-16 educational experiences, and transition to the workforce of women ages 25-45 who have graduated from college in a STEM major, with particular emphasis in studying the experiences of women in engineering and computer science, are examined.

Introduction

Despite decades of studies addressing women's interest and persistence in STEM careers, women are still underrepresented in STEM fields [7] [2] [3]. Though women's presence in the STEM workforce has increased in the past 30 years (figure 1), gender equity has not been achieved. Furthermore, women's interest and persistence in several STEM fields is not improving. For example, the number of women earning degrees and participating in the workforce in engineering fields and computer science (figure 2) has either remained unchanged or, in some instances, decreased in recent decades [7] [8] [9] [10]. This underrepresentation of women in STEM fields is puzzling considering women's advancement in other professional careers [2]. The lack of women in STEM fields has serious consequences for the nation's economy as it negatively impacts the number of qualified workers in high demand STEM fields in the labor force [2] [11] [8] [13] [14]. Additional data on women's interest and persistence in STEM fields is necessary in order to address this societal concern [13].

Figure 1 Percentage of women in selected STEM occupations, biological sciences, mathematics and computer science, chemistry, physics and astronomy, and engineering, 1960-2000 [3]

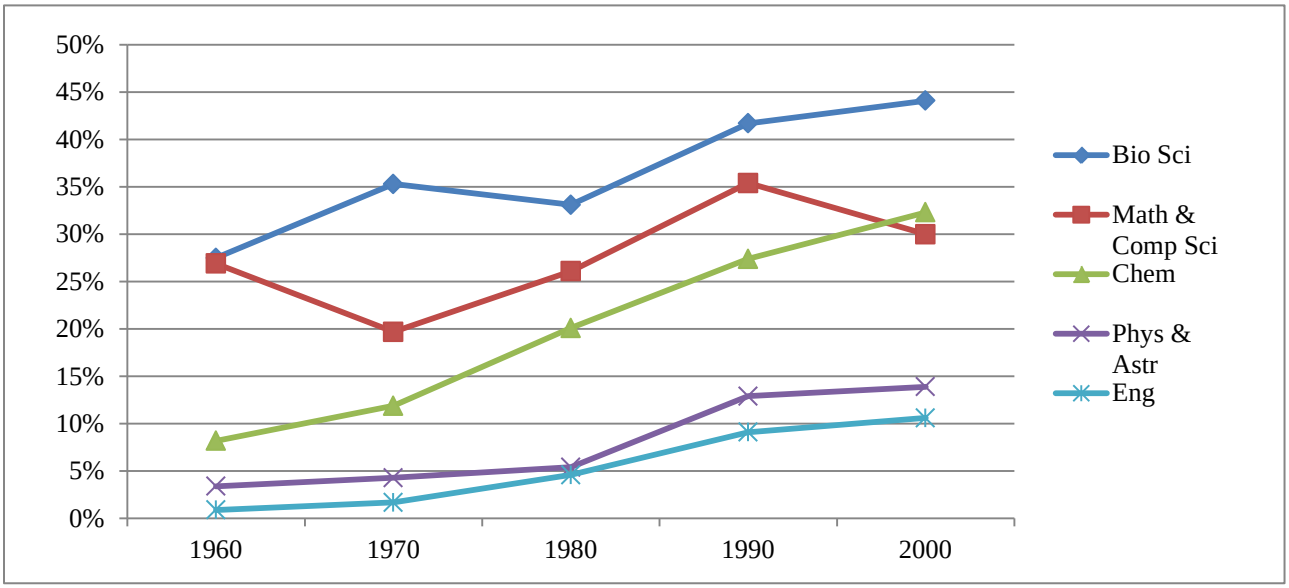
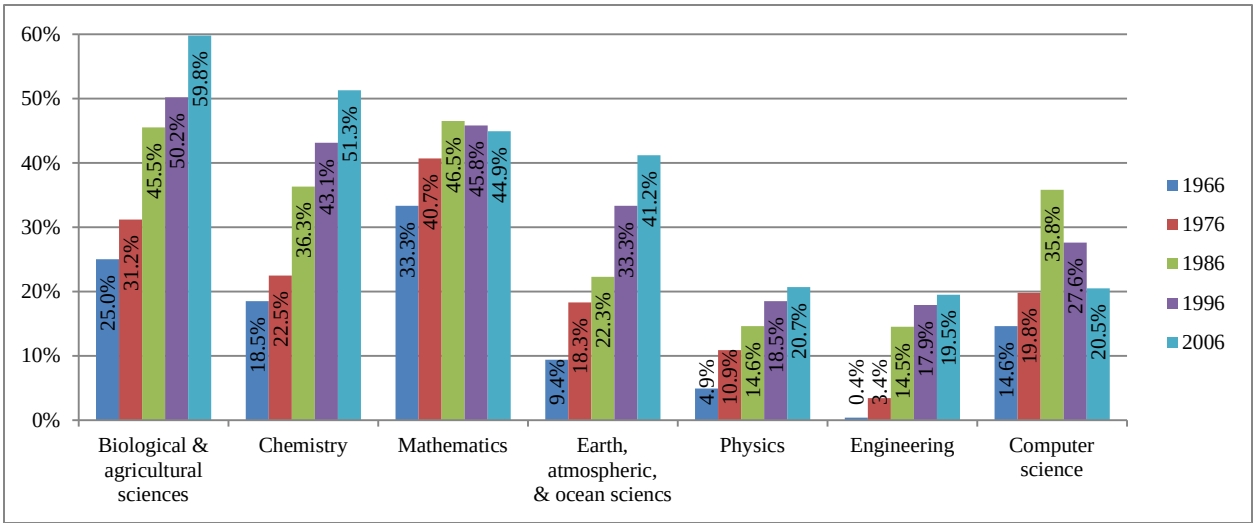


