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The Effect of Generation on Retention of Women Engineers in Aerospace and Industry

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THE EFFECT OF GENERATION ON RETENTION OF WOMEN ENGINEERS IN AEROSPACE AND INDUSTRY

by

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This Dissertation was prepared under the direction of the candidate's Dissertation Committee Chair, Dr. Tim Brady, Professor, Daytona Beach Campus; and Dissertation Committee Members Dr. David Esser, Professor, Daytona Beach Campus; Dr. Haydee Cuevas, Assistant Professor, Daytona Beach Campus; and Dr. Peggy Chabrian, External Member, and has been approved by the Dissertation Committee. It was submitted to the College of Aviation in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Aviation

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ABSTRACT

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The purpose of this dissertation was to determine the nature and extent of differences between generational cohorts regarding the effect of family factors on retention of women in engineering, with an emphasis on women in the aerospace industry. While 6% of the aerospace workforce is made up of aeronautical engineers, an additional 11.2% of the aerospace workforce is drawn from other engineering disciplines. Therefore, the analysis included all engineering sub-disciplines. In order to include women who had left the workforce, women in all industries were used as a proxy for women in aerospace.

Exits to other fields were modeled separately from exits out of the workforce. The source of data was the National Survey of College Graduates. Women engineers were divided into the Baby Boom cohort (born 1945-1964), the Generation X cohort (born 1965-1980), and the Millennial cohort (born 1981-1997). A time-lag design was used to compare generational cohorts when they were the same age.

The results of this study showed that generational cohort did not affect retention of women in engineering. However, generational cohort affected family formation decisions, with Millennial women marrying and having children later than their counterparts in the Generation X and Baby Boom cohorts. Generational cohort also affected the influence of motherhood on retention in the workforce, with Generation X

and Millennial mothers more likely to stay in the workforce than their counterparts in the Baby Boom cohort. There was no significant difference between Generation X and Millennial women in the proportion of mothers who stayed in the workforce.

Generational cohort influenced the reasons women left the workforce. Women in the Millennial cohort were more likely to cite not needing or wanting to work, while women in the Generation X cohort were more likely to cite family responsibilities. Among mothers in the Millennial cohort who were out of the workforce, the proportion who cited not needing or wanting to work as a reason for being out of the workforce was much larger than the proportion citing family responsibilities. Among mothers in the Generation X cohort who were out of the workforce, the relationship was reversed, with a larger proportion of women citing family factors than not needing or wanting to work.

Generational cohort also affected the influence of motherhood on leaving engineering for another professional field, with Generation X and Millennial mothers more likely to stay in engineering than their counterparts in the Baby Boom cohort. Women in the Baby Boom cohort were more likely than women in the Generation X cohort to cite family factors as the most important reason they left engineering for another professional field. There was no significant difference between women in the Generation X cohort and women in the Millennial cohort regarding the most important reason they left engineering for another field.

These results should help aerospace leaders understand the role of family factors in the workforce decisions of Millennial women engineers, and enhance the aerospace industry's ability to recruit and retain the best and brightest for tomorrow's aerospace workforce.

DEDICATION

For Abigail, Claire, Anna, and Andrew. And for Peter.

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CHAPTER I

INTRODUCTION

The engineering workforce in the aerospace industry is aging, with up to half of the workforce eligible to retire in the next five years (American Institute of Aeronautics and Astronautics, 2012). Young workers are needed to replace retirees, but competition for qualified engineers is intense (Hedden, 2015). In order to attract and retain talented workers, the aerospace industry needs to explore how the characteristics and priorities of the workforce have changed over time (Department of Labor, 2008). In particular, the industry needs to understand under-represented groups in order to increase its recruitment and retention of these populations (Department of Labor, 2005).

Women represent an underutilized resource that may be leveraged to benefit the aerospace industry. However, women in the Millennial generational cohort who are entering the workforce today may have different challenges and goals than women already in the aerospace industry's engineering workforce. Understanding the demographic differences between young women in the field now and women who entered the field twenty years ago will help employers develop programs that can promote retention of talented, experienced workers.

Aerospace Engineering

Aerospace engineering represents a critical component of the aerospace and defense (A&D) industry. America's approximately 80,000 aerospace engineers design, test, and build aircraft, spacecraft, missiles, and satellites (National Science Foundation, 2015). The products and services designed by these engineers represent a vital contribution to the U.S. economy. The aerospace industry generates 2.23% of the U.S. gross domestic product (Deloitte, 2012). In 2014, aerospace manufacturing maintained a $61.2 billion positive trade balance, despite an overall U.S. trade deficit of $508 billion (Aerospace Industries Association, 2015; Census Bureau, 2015). Engineers, who represent 17.2% of the A&D workforce, are a vital part of this equation (National Academy of Engineering, 2012).

Women in aerospace engineering. Only 13% of bachelor of science degrees in aerospace engineering are awarded to women (Yoder, 2012). Aerospace engineering has one of the lowest proportions of women among all engineering disciplines, fourth only behind computer, mechanical, and electrical engineering. By contrast, environmental and biomedical engineering are almost at gender parity. Similarly, women constitute only 13% of the aerospace engineering workforce.

Because there are so few women aerospace engineers, even nationally representative datasets such as the Scientists and Engineers Statistical Data System (SESTAT) contain insufficient records for many types of statistical analyses. Although recent iterations of the SESTAT surveys have oversampled women in order to combat this problem, earlier iterations did not compensate for the small numbers of women in particular disciplines. Therefore, this study used all women engineers as a proxy for studying women aerospace engineers.

Women in all Engineering Disciplines

A further reason for studying all engineers instead of only aerospace engineers is that while 6% of all aerospace manufacturing workers are aerospace engineers, 11.2% are engineers from other sub-disciplines (National Academy of Engineering, 2012). In 2013, the engineering sub-disciplines in highest demand in the aerospace industry were actually systems and computer software engineering (Aerospace Industries Association, 2013).

Women are underrepresented in the overall engineering training pipeline and workforce as well. Women earn 57% of all bachelor degrees but only 18% of Bachelor of Science in Engineering (BSE) degrees (National Center for Education Statistics, 2010; National Science Foundation, 2012; Yoder, 2012). Women constitute 47% of the general workforce but only 15% of the engineering workforce (Department of Labor, 2010; Hedden, 2015; National Science Foundation, 2015). Among engineers in the aerospace industry, which includes aerospace as well as other engineering sub-disciplines such as systems and electrical engineers, 14.6% are women (Hedden, 2015).

In the general workforce, women's participation has been steadily increasing over the past fifty years, particularly among those with college degrees (Department of Labor, 2010). While the absolute number of women pursuing engineering degrees has also increased, the percentage has remained relatively unchanged over the past thirty years (National Science Foundation, 2015).

Increasing the Representation of Women Engineers in the Aerospace Industry

Several factors suggest that increasing the participation of women in the engineering workforce may be beneficial for the aerospace industry. First, the demographic characteristics of the U.S. workforce are changing (Karoly & Panis, 2004). Second, diversity has proven economic benefits (Badal & Harter, 2014). Third, engineering and aerospace are vital to U.S. economic strength (Beede et al., 2011; U.S. Congress Joint Economic Committee, 2007).

As the growing participation of women in the general workforce would suggest, the demographic profile of the American workforce is changing. The general workforce is now nearing gender parity, since women's workforce participation has increased while men's participation has decreased (Karoly & Panis, 2004). Further, 38% of women in the workforce now have college degrees, compared to 11% in 1970 (Department of Labor, 2010). From 2000 to 2009, women as a share of all college-educated workers increased from 46 to 49 percent (Beede et al., 2011). The increasing presence of highly educated women in the workforce, coupled with their underrepresentation in engineering, suggests that women may represent an untapped source of talent.

Balancing the representation of men and women has also been associated with positive outcomes for business and management teams. Gender diversity in business organizations is associated with improved financial performance, including increases in sales revenue, customers, and relative profits (Badal & Harter, 2014; Herring, 2009; Hoogendoorn, Oosterbeek, & Van Praag, 2013). Gender balanced teams completing a variety of cognitive tasks score higher than all male teams on measures of collective intelligence (Woolley, Chabris, Pentland, Hashmi, & Malone, 2010). In design and manufacturing, gender diversity in working teams increases innovation (Liang, Kao, Yang, & Chien, 2014).

Maintaining strength and leadership in science and engineering in the United States is critical to the health of the U.S. economy. Technological innovation and change is responsible for 50% of the economic growth in the United States between 1950 and 1993 (Jones, 2002; U.S. Congress Joint Economic Committee, 2007). Advanced industries, for example aerospace manufacturing, computer software, and chemical production, among others, account for 17% of the total U.S. gross domestic product (Muro, Rothwell, Andes, Fikri, & Kulkarni, 2015).

Because of the increased presence of women in the workforce, the benefits of gender diversity in the workplace, and the importance of engineering and aerospace to the U.S. economy, much attention has been focused recently on the gender gap in participation in science, technology, engineering, and math (STEM). The majority of this research has focused on causal factors for the underrepresentation of girls and women (Hill, Corbett, & St. Rose, 2010; Shapiro & Williams, 2012), accession of women into STEM majors (Hall, Dickerson, Batts, Kauffmann, & Bosse, 2011), retention of women in STEM majors (Cech, Rubineau, Silbey, & Seron, 2011), and career processes of women faculty in STEM fields (Xu, 2008).

Research on retention of women engineers already in the workplace is less common. The existing research on factors affecting retention of women in engineering has focused on individual psychological factors (Ayre, Mills, & Gill, 2013; Buse, Bilimoria, & Perelli, 2013; Singh et al., 2013), workplace factors (Hewlett et al., 2008; Hunt, 2012; Singh et al., 2013), and family factors (Frehill, 2012; Hunt, 2012; Preston, 1994).

The role of family factors in driving workforce participation decisions among women engineers is controversial. Kahn and Ginther (2015) and Morgan (2000) found that family factors play a large role in the departure of women in engineering. On the other hand, Hunt (2012) found that the influence of family factors was not as important as issues of pay and promotion.

In studying social phenomena, however, the concept of change over time is critical, since patterns may exist that are not apparent until studied over a period of time (Van Krieken et al., 2013). Changes over time in women's progress from STEM bachelor's degrees to doctoral degrees have been studied (Miller & Wai, 2015), as have changes over time in the retention rate of women in the first eight years of their engineering careers (Kahn & Ginther, 2015). However, to date, little research has been published on changes over time in the role of family factors in retention of women in engineering.

When studying change over time, three effects can be distinguished: age effects, or the change in an outcome due to maturation; period effects, or the change in an outcome due to an event in time, such as an economic recession; and cohort effects, or the change in an outcome due to membership in a generational cohort. The concept of generational cohort is based on the theory that experiencing the same event in a defined period of time creates a group identity that serves to locate an individual within a larger social whole (Mannheim, 1952). Cohort membership can be defined by any significant life event that is experienced in a given period of time (Pilcher, 1994). Generational cohorts are defined by birth within a given range of years. The most salient way to demarcate one generational cohort from another is by changes in the birth rate. Hence the Baby Boom generational cohort is usually defined by the higher number of births from the years 1945 to 1964. Although the boundaries of other cohorts have greater variability in the literature, the Generation X cohort can be defined as those born from 1965-1980, and the Millennial cohort as those born from 1981-1997 (Lyons & Kuron, 2013; Twenge & Campbell, 2008).

Research on the effects of generational cohort on workplace attitudes and behaviors is complicated by the confounding of age, period, and cohort (APC) effects. Because of the linear dependency between age, period, and cohort, in which period = age + cohort, finding a single solution for all three variables at once is impossible. Three types of research designs can be used to mitigate this problem, generally by holding one of the variables constant. Longitudinal designs compare two or more cohorts as they age (Kahn & Ginther, 2015). Time-lag designs compare two or more cohorts at the same age at different periods in time. Cross-sectional designs, the weakest of the three approaches, compare age and cohort, holding period constant (Lyons & Kuron, 2013; Twenge, 2010).

Significance of the Study

The loss of experienced women from the engineering workforce has practical social and economic consequences. Demand for qualified STEM workers is projected to increase by 17% between 2008 and 2018, with 24% of the job growth occurring in engineering (Beede et al., 2011; Sargent, 2014). The lower retention rate of women in engineering compared to men represents a loss of talent for employers and a loss of lifetime earning potential for women.

Regarding the importance of generation to the aerospace workforce, the Interagency Aerospace Revitalization Task Force noted that research is needed on "generational differences and the potential impacts on the aerospace industry, as it transitions from a workforce dominated by Baby Boomers to a workforce where Generations X and Y play an increasingly larger role" (Department of Labor, 2008, p. 9).

This study was the first to look at the effects of generational cohort on the relationship between family factors and field exits from engineering among women. The results of this study can be applied to the problem of low retention of women in engineering by informing academia and industry about the enduring obstacles to retention of women in engineering. In addition, the results increased the body of knowledge regarding the challenges faced by women engineers, and will allow development of targeted interventions to retain different cohorts of women throughout their professional lives.

The literature on retention of women in engineering primarily uses longitudinal data or cross sectional data from a single point in time. This study was one of the first to use a time-lag design in order to add the dimension of social change over time to the literature.

Statement of the Problem

The A&D industry employs engineers from a variety of disciplines, including aerospace, civil, electrical, environmental, industrial, materials, and mechanical engineering (National Academy of Engineering, 2012). The total population of engineers reflects the different specialties within the aerospace industry, and represents the pool of talent from which the engineering workforce in the aerospace industry is drawn. Therefore, the total population of women engineers was used as a proxy for women engineers in the aerospace industry.

To date, research is lacking on how the influence of family factors on field exits among women engineers has changed over time. Cross-sectional studies have compared women engineers to women in other professional fields, or female engineers to male engineers, but few studies have compared women engineers today to women engineers from earlier generations.

Comparing today's women engineers to a variety of different reference groups provides the most complete understanding of the role of family factors on field exits. In particular, understanding how the influence of family factors has changed over time helps distinguish between continuing obstacles and those that are no longer relevant. Identifying persistent obstacles can help focus efforts to increase retention of women engineers, with the attendant benefits to the aerospace industry and to women themselves.

Purpose Statement

The purpose of this study was to determine the nature and extent of differences between generational cohorts regarding the effect of family factors on women's field exits from engineering. Exits to other fields were modeled separately from exits out of the workforce. Women in all engineering fields were studied as a proxy for women in aerospace engineering and other sub-disciplines in the aerospace industry.

Research Questions and Hypotheses

The overriding research question (RQ) posed in this study was: Has the relationship between family factors and field exits among women engineers changed over successive generations? In order to answer this broad question, several more specific questions were posed. When the literature was sufficient to guide an expectation of the answer, a hypothesis was included.

1. RQ1: Has retention of women in engineering changed over successive generations?

    Hypothesis 1: The retention of women in engineering has increased over successive generations.

2. RQ2: Have family formation decisions among women engineers changed over successive generations?

    Hypothesis 2a: The proportion of women engineers who are married has decreased significantly over successive generations.

    Hypothesis 2b: The proportion of women engineers who have children has decreased significantly over successive generations.

    Hypothesis 2c: The average number of children per woman engineer has decreased significantly over successive generations.

3. RQ3: Is having children associated with field exits?

    Hypothesis 3a: Having children significantly increases the probability of field exits out of the labor force.

    Hypothesis 3b: Having children does not have a significant effect on exits to other fields.

Hypothesis 3c: The probability of field exits out of the labor force increases quadratically with each additional child.

4. RQ4: Does generation influence the effect of having children on field exits?
5. RQ5: Among women who have left engineering for another field, have their reasons for leaving changed over successive generations?
6. RQ6: Among women who have left engineering to exit the workforce entirely, have their reasons for leaving changed over successive generations?
7. RQ7: Among women engineers with children, does generation affect the percentage of women who leave the workforce for family reasons?

Delimitations

This study was limited to women engineers born in the United States because generational cohorts may not have the same meaning in an environment outside the United States (Mannheim, 1952; Pilcher, 1994). The generational cohorts were limited to the Baby Boom cohort (born 1945-1964), the Generation X cohort (born 1965-1980), and the Millennial cohort (born 1981-1997). Earlier cohorts did not include enough women engineers to allow valid inferences. The period of the study was limited to 1982-2013, because these were the years that captured the career experiences of all three cohorts. The ages studied were from 20-68 for the Baby Boom cohort, 20-48 for the Generation X cohort, and 20-32 for the Millennial cohort, because the oldest member of the Generation X cohort was 48 in 2013, and the oldest member of the Millennial cohort was 32 in 2013.

Although life course interviews are a commonly used method for research involving life and career choices, the survey method was used to improve generalizability of the study.

Limitations and Assumptions

The sample size was limited by the number of engineers included in the Census Bureau's survey. The scope and nature of the survey were predetermined by the Census Bureau. This study assumed that the participants answered truthfully and accurately.

Ideally, this study would have used as its sampling frame those women engineers who were employed in, or had departed from, the aerospace industry. However, the National Survey of College Graduates (NSCG) only included the type of employer for respondents who were in the workforce at the time of the survey. Therefore, selecting women based on employment in the aerospace industry would have excluded women who had left the workforce, which would have resulted in serious bias. Therefore, this study assumed that the relevant qualities and characteristics of women in the general engineering population were not significantly different from the qualities and characteristics of women engineers who worked in the aerospace industry.

Definitions of Terms

Age Effects — Age effects refer to those changes in an outcome that can be attributed to the maturation of individuals over the life course.

Age-Period-Cohort	Age-Period-Cohort (APC) refers to the study of changes in outcomes over time. APC studies generally seek to identify the amount of variance in an outcome due to age effects, period effects, or cohort effects.
Age-Period-Cohort Identification Problem	The Age-Period-Cohort identification problem refers to the fact that, due to the linear relationship between the variables, several solutions exist to any regression problem involving these three variables.
Baby Boom cohort	The Baby Boom cohort refers to the group of individuals born from 1945 through 1964.
Cohort Effects	Cohort effects refer to those changes in an outcome that can be attributed to membership in a birth cohort.
Engineer	An engineer is defined as someone who has earned a Bachelor of Science in Engineering.
Engineering Workforce	The engineering workforce is defined as the population of individuals who have earned a Bachelor of Science in Engineering, and who are currently employed in an occupation that is categorized by the U.S. Census Bureau as engineering.