Figure 2 B.S. degrees earned by women in selected fields, 1966-2006 **[3]**



Though researchers have identified some of the enabling and disabling factors that influence women's persistence in STEM fields, to date women have not achieved gender equity in STEM fields. The literature review illustrates the complexity of women's lack of participation in STEM fields, meriting continued comprehensive study. Dingel [11] asserts that the numerous studies completed on women's persistence in STEM, mostly based on quantitative methods, have not provided a complete understanding of why women leave STEM. The few qualitative studies in the literature are based on data from the early to mid-1990s or are limited to women's career development through college. In asking women to review career-related decisions and choices

retrospectively through life course interviews, a more holistic understanding of cultural, familial, and educational experiences that contribute to interest, pursuit, and continued involvement in STEM can be gained. This data is necessary in order to update instructional strategies and develop programs aimed at dispelling identified myths and stereotypes related to STEM careers as well as fostering identified coping skills and self-esteem related to persistence in STEM fields.

The authors have established an interview protocol to answer the research question: *What experiences influence women's interest, pursuit, and continued involvement in STEM careers?* To date the researchers have completed a pilot study to validate the protocol and ensure the correct questions are being asked to obtain the information needed. This paper presents the interview protocol and the results of a very small pilot study. While the subject population size must be expanded greatly for the actual study, preliminary results show promise. The researchers have considered K-16 educational experiences, as well as the role of culture, family, mentors, teachers, counselors, and early job experiences on the choices and decisions women make about education and careers within STEM. Furthermore attributes and skills necessary to persist in STEM fields, particularly the fields of engineering and computer science are considered.

Theoretical Basis for this Study

Potential relevant literature streams include: the pedagogy of women's learning and development throughout the lifespan [16] [17] [14] [19] [20] [17]; social cognitive theories of gender development and socialization [22] [19]; women's career development [20] [25] [26] [27], and the literature related to women's selection, representation, and persistence in STEM fields (eg [3]).