Field Exit out of the workforce entirely	A field exit out of the workforce entirely occurs when an individual with a Bachelor of Science in Engineering is not employed and not looking for work.
Field Exit to another occupation	A field exit to another occupation occurs when an individual with a Bachelor of Science in Engineering is working in a field that is not related to engineering.
Generation X cohort	The Generation X cohort refers to the group of individuals born from 1965 through 1980.
Millennial cohort	The Millennial cohort refers to the group of individuals born from 1981 through 1997.
Period Effects	Period effects refer to those changes in an outcome that can be attributed to the period of time in which the outcome is measured.

List of Acronyms

A&D	Aerospace and defense
APC	Age-Period-Cohort
BSE	Bachelor of Science in Engineering
HAPC	Hierarchical Age Period Cohort
ICPSR	Interuniversity Consortium for Political and Social Research

NSCG	National Survey of College Graduates
NSF	National Science Foundation
RQ	Research Question
SESTAT	Scientists and Engineers Statistical Data System
SPSS	Statistical Package for the Social Sciences
SSE	Survey of Natural and Social Scientists and Engineers
STEM	Science, Technology, Engineering, and Math

CHAPTER II

REVIEW OF THE RELEVANT LITERATURE

This chapter reviews the literature on subjects relevant to the study, including historical changes in the role of work in peoples' lives, the influence of gender on work, the influence of gender on work in engineering, and the influence of generation on work. Because much of the discussion surrounding women in STEM fields involves work and family issues, an understanding of the historical role of work in peoples' lives, with a particular focus on the role of work in women's lives, is an appropriate starting point. Next, understanding the current state of women in the general workforce serves as a springboard to examine the state of women in engineering. Finally, the sociological construct of generation and its impact on the workplace is discussed.

Historical Attitudes to Work

Any discussion of work should begin with a definition of the term *work*, and a statement of the delimitations of the population being studied. In this context, work is defined as "productive activity for household use or for exchange" (Tilly & Scott, 1987, p. 5). While childcare, cooking, and housekeeping would be clearly defined as work by most who have done them, the focus for this research is on work that could lead to wage earning. Thus, childcare, cooking, and housekeeping is considered work when performed in exchange for wages but not when performed for family necessity.

The development of work as a concept separate from subsistence has occurred throughout the world, but this discussion will focus on England and the American colonies in the pre-industrial age, and on the United States in the post-Industrial age.

Attitudes and behaviors in the United States, which are the primary focus of this study, were initially transplanted from England, and then grew in a particularly American way (Kessler-Harris, 2003; Tilly & Scott, 1987). Hence the focus is on historical forces that influenced the experience of work in the United States.

Pre-industrial Concept of Work. Prior to the Industrial Revolution, work was initially organized in terms of the "family economy" (Tilly & Scott, 1987, p. 12). The farm in rural areas, and the shop in urban areas, were the locus of economic activity. The English economy at this time depended heavily on agriculture, with approximately 65% of the population engaged in farming. The entire family was employed in some fashion for the production of food and goods for subsistence and trade. The "interdependence of work and residence" (Tilly & Scott, 1987, p. 12) was a hallmark of the family economy. In the 18th century, as land ownership in England became concentrated among a small number of wealthy individuals, rural people gradually became wage-earning agricultural laborers on someone else's land, or home-based manufacturers of textiles or other goods traded for money. Peasants unable to maintain their own households worked as servants in slightly wealthier households.

In urban settings, economic activity was more diverse, yet still primarily based in households or small shops. Widows, young men and women whose families could not provide employment, and disenfranchised migrants from the countryside provided the wage earning labor force. As in the rural areas, work and family was an "indivisible entity" (Tilly & Scott, 1987, p. 21), with one's role in work reflecting one's position in the family and vice versa.

In the American colonies, to an even greater extent than in England, every able bodied individual was expected to contribute to production. This imperative was reinforced in the Puritan colonies by the concept of prosperity as a sign of “divine favor” (Kessler-Harris, 2003, p. 5). As in England, cottage industries provided some degree of specialization of labor, but the unit of economic production and consumption remained the family. Work and family roles were intertwined, with leadership in the family implying leadership in the work setting.

Industrial Revolution. The Industrial Revolution and the consequent rise of industrial capitalism as the dominant economic system in the West led to profound changes in the conduct and conceptualization of work. Industrialization meant that manufacturing could be accomplished more efficiently at a single central location, rather than within individual homes. The attendant growth of factories led to the perception of “work” as a productive activity accomplished outside the home during set hours in return for payment (Edgell, 2011). The major differences between work in pre-industrial societies and industrial capitalist societies is summarized in Table 1.

Table 1

Comparison of Key Features of Work in Pre-industrial and Industrial Capitalist Societies

Key relevant features of work	Pre-industrial societies	Industrial capitalist societies
Unit of production	Family/household	Individual adults/large-scale organizations
Division of labor	Rudimentary/low degree of differentiation	Complex/high degree of differentiation
Time	Irregular/seasonal	Regular/permanent
Meaning of work	Necessary evil	Work as a virtue
Purpose of work	Livelihood/subsistence/short term profit	Maximum reward/income long-term profit
Embeddedness of work	Embedded in non-economic institutions	Separate from other institutions
Roles of men and women	Some gender specialization	Considerable degree of gender specialization

Note. Adapted from *The sociology of work: Continuity and change in paid and unpaid work*, by S. Edgell, p. 8. Copyright Stephen Edgell, 2011.

As work slowly evolved from a family activity to an individual activity, workers became more independent of family structure and more reliant upon work for self-definition. As Edgell (2011) notes, "work ceased to be embedded in non-economic social institutions, such as the family, and became a separate, distinct institution in terms of space, time and culture" (p. 17). Occupations also underwent dramatic change, from agriculture to manufacturing and eventually to services such as education and communication. Industrial capitalism meant that work was no longer driven by seasonal patterns involving periods of intense labor and rest. Industrial capitalism imposed a *work-time discipline* that dramatically increased the time spent on work, until labor laws were introduced to protect workers.

As a result of the economic growth brought about by the technological advances of the Industrial Revolution, attitudes toward the goal of work shifted from guaranteeing subsistence to promoting prosperity. Instead of working enough to comfortably survive, work and the generation of wealth became a primary goal. In the United States, the historical Puritan emphasis on the spiritual dimension of work facilitated a change in perspective from work as necessary for survival to hard work as a religious virtue. Thus the labor demands of industrial capitalism were reinforced by the religious injunction for hard work (Edgell, 2011).

The cumulative result of these changes was that in industrial capitalist societies, work was the driving force shaping lives. Edgell (2011) explains that:

> For the vast majority of people in industrial capitalist societies, their whole lives are organized with reference to work; they spend their early years in education in order to be able to obtain work, the next 40 years or so in work, and their last years recovering from work. (p. 18)

Beyond merely a means for survival, work became the central theme around which modern industrial lives were organized. At the same time, the economic necessity of work was augmented by the social rewards of work. As self-definition relative to a family structure declined, self-definition by work increased, so that work satisfied social and affective needs as well as economic.

Information Revolution. The advent of computing technology and the consequent rapid evolution in work processes are now giving rise to modifications in the concept and execution of work that may be as far reaching as the changes wrought by the

Industrial Revolution. Technological advancements may lead to changes in the way business is organized and may alter the character of employment relationships. As the effects of this information revolution begin to ripple out, ideas about the role and performance of work are continuing to evolve. Connectivity has reduced the importance of temporal and geographic co-location, increasing the flexibility of where work is performed, but also increasing the time during which workers need to be available (Karoly & Panis, 2004). Improvements in information technology mean that the strict time and location demands imposed by industrialization may be loosened. The proportion of workers in non-standard employment arrangements such as contract and temporary work may increase as a result of enabling technologies and increasing economic pressure (Karoly & Panis, 2004). These changes mean that young workers may be moving into a more flexible but less secure work environment than their predecessors.

Evolution of the Engineering Disciplines

Development of Engineering as a Profession. The profession of engineering in the West has also changed over time. Engineering as a trade emerged in the Renaissance as an outgrowth of the medieval traditions of both building for civil purposes and designing for war (Picon, 2004). Engineers, like other craftsmen and artists of the time, generally worked alone for a single patron. By the early 18th century, however, the demand for military engineers in France and the coalescing of civil engineers into trade organizations in England led to the formalization and consolidation of engineering as a discipline. The United States inherited both the French legacy of a corps of statesponsored military engineers and the British legacy of a trade organization of civil engineers. During the 19th century, engineering diversified into a number of sub-disciplines, including mechanical, electrical, and chemical engineering. The process of differentiation continued into the 20th century with the advent of industrial, systems, aerospace, environmental, and software engineering, among many others. Beginning in France in the 19th century, engineers also increasingly took on managerial roles, creating, in effect, another sub-discipline in engineering, that of the engineering manager (Picon, 2004).

Engineering at the Start of the 21st Century. Changes in the discipline of engineering over time have resulted in the profession we see today: a "continent" of diverse geography and topography unified by the goal of applying science and mathematics to solve practical problems (Picon, 2004). In the United States, a bachelor's degree is necessary and sufficient to work as a professional engineer. In 2012, 504,690 students were enrolled in bachelor's degree programs in engineering in the United States, 105,371 students were enrolled in master's degree programs, and 72,245 students were enrolled in doctoral programs (Yoder, 2012).

At the graduate level, engineering education is strongly driven by immigration and visiting students. Only 9% of students enrolled in undergraduate engineering programs are foreign born, but 43% of students enrolled in master's degree programs and 54% of students enrolled in doctoral programs are foreign born (Yoder, 2012).

Women constitute 15.0% of the engineering workforce, though the proportion of women varies by discipline, as shown in Table 2 (Department of Labor, 2010; National

Science Foundation, 2015). In 2012, women earned 19% of Bachelor of Science in engineering degrees (Yoder, 2012). This would suggest that the representation of women in engineering will increase over time. However, to date the higher percentage of women students has not translated into a higher percentage of women in the workforce, as shown in Figure 1.

Table 2

Employed Engineers by Gender and Occupation

		Female		Male	
Discipline	Total	Number	Percent	Number	Percent
Engineers	1,263,791	189,380	15.0	1,074411	85.0
Aerospace engineers	80,262	10,196	12.7	70,066	87.3
Chemical engineers	60,777	15,023	24.7	45,754	75.3
Civil engineers	208,248	36,028	17.3	172,220	82.7
Electrical engineers	242,100	24,211	10.0	217,879	90.0
Industrial engineers	46,003	7,796	16.9	38,207	83.1
Mechanical engineers	271,809	24,031	8.8	247,788	91.2
Other engineers	354,592	72,095	20.3	282,497	79.7

Note. Data from 2013 NSCG.

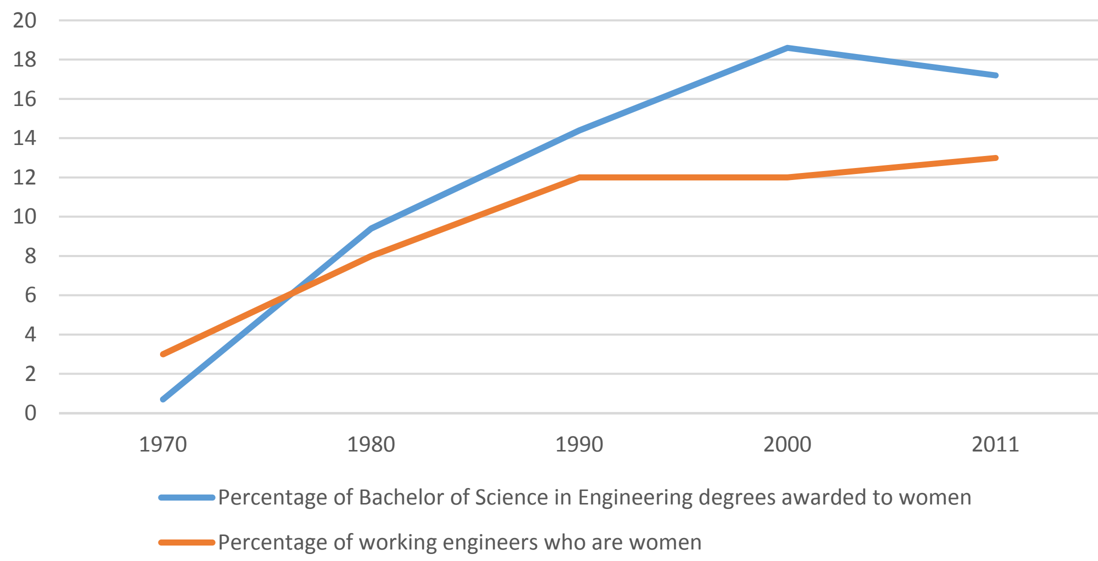

Figure 1. Percentage of Bachelor of Science in engineering degrees awarded to women compared to percentage of engineering workforce who are women, 1970-2011. Based on data from T. Snyder and S. Dillow, 2015, *Digest of Educations Statistics 2013*, p. 593, and C.L. Landivar, 2013, Disparities in STEM employment by sex, race, and Hispanic origin.

The sectors of the economy in which scientists and engineers are employed are shown in Figure 2. While wages vary considerably by discipline, the mean engineering salary in 2011 was $99,738 (Sethi, 2011).

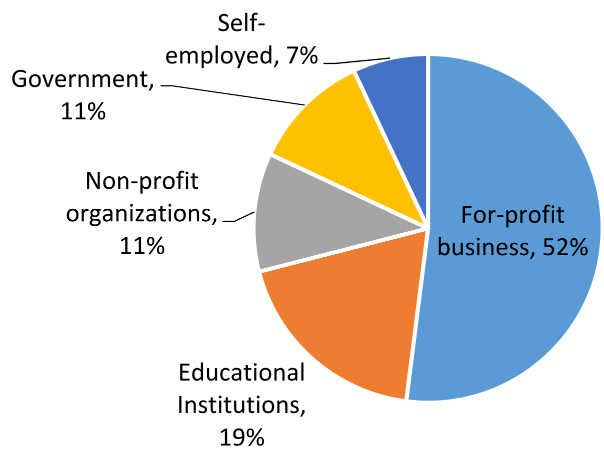

Figure 2. Employment of scientists and engineers in the United States by type of employer, 2010.

The Influence of Gender on Work

Gender and Work in the Pre-industrial World. During the pre-industrial era, work for both men and women was not clearly differentiated from other activities. "Work was not a special subject, it was part of the general social and spiritual framework" (Anthony, 1977, as quoted in Edgell, 2011, p. 37). In the absence of any economic surplus, both men and women remained engaged in productive work as long as they were able.

In pre-industrial societies, some amount of gender specialization occurred, but within the primary economic unit of the family, the divisions were not stark and unbreakable. The extent of gender specialization in pre-industrial societies, however, is a subject of debate among scholars (Edgell, 2011; Tilly & Scott, 1987).

In colonial America, roles were clear in terms of social hierarchy, with married men acting as head of the household, and therefore the economic unit. In terms of work activity, however, roles were more fluid, with men participating in domestic chores and women working in the fields and workshops, as necessity demanded. For this reason, and because the jobs normally performed by women in the home, such as weaving and food preparation, were so obviously necessary, respect for women's work was equal with men's, even if women's status remained lower.

Gender and Work Following the Industrial Revolution. Gender specialization was greatly accelerated by the Industrial Revolution. Grint (2005) states that industrial capitalism "polarized the work opportunities of men and women" (p. 66). One consequence of gender specialization was that women became concentrated in jobs involving low skill and low pay.

As industrialization and capitalism became dominant characteristics of the economic system of the West, the role of women both within and without the household began to change. The advent of industrial machinery led to a decline in the economic value of women's household work. At the same time, the growing employment of men outside the home in cold and indifferent environments led to the idealization of home life and an increasing emphasis on the woman's role as guardian of the sanctuary of the home rather than productive worker.

Wage work for women outside the home, therefore, was concentrated among unmarried women, and was generally expected to last only a few years. Because work inside the home, whether for wages or not, was considered more genteel, a wealth divide appeared, in which jobs outside the home were primarily relegated to women with no other choice. For women who did have to engage in wage work, the possibilities were either domestic service or manufacturing. In the middle of the 19th century, less than

10% of the population of the United States was employed in manufacturing, but of these, half were women. In industries that produced goods previously made at home by women, such as textiles, women constituted up to 90% of the paid workforce. In summary, women's wage work during this period was primarily in domestic service and manufacturing, and was characterized as a necessity for some women but only as a preparation for the true and enduring role of women as wives and mothers.

Toward the end of the 19th century, declining birth rates, smaller families, and innovations in household technology meant that women, particularly wealthy women, had more time. During the American Civil War, women banded together to form various aid societies, whether for the abolitionist cause or to aid war widows. The resulting transition from the view of woman as guardian of the home to woman as guardian of home values in the larger world had far reaching implications. Increasingly, women engaged in work outside the home in fields that fit the societal role ascribed to women, such as nursing, social work, and teaching. Married women, in particular, began entering the paid workforce in much higher numbers. Nevertheless, wage work for women was always secondary to the more important and desirable role of women as wives and mothers.

World War I brought further changes. The demonstrated capability of women who filled jobs during the war led to an increased consciousness of women's potential in the labor force, much as it would thirty years later after World War II. However, these changes should not obscure the position of the majority of wage earning women, who were still engaged in domestic service or its equivalent, such as commercial laundry. The concentration of women in certain occupations was dramatic. Between 1910 and 1940, only ten sectors accounted for the employment of 86% of all wage earning women, as shown in Table 3 (Kessler-Harris, 2003). Only one in fifteen married women worked for wages, and these were still primarily poor women.