This literature asserts that women's learning, in formal settings as well as informally through life experiences, needs to be understood within the a broader social context that encompasses the social determinants of gender roles and norms [19] [20] in order that women might overcome self-imposed as well as structural limits on career opportunities and outcomes. While women make up more than half the population of the world, women's experiences in work and learning, as well as research about women's lives, has been consistently undervalued and misrepresented [16] [19] [20] [17]. To be female is to be a gendered product of social and cultural beliefs and practices. Understanding the trajectory of women's career development therefore requires investigation into multiple social and cultural influences, including race, ethnicity, and diversity in perspectives [19] [20] [25].

Sociocognitive influences in gender role development include modeling significant people in familial, social, educational, and occupational environments [22]. Mass media can also be a source of substantial influence. The impact of gender role socialization on girls' choice to pursue STEM careers has been alluded to in the literature [28]. The impact of sociocognitive influences on girls' interest in STEM careers will be further considered in this study, as well the influences of K-16 education and early to mid-career experiences in the workplace.

Data Collection Plan

Based on the review of the literature, an in-depth interview protocol [25] was developed for the pilot study. For the pilot study, the researchers conducted two interviews spaced about a week

apart following an brief introductory conversation to introduce the study to participants. The first interview lasted approximately 90 minutes and the second, from 60 – 90 minutes. Participants were screened for participation and the researchers explained the study and gathered basic demographic information. Informed consent, according to the Institutional Review Board procedures of Virginia Commonwealth University, were conducted at the initial interview session. At that meeting, the researchers reviewed the purpose of the study, answered any questions a participant had, and gathered any demographic data not yet obtained through the screening process. These steps are part of the approach that Seidman [25] recommends to build rapport and establish a researcher-study participant relationship necessary for in-depth interviewing.

First Interview

The first interview explores participants' life history including early socialization within the family and community; the K-16 educational experience; and other informal learning experiences that influenced the woman's thinking, choices, and decisions about education and careers in STEM. Questions are open-ended and exploratory, allowing the participant significant freedom to describe her experience in a manner that does not direct or constrain the perspective she provides. The protocol for questions in both interviews is displayed in Table 1. Prior to initiating interviews, all researchers who are part of the interview team are trained in the format and approach for interviewing to be used to ensure consistency in data gathering. Likewise, researchers involved in the coding team for analyzing interview transcripts also receive training.

Second Interview

The second interview allows participants to describe the details of present experience through a narrative about her current career, including what she learns formally and informally through other people, mentors, or job assignments that influences her STEM career decision-making. The interviewer asks the participant to reflect back on the history of her choices by describing the turning points, significant life or job events, and experiences that led to STEM career persistence or decision to leave. The researchers are attuned to both overt as well as minimally expressed bias and discrimination issues and seek to build rapport in a manner that allows further explication of how these occurred for women in STEM fields.

To assist women in the reflective process of the second interview, the researchers share a synopsis of the first interview, asking each study participant to verify that the researchers' summary captures the essence of what the participant has said. Not only does this memory checking enhance credibility and validity, it enables the study participant to "see the whole" and allow her to engage more fully in reflecting on the choices and decisions that shaped her career path.