Table 3

Sectors Accounting for 86% of Women's Employment from 1910-1940

Domestic Service	Nursing
Textiles and Apparel	Clerical Work (stenographers, secretaries)
Teaching	Food Service (cooks, waitresses, barmaids)
Farming	Personal Services (laundry, beauty, hairstyling)
Sales	Telephone and Telegraph Operators

Note. Adapted from "Women's Occupations Through Seven Decades," by J.M. Hooks, 1947, U.S. Government Printing Office.

World War II is widely acknowledged as a watershed in women's labor force participation. Certainly, many jobs were opened to women that had previously been closed. But other changes were more subtle and possibly far reaching. Employment outside the home, once thought unequivocally to interfere with a woman's more important role in the family and to serve only as the last resort to prevent financial ruin, was now perceived as a patriotic duty. Although some of the increase could be due to other demographic factors, women's employment outside the home increased by roughly 80% between 1940 and 1945 (Kessler-Harris, 2003). However, the change in women's workforce participation was temporary. After the war, women left the workforce at much higher rates than men, either of their own choice or because they were fired. In some sectors, such as the traditionally female trades involving food, clothing, and textiles, large numbers of women left their jobs voluntarily. By contrast, in sectors such as heavy industry, many women wanted to stay in their jobs. Particularly in steel, iron, automobile, and machinery plants, employers laid off women to make room for returning soldiers seeking to resume their old jobs (Kessler-Harris, 2003).

The three decades following the war saw slow but steady changes in women's workforce participation. In 1950, women made up 29% of the workforce. By 1965, women constituted 35% of the workforce. By 1975, that figure had risen to 40% (Kessler-Harris, 2003). Further, women became more likely to stay in the workforce after they married and were more likely to hold full time jobs. The rise of the consumer economy placed economic pressures on families that encouraged, and in some environments, demanded, two incomes.

Unlike during the war years, the post-war changes in employment went hand in hand with enduring changes in attitudes toward women in the labor force. In 1955, the White House Conference on Effective Uses of Woman-power was still able to say, "The structure and substance of the lives of most women are fundamentally determined by their functions as wives, mothers, and homemakers" (Kessler-Harris, 2003, p. 300). But by the 1970s, economic pressures and the consequent economic empowerment of women challenged long-held beliefs about the role of women. Paid work, which had been defensible for women only as a means of supplementing family income in hard times, or as a patriotic wartime duty, could now be justified by the woman's own desire to work.

By the late 20th century, mothers were no longer constrained by societal expectations to remain out of the labor force to care for their children. At the same time, the growth of the consumer economy meant that fewer families could afford to get by on a single income. As a result, the workforce participation rates of women with small children grew rapidly, so that by 1995, 70% of married women with children under the age of 18 were in the paid workforce.

Gender and Work in Engineering Following the Industrial Revolution. While the rate of women's participation in the paid workforce tripled in the 20^{th} century, women were still concentrated in certain industries. For the most part, these were occupations that extended women's roles within the family, like teaching, nursing, and social work. Even women employed in the industrial sector followed this pattern, usually working in textile mills.

The gender specialization fostered by the Industrial Revolution was particularly visible in heavy industrial settings. In the 19^{th} century in the United States, most engineers gained experience through on the job training in settings such as railyards and machine shops rather than from formal schooling (Bix, 2004). Women, at that time considered the guardians of the peaceful, restorative home front, were not considered fit for the rough and tumble work environment where engineers learned their trade. Of the schools that did provide an academic engineering education, only a few admitted women. Consequently, women engineers in this period were extremely rare and were primarily regarded as "oddities at best, outcasts at worst" (Bix, 2004, p. 27).

World War II had as profound an effect on women engineers as it did on women in the general workforce. Companies seeking to hire qualified women engineers found they had to collaborate with universities to create engineering education programs to make up for the lack of trained women engineers. In one such program, the Curtis-Wright aircraft company collaborated with seven colleges to educate over 600 young women engineers, known as the “Curtis-Wright Cadettes” (Bix, 2004). As in the general workforce, the work performed by these women was seen as a patriotic duty. Also as in the general workforce, the end of the war meant a return to conservative, gendered roles in the workplace. The presence of women in engineering returned to pre-war levels with very little change over the ensuing twenty years, so that by the 1960s, still less than 1% of engineering undergraduates were female.

Due to political and social changes in the United States, women’s participation in engineering education and employment grew rapidly in the 1970s. Increased enforcement of the 1964 Civil Rights Act, combined with the burgeoning women’s movement, led to increases in women’s participation in engineering. Purdue University, for example, increased its enrollment from 46 women engineers in 1968 to over 1,000 women engineers in 1979. Employers who had portrayed engineering as an overtly gendered, male occupation in past recruitment efforts now explicitly targeted women.

The late 20th and early 21st century saw a steady increase in women’s participation in engineering, as well as most other STEM fields, as shown in Figure 3 (Hill et al., 2010).

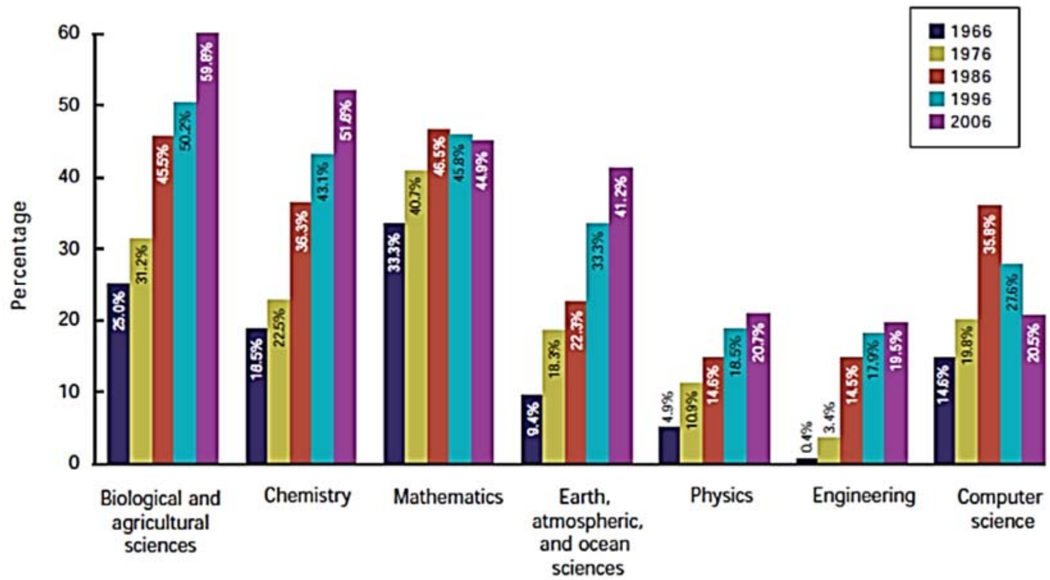

Figure 3. Percentage of bachelor's degrees earned by women in STEM fields, 1966-2006.

While women's participation in engineering has increased dramatically over the past fifty years, the representation of women varies considerably by subspecialty. Some specialties, notably environmental engineering, have almost achieved gender parity, while other specialties such as aerospace and computer engineering continue to be predominantly male. Figure 4 shows the percentage of bachelor's degrees in engineering awarded to women by discipline (Yoder, 2012).

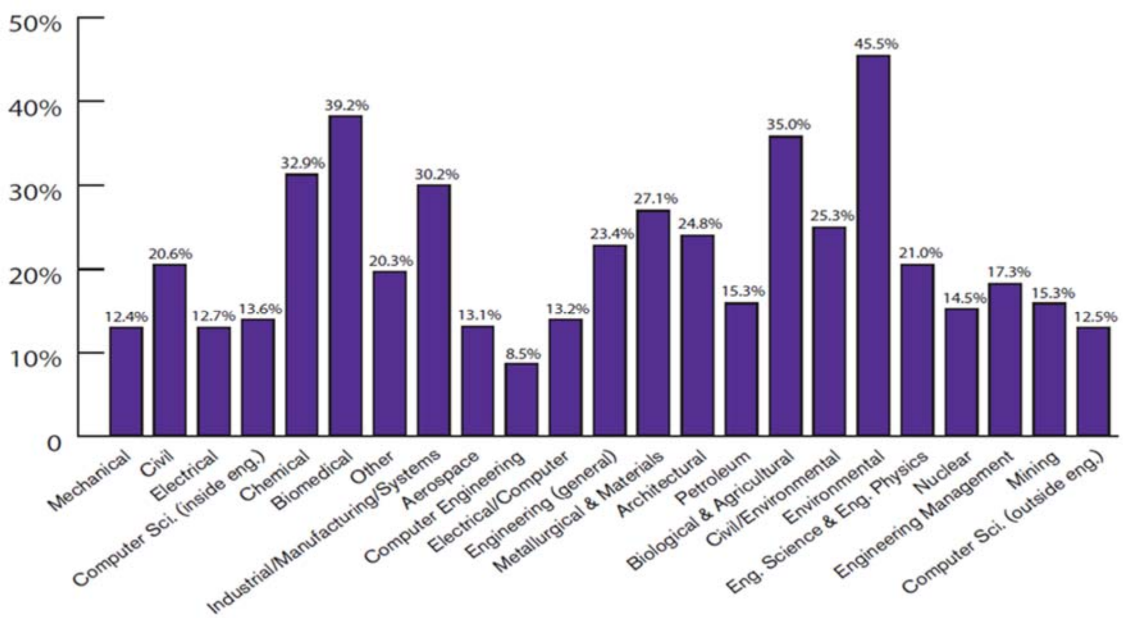

Figure 4. Percentage of Bachelor of Science degrees in engineering awarded to women by discipline.