Table 1. Interview Protocol

Interview 1 – 90 minutes	Interview 2 – 60 to 90 minutes
Growing Up Experiences and Influence of Family 1. Tell us about the people who had a significant influence on your thinking about education and career as you were growing up. • Why do you think their opinions mattered to you? • Did the importance of these opinions change over time? 2. As you were growing up, what messages did you get from your family about jobs and education appropriate for women? 3. When you were a child, what did you dream of being or doing when you grew up? • How did this change as you grew into adolescence? • How were your goals and aspirations different in college? Or as you entered a career field? 4. What were the messages you received from the media (television, movies) and your community about appropriate roles for women? 5. How did you perceive yourself as a child in terms of body image, intelligence, self-esteem or potential? • What about as an adolescent? • Did this change as you became older? If so, to what do you attribute that change? **Experiences in School** 1. What attitudes and beliefs did you hold about your own abilities in math and science during your school years? • How did these change over time? 2. What was the effect of people who were role models or mentors to you in a school setting on your educational choices and career decisions? • Were there any particular significant experiences or events that influenced your interests or career choices? • What influences did teachers and/or school counselors have on what you studied and the career fields you considered? 3. As you were finishing high school and thinking about college, what influences shaped your decisions about career possibilities and your choice of studies? (family, friends, romantic relationships) **College Experiences and Workforce Entry** 1. Tell us about the experiences you had in college with professors, counselors, classmates, or significant others during your undergraduate years and how they affected the decisions you made about careers and work choices.	**Career Experiences** 1. What opportunities have there been for you to learn what you need to know to be successful in your career? • What formal (classroom or institutional) learning experiences have influenced you? • How would you describe what you have learned informally, lessons from experience? • How would you describe the role of others such as mentors, role models, bosses, and family on your learning during your career? 2. How do you balance your personal life with your worklife? • Has that changed over time? 3. What career challenges or barriers or setbacks are you facing in your job now? • How are these different from ones you have faced in the past or in other jobs? • How are you coping with these? 4. Do you think you've ever experienced any gender discrimination in the workplace and if so, would you tell us about it? • How did you cope with it? • Have you experienced changes in gender discrimination throughout your career? 5. What else would you like to tell us about what it is like to be a woman in your career field? **Reflection on Career** Think about the history of your career—how you came to be where you are now and how this evolved over time. 1. When you look back on this career path, how has changed over the years, and to what do you attribute the changes? 2. What was the best career advice you received? 3. Based on what you know now, what advice would give to a girl at various stages in school? Elementary school/ Middle or High School, College/ or Soon to enter the workforce today? 4. When you think back on your life and career history, what stands out for you about the choices and decisions you have made? (major dilemmas, transitions, obstacles)

2. During the time when you were finishing your undergraduate education, what experiences influenced the type of work you sought or considered? 3. Once you began your first job after college, what experiences, people, or relationships influenced whether or not you stayed within that career field? (colleagues, mentors, friends, family, romantic relationships, spouses, or children) 4. How did you come to be doing the kind of work that you are in right now?	5. What were the pivotal points in your personal career journey—those times when the path chosen made all the difference? (Childhood, adolescence, 20s, 30s, 40s) 6. What are your thoughts about being a woman in your career field today? 7. Where do you see yourself in the next 5 and 10 years, and why?

Data Analysis

The researchers used qualitative data software to aid in analysis of what will be a large, complex dataset, based upon the initial findings of the pilot study. Atlas.ti, which allows multiple researchers to enter and code data concurrently, has the capacity to perform a wide range of analyses, enabling researchers to look for inter-relationships and see complex patterns. For the pilot study inter-rater reliability of coded data was done informally with discussions between coders and comparisons of the coded data. As the researchers learn about women's experiences, the emergent properties of qualitative design will inevitably continue to shape the questions the researchers ask and allow for the exploration of emerging trends and patterns in more detail. Creswell [26] describes the systematic process of data analysis in grounded theory as following a standard format for coding:

- In an initial process of open coding, the researcher segments information into bits of text as discrete categories. Each category represents a unit of information composed of events, happenings, or instances [5]. In grounded theory, further examination looks for extreme possibilities and places them on a continuum that expresses the range of occurrences. Data analysis proceeds concurrently with data gathering and interview data are continuously compared to emerging categories through constant comparison methods [26] [5]. Codes and categories are sorted, compared, and contrasted until further analysis produces no new codes.
- Upon completion of open coding, researchers re-assemble the data in new ways to create a coding paradigm or logic diagram [26] enabling the researchers to identify central themes about STEM choices and decision-making. This process, called axial coding, examines causal conditions, context, and intervening conditions that influence STEM-related educational and career decisions. Following a reorganization of data into this new framework, researchers identify a major "story line" that integrates categories to produce conditional (theoretical) propositions about STEM-related career choices and decisions among women. This depiction of theory can be narrative or visual, in the form of a diagram or chart, and includes the social and historical context.

The end result of the constant comparative method of data analysis is advancement of substantive-level theory [26] that is written by the researchers who have studied the problem. Theoretical propositions become available for others to subject to further empirical testing because the relationships among variables (the categories from field-based interviewing) have been fully described.

Pilot Study Data Analysis

In the spring of 2010, the researchers received a Research Initiation Award from the School of Education at Virginia Commonwealth University to develop a small-scale pilot study of 6 to 10 participants in preparation for this proposal. In developing the pilot study, the researchers consulted with a research methodologist on the design and the interviewing methodology. Preliminary data analysis has been completed, although the researchers are continuing to explore the pilot study data through use of qualitative software for evidence of more in-depth patterns in addition to the initial themes that emerged from hand-coding and early analysis. Thus far, the researchers have interviewed five women of diverse ages, race, ethnicity, and background in the fields of engineering, computer science, and STEM education. The researchers have experienced no difficulties recruiting participants.

Five women of diverse ages, race, ethnicity, and background in the fields of engineering, computer science, and STEM education were interviewed. While this pilot sample is very small and far from representative, it has presented some interesting early results and provided the researchers with an interview protocol and data analysis process, which the researchers will use to inform a larger study. Following Creswell's description of the systematic process of data analysis in grounded theory the researchers met regularly to review the interview transcripts and develop, sort, compare, and contrast codes and categories until no new codes were created. Based upon that qualitative analysis of the pilot study data, the researchers identified the following codes and categories:

Table 2. Data Coding

Primary Code	Sub-Code	Descriptor of category of responses
Family	Sources	Familial influences included sources: mother, father, brother, sister, grandmother, partner, and extended family.
	Messages & Values	Familial messages and values conveyed including, gender role messages (mixed traditional, nontraditional, and challenging them), exposure to different careers and career decision option, education, care giving and familial support.
Friends/Peers	Support & Encouragement	Examples of support and encouragement friends provided for the choices and decisions the subjects made.
	Competitors & Barriers	Examples of peer competition sometimes with males in particular and the barriers that arose because of peer influences
Career	Aspirations, Interests, & Satisfaction	Personal aspirations, interests, and predilections that motivated the subjects to pursue or not pursue a STEM career . Career satisfaction and the factors that influence job satisfaction including work environment, job challenges, projects, compensation, coworkers, etc.
	Critical Events & Experiences	Examples of life changing event, and critical turning points in career and specific job experiences that influenced choices to remain or leave a STEM career.
	Career Entry & Rewards & Benefits	Examples of entry points into a STEM career, the monetary and nonmonetary rewards and benefits of STEM careers both perceived and actual.
	Coping Strategies & Planning	Examples of coping strategies and mechanisms to deal with challenges, barriers, discrimination, work life balance, etc.
	Barriers &	Examples of barriers and challenges that have impacted career

	Challenges & Discrimination	choices and opportunities along with personal experiences with discrimination and bias (gender, races, age, etc).
	Mentors & Collaborators	Examples of mentors and collaborators or the lack thereof influencing career decision and career satisfaction
	Continuing Education & Professional Development	Impacts continuing education and professional development have on career advancement and overall job satisfaction. Opportunities for career advancement, professional certification, and complementary professional experiences.
Personal	Gender Roles	Discussion of subject's confidence to challenge traditional gender roles
	Autonomy	Personal autonomy and independence are character traits that fostered subject's confidence in ability to pursue STEM
	Childhood and Adolescent	Childhood and adolescent experiences and perceptions help shape the subjects choice to pursue STEM
	Self Awareness and Efficacy	The subject's self efficacy in STEM and self awareness tying into an internal locus of control contribute to pursuing a STEM career.
	Challenges & Curiosity	Both the desire to face a challenge and conquer it along with intellectual curiosity are factors presented .
	Locus of Control	Both internal (passion, values, determination, etc) and external (parental pride and expectations) factors shared.
Higher Education	Barriers & Challenges	Several different barrier or challenges presented including, prejudice, bias, lack of practical examples, preparedness, stale curriculum, professor attitude, etc.
	Work Experiences	Subject's discussion of internships, co-ops, etc. or lack thereof influenced/impacted their choice to pursue a STEM career.
	Professors & Advising	Examples of the impact that advising or the lack thereof had on the subject's experience in college along with the impact of professors.
	Peers and Support Services	Examples of the peer support, study groups and other students support services that help subjects succeed in college.
	Math & Science	Discussion of subject's ability, affinity, and efficacy in math and science along with challenges in these subject areas in college.
K-12 Education	STEM Interest & Opportunities	Examples of experiences in K-12 that motivated subjects interest in STEM.
	Math & Science	Ability, affinity, and efficacy in math and science along with challenges in these areas in K-12.
	Teachers & Counselors	Examples of the impact (or lack thereof) that teachers and counselors had on the subjects STEM career decision.
	Barriers & Challenges	Examples of barriers to success in K-12 including large class sizes, lack of advising, and performance in classes
Social & Media	Experiences, & Media Influences	Media influences (limited) and personal experiences and in some cases misconceptions which influenced STEM career choice
Work	Barriers & Challenges	Recollection of events that impeded professional advancement or were challenges that had to be overcome.
	Strategies & Boundaries	Successful strategies and coping mechanisms including establishing boundaries to manage work and succeed/advance in the workplace.
Advice	Girls, Teens, College Students, & Women	Relevant advice (academic, personal, career, etc.) that the subjects found important at the different stages of life in order to encourage the pursuit of and success in STEM careers.