Women in the General Workforce at the Start of the 21st Century. The increasing presence of women, particularly mothers, in the paid workforce has not been without its difficulties. Young women, particularly the well-educated, entering the labor market in the early 21st century face far fewer institutional and cultural barriers than their predecessors. But as women ascend the career ladder, fewer and fewer of them remain. Women earn 58% of undergraduate and 63% of graduate degrees in the United States but hold only 18% of the leadership positions in business, academia, and industry (Lennon, Spotts, & Mitchell, 2013; National Center for Education Statistics, 2010).

Women's career paths today still differ from those of men. One third of professional women leave the workforce at some point in their careers, compared to one quarter of professional men. Although workforce exits are usually temporary, with the average departure lasting 2.2 years, women also often take what Hewlett (2007) calls the "scenic route", engaging in part time work or jobs with fewer responsibilities, as shown in Figure 5.

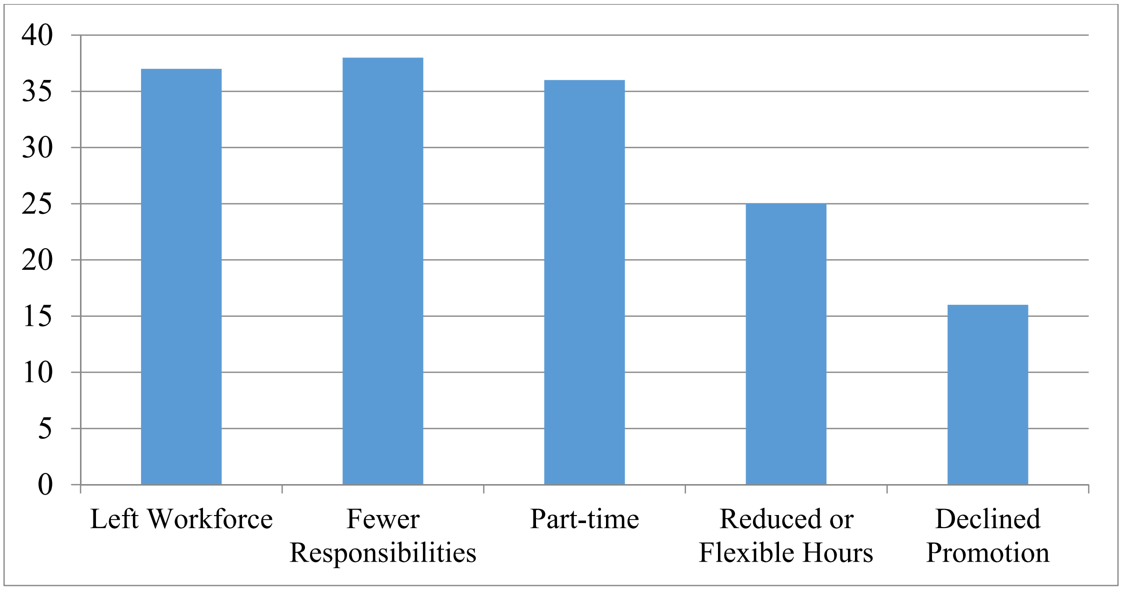

Figure 5. Percent of professional women who reported engaging in non-linear career paths. Respondents could select multiple categories.

Workforce exits. The question of why women leave the workforce has generated some controversy. Lisa Belkin's 2003 New York Times magazine cover story entitled "The Opt-Out Revolution" set off a firestorm of debate about the idea that highly educated young women were opting out of their careers in favor of their families. Many journalists and academics insisted that no such revolt was taking place, while some sociologists countered that both men and women were opting out because of excessive demands from employers. Anne-Marie Slaughter's 2012 article in the Atlantic Monthly about her own choice to step down from her position as director of policy planning for the State Department in part to spend more time with her family highlighted the difficulties of “having it all”, while Sheryl Sandberg’s clarion call *Lean In* (2013) encouraged women to stay the course. The so-called “mommy wars” appeared to pit working mothers against stay at home mothers. Amid the popular arguments from both feminists and traditionalists, scholars sought to uncover patterns based on hard data.

In her 2007 study of 2,443 highly qualified women, Hewlett found that among women who had left the workforce, 45% identified childcare as a factor in their decision to leave. Cabrera’s (2006) study of 2,000 female business school graduates reflects Hewlett’s results, showing that 47% of women stopped working at some point in their careers, with 35% of women identifying childcare as the primary reason.

However, not all exits for care-giving were due to children. Among the professional women in Hewlett’s study, 44% did not have children. But in the United States, 71% of those who spend 40 or more hours caring for an elderly relative are women (Cabrera, 2006). Eldercare was identified by 24% of respondents as a factor in their decision to leave the workforce.

Care-giving issues were not the only reason women left the workforce. Women also identified unsatisfying careers, feeling stalled in their careers, and not needing a second salary as contributing factors in their decisions to leave the workforce, as shown in Figure 6 (Hewlett, 2007). Mainiero and Sullivan (2006) contend that caregiving responsibilities often combine with unsatisfying careers to give women a reason to leave and little reason to stay.

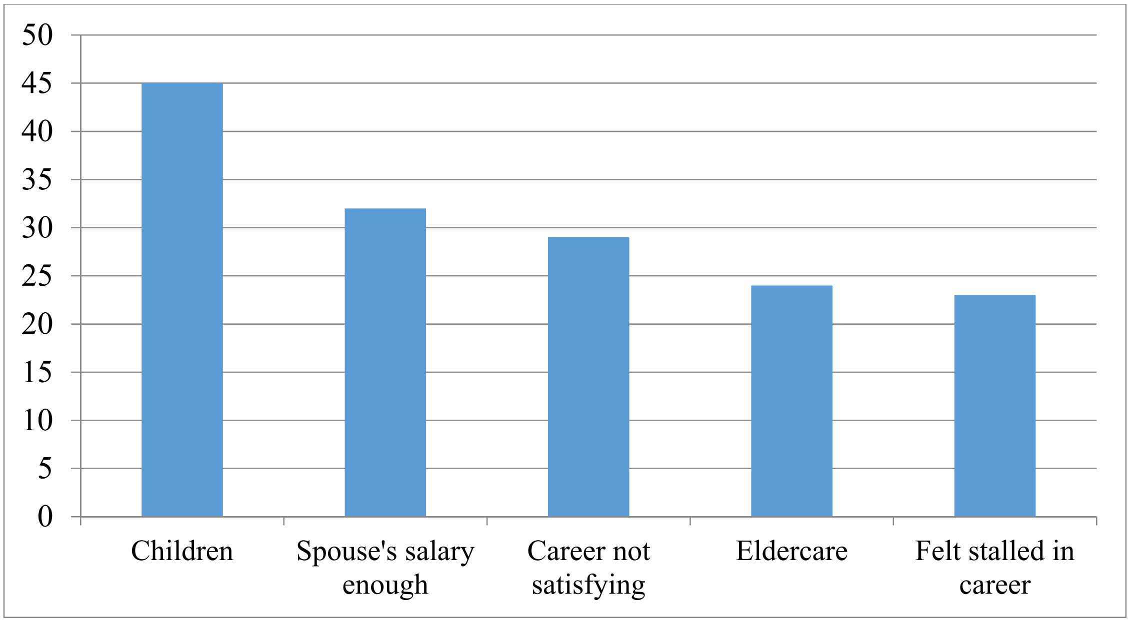

Figure 6. Self-reported factors contributing to workforce exits among professional women. Respondents could select multiple categories.

Rejoining the workforce. According to Hewlett (2007), 93% of highly qualified women who left the workforce wanted to return, but only 80% were able to. Of these, 40% returned to full time paid work, with the remainder returning to part time work (24%) or starting their own businesses (9%). Cabrera (2006) found that 70% of female business school graduates who left the workforce eventually returned. Of these, 29% said that returning was difficult. Many women said they would like to go back to work but found it impossible to balance family needs with full time work. Women also expressed their frustration with the lack of meaningful part time work. Women who do return have a considerably reduced earning capacity. By the time a woman has been out of the workforce for three years, her earning capacity will be 63% of what she was earning when she left the workforce (Hewlett, 2007).

Women in STEM

The departure of women from STEM fields has also been the focus of much research. Using the 1979 National Longitudinal Survey of Youth, Glass, Sassler, Levitte, and Michelmore (2013) compared women in STEM to women in non-STEM professional fields. The results showed that, compared to non-STEM fields, workforce participation for women in STEM is a "leaky pipeline" with fewer and fewer women remaining as job tenure increases, as shown in Figure 7.