Parental support has been identified in many studies as being a factor that encourages women's participation in STEM (e.g., [28]). The pilot study participants supported this finding, asserting that parental support (from either mothers or fathers) emphasized the necessity that their daughter pursue a career that would allow her to be self-sufficient in life and achieve financial independence. Participants indicated that parents and grandparents provided support for STEM career choices with messages that encouraged nontraditional gender roles. Consistent with the supposition that the media fosters traditional gender roles [29], the pilot study participants in STEM careers were not exposed to large amounts of media and thus considered media's influence on their life roles inconsequential.

Pilot study participants identified the importance of STEM-related high school summer camps, co-op experiences, and internships in STEM in shaping their college major decisions. They identified pre-conceived myths about the relative importance of mathematics courses needed to achieve an IT degree, and described a decided lack of positive influence from school counselors and college advisors in supporting them in STEM-related college decisions. Given the dearth of literature in school counseling and academic advising publications, this early finding is not surprising, but nonetheless disturbing. School counseling literature is just beginning to address the counselor role in encouraging girls to pursue STEM careers [33] [31] [32] [36] and college academic advisors have only recently been exposed to articles on supporting young women pursuing STEM careers [37] [35]. Noticeably absent in the literature is research and corresponding programs specifically targeted to counselor educators who train school counselors and student affairs professionals.

Conclusion

This pilot study provides a foundation for a larger study to explore factors that encourage or discourage women's interest and persistence in STEM fields. The researchers anticipate that this larger study will result in theoretical propositions that will be available to researchers for further empirical testing. Furthermore, this study's additional and more descriptive identification of factors encouraging persistence in STEM is necessary for new program development and revisions in existing teaching, advising, and counseling programs in K-16 education. Teacher, advisor, and counselor training programs will be informed by the results of this study as well. Additionally, study results will be used in the development of programs for human resource departments in STEM fields.

The researchers' disciplines of engineering, mathematics education, school counseling, educational psychology, educational administration and leadership, student affairs in higher education, adult education, and human resource development will benefit from a more comprehensive understanding of the factors that encourage or discourage interest and persistence in STEM fields. Some of these disciplines have only begun to examine the significant underrepresentation of women in STEM fields, and practitioners in these fields do not have easy access to information on interventions to remedy this inequity. For example, very little research related to the underrepresentation of women in STEM fields has been published in school counseling journals. Yet school counselors play a critical role in ensuring that girls have the academic background to pursue STEM majors in college and need up-to-date information on the stereotypes and other barriers that inhibit girls' performance in STEM classes and interest in STEM careers. Furthermore, school counselors will be able to use the results of this study to

design programming for girls, teachers, and parents that focus on fostering identified coping skills and building other skills and attributes necessary to succeed in STEM careers.

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