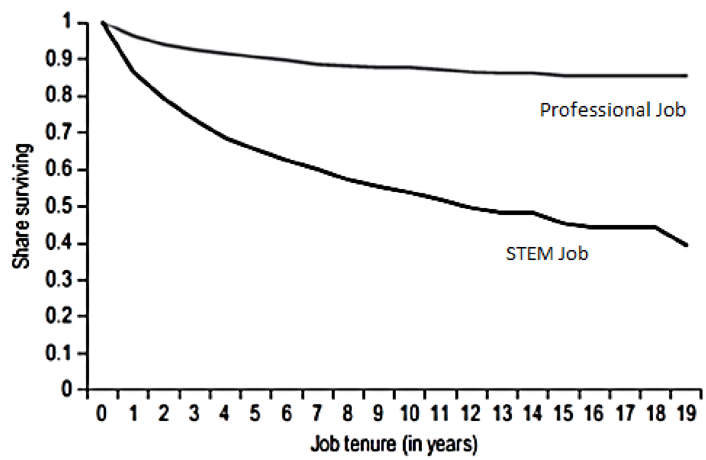

Figure 7. Kaplan-Meier survival estimates of exits out of field or labor force for women in STEM and professional non-STEM careers.

Even after controlling for "adolescent career and family expectations, actual marriage and childbearing, spouse characteristics, and job characteristics," (Glass et al., 2013, p. 741) women in STEM fields were nine times more likely to leave their fields for other occupations than women in professional, non-STEM fields. However, women in STEM fields were no more likely than women in other professional careers to leave the workforce entirely.

The birth of a first child did not have any significant effect on field exits to other occupations for women in STEM or non-STEM fields, although it significantly increased exits out of the labor force entirely for women in both STEM and non-STEM professions, but particularly for women in STEM. Women in non-STEM professional fields who had a second child were 2.5 times more likely to leave the workforce than women who did not have a second child ($p<.05$). Women in STEM professional fields who had a second child were 5.2 times more likely to leave the workforce than women who did not have a second child ($p<.1$) (Glass et al., 2013). Overall, these results suggest that having more than one child is less compatible with a career in STEM than a career in other professional fields, and that women in STEM choose to leave the workforce entirely rather than switch careers when faced with a choice of how to manage two or more children.

Glass et al. stress that most of the field exits for women in STEM are to other occupations, not out of the workforce, and that the supposed exodus of mothers from STEM fields only accounts for a small amount of the variation in field exits. Glass et al. also found that there was no significant effect of the interaction of gender ideology with motherhood on field exits from STEM to other professions, suggesting that workforce exits to other professions among mothers were not due to adherence to traditional gender roles. Unfortunately, the authors do not report testing the effect of the interaction of gender ideology with motherhood on workforce exits out of the workforce entirely. One limitation inherent in this study is that the results cannot readily be generalized outside the cohort of women born between 1957 and 1965. Glass et al. acknowledge that young women entering STEM fields today may differ from the “pioneering cohort” in their study.

Factors contributing to field exits for women in STEM. In their study of STEM careers in the private sector, Hewlett et al. (2008) identified five workplace factors that were pushing women out of STEM. These included a hostile macho culture, isolation, mysterious career paths, extreme work pressures, and systems of risk and reward that favored men’s risk-taking strategies.

Hewlett also found that women’s perceptions of their opportunities in private sector STEM companies became more negative with age. For example, agreement with the statements “women are not given second chances” and “women don’t get the recognition they deserve” was higher in each successive age group. However, the cross sectional research design makes it impossible to determine if women became progressively more pessimistic as they aged or whether younger women were entering a different environment than their predecessors. A time-lag approach would be needed to separate the effects of age and cohort.

Women in engineering. One limitation of research on women in STEM occupations is that not all STEM fields are the same. Fields such as health care and life sciences have a much higher proportion of women and much higher retention of women than fields with a lower proportion of women. In some fields women’s retention is higher than men’s. Engineering has one of the lowest levels of representation of women among STEM fields, as shown in Figure 8, as well as one of the lowest retention rates.

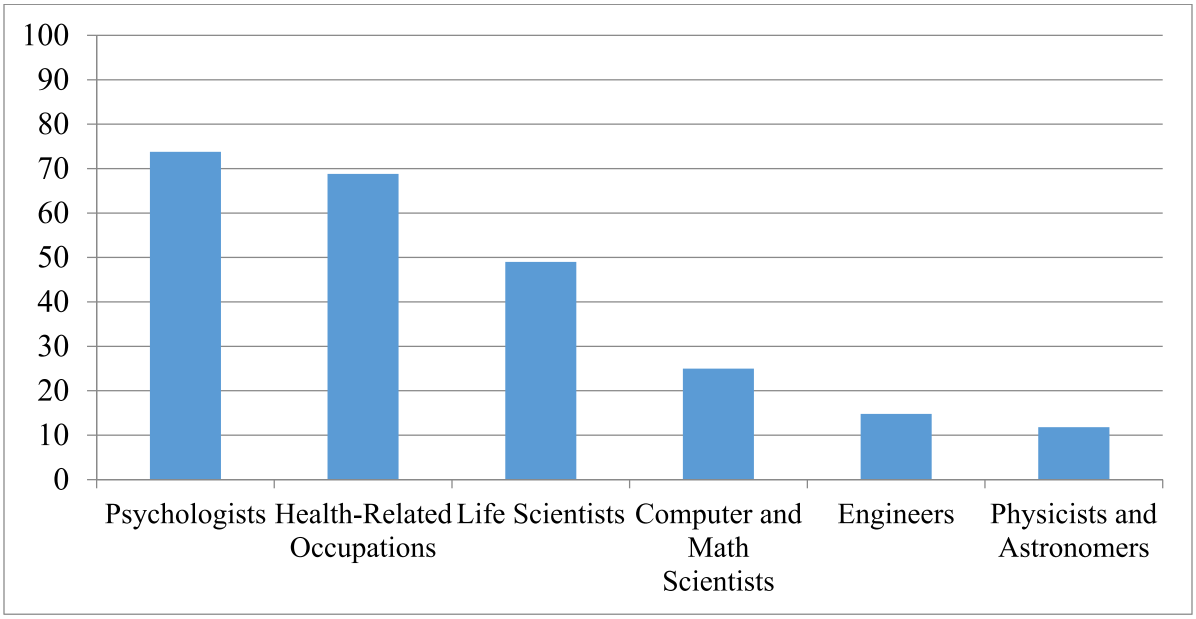

Figure 8. Employed women as a percentage of the science and engineering workforce in each discipline.

Hewlett et al. (2008) found important differences in the experiences of women in engineering versus women in science in the private sector. The subjective sense of isolation was particularly prevalent among women in engineering, where 44% of women reported feeling isolated, compared to only 27% of female scientists. The perception of isolation is reflected in the reality of representation, as women make up 66% of young private sector scientists but only 21% of young private sector engineers. Further, 63% of women engineers in Hewlett's study believe that behaving like a man will increase their prospects for advancement, while only 46% of female scientists shared this opinion.

Factors affecting field exits for women in engineering. Research on women in engineering has concentrated on academic settings, such as the undergraduate or faculty experience. Far less work has been done on understanding field exits among women already in the engineering workforce. The studies that have been done on the factors that affect women's field exits from engineering have concentrated on three types of factors: personal qualities, job factors, and life factors.

Personal qualities. Studies of personal qualities have explored the role of optimism, self-efficacy, and identity (Buse & Bilimoria, 2014), as well as professional role confidence (Ayre et al., 2013; Cech et al., 2011). Using a sample of 495 women engineers, Buse and Bilimoria (2014) found that self-efficacy, optimism, hope, and identity are mediated by the "ideal self", which then predicts engagement and commitment to engineering. The authors conclude that "the acknowledgement (of discrepancies between one's ideal self and one's real self) often results from a tipping point, where women discover that their real self is not aligned with their ideal self. This discovery motivates them to leave engineering careers" (p. 10). Buse and Bilimoria (2014) write that in contrast,

> Women who persisted…described themselves in engineering terms and discussed their work in engineering as challenging and meaningful. Their ideal self was aligned with their real self, here conceptualized as work engagement. The ideal self directly impacts work engagement and greater work engagement results in greater commitment to engineering. (p. 6)

Buse and Bilimoria's snowball sampling method may have introduced bias into their results, as only 16% of respondents identified themselves as "not an engineer or any position related to engineering or unemployed or a student", while nationally representative surveys show that 30% of women BSEs do not work in engineering (Frehill, 2008).

Similarly, Ayre et al.'s (2013) qualitative study of a graduation cohort from an Australian civil engineering school found that women who stayed in engineering were notable for their confidence in their abilities as engineers and their sense of belonging in the profession. However, the sample did not include women who had left engineering, making it difficult to draw conclusions about what distinguishes women who stay in engineering versus women who exit the field.

In their longitudinal study of the persistence of women in undergraduate Bachelor of Science in engineering programs, Cech et al. (2011) found that persistence in engineering as an undergraduate was predicted by "expertise confidence", or confidence in one's ability as an engineer, while intentions to pursue engineering after college was predicted by career fit confidence, or belief that one is well suited for the culture and profession of engineering.

Conversely, using a sample of 5,562 female graduates with a Bachelor of Science in engineering, Fouad, Singh, Fitzpatrick, and Liu (2011) found that women who stayed in engineering were no different from women who left engineering in terms of their "confidence in their abilities or the positive outcomes they expected from performing engineering-related tasks" (p. 6). Fouad, Singh, Cappaert, Chang, and Wan (2015) also found no difference between women who stayed in engineering and those who left in terms of self-efficacy, outcome expectations, or job interests as measured by the Strong Interest Inventory. However, Fouad et al. (2011) did find that among those women who remained in engineering, the "lack of self-confidence in their ability to manage multiple work-nonwork roles" (p. 9) led to higher levels of work-nonwork conflict, which in turn led to a greater intention of leaving engineering. Fouad et al. (2015) found that turnover intentions predict field exits, suggesting that higher levels of work-nonwork conflict might increase field exits.

In summary, the research on personal qualities suggests optimism, self-efficacy, and identity affect the ideal self, which in turn affects engagement and commitment among women engineers. However, there is little evidence that women who remain in engineering differ from women who have left engineering in terms of optimism, self-efficacy, and identity. Among students who have not yet committed to a career in engineering, personal qualities may have more influence on retention.

Job factors. Most researchers acknowledge that workplace factors also play a role in women's field exits from engineering. Workplace factors generally fall into three categories: supports, barriers, and characteristics. Workplace supports that have been studied include mentoring (Fouad et al., 2011), training and development (Singh et al., 2013), supportive work/life climate (Singh et al., 2013), and supervisory support (Buse et al., 2013; Singh et al., 2013). Workplace barriers that have been studied include a potentially hostile culture for women, isolation, lack of clear path for advancement (Frehill, 2008; Hewlett et al., 2008; Hunt, 2012), and work overload (Fouad et al., 2011; Hewlett et al., 2008). Job characteristics that have been studied include changes in professional interests (Frehill, 2008; Hunt, 2012), pay and promotion issues (Frehill, 2008; Hunt, 2012), job satisfaction, and occupational commitment (Fouad et al., 2015).

Workplace supports. In a study of 5,562 women engineers, Fouad et al. (2011) found no difference in the incidence or quality of mentoring between women who stayed in engineering and those who left. However, the authors did find that women who stayed in engineering were significantly more likely to perceive opportunities for training and development. This is consistent with the results from Singh et al. (2013), who found that training and development opportunities were related to job attitudes and turnover intentions through the mediation of self-efficacy and outcome expectations. The role of work-life benefits was more equivocal, with current engineers more likely to have made use of work-life benefits but less likely to have such benefits available (Singh et al., 2013). The role of supervisory support is also not clear. Buse et al. (2013) found that supervisors were not important to career decisions for either women who stayed or women who left. However, Fouad et al. (2011) found that women who stayed in engineering were significantly more likely to report having supportive supervisors. In a later study, Fouad et al. (2015) also found that managerial support for work-life balance predicted persistence.

Workplace barriers. In their study of women with STEM degrees who have worked in private sector science and technology companies, Hewlett et al. (2008) found that many women reported experiences suggestive of a hostile culture for women in private sector STEM fields, as shown in Figure 9.

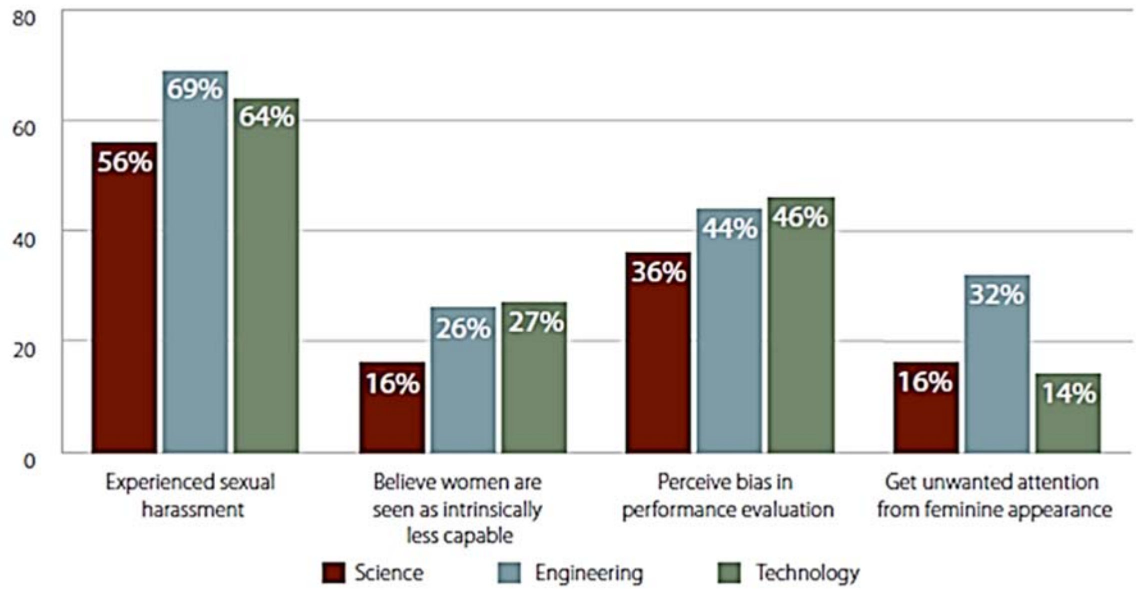

Figure 9. Percentage of women experiencing negative gender-related outcomes in private sector STEM occupations.

Fouad et al. (2011) also found that experiencing negative behaviors in the workplace reduced job satisfaction and increased intentions to leave the company as well as the field of engineering. Additionally, Frehill (2008) found that women were three times more likely than men to identify negative work climate issues as the reason for leaving engineering. However, some evidence exists that the climate might be improving, as the percentage of engineers who have observed or experienced unequal treatment due to gender declined significantly between 1993 and 2005 (Frehill, 2007).

Among women engineers who have worked in private sector STEM fields, 44% reported feeling isolated at work. Given the low representation of women in engineering in general, this result is not surprising. The impact of isolation on retention in this setting is unknown.

Other work related factors. The results of the Society of Women Engineers (SWE) Retention Study show that interest in another career is the most frequently cited reason for leaving engineering among both men and women, though more men cited this reason than women, as shown in Figure 10 (Frehill, 2008). This result is supported by Hunt (2012), who found that changes in career interests could not account for excess female exits from engineering.

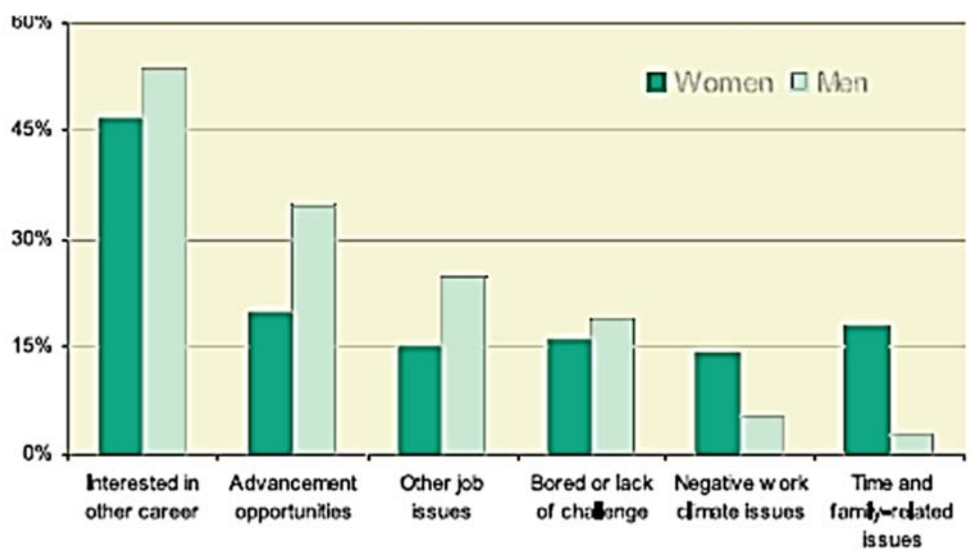

Figure 10. Self-reported reasons for leaving the field of engineering among 6,000 respondents to the Society of Women Engineers Retention Study. Adapted from "A Review of the Findings," by L. Frehill, 2008, The Society of Women Engineers National Survey about Engineering.

Lack of advancement opportunities is the second most cited reason among both men and women, though once again a higher proportion of men cite this reason (35%) than women (20%). This result is contradicted by Hunt (2012), who found that pay and promotion issues accounted for the majority of excess female exits from engineering. This apparent contradiction may be due to the inclusion of pay in Hunt's analysis, while

Frehill's included only promotion opportunities. Hewlett et al. (2008) found that 44% of women engineers in the private sector felt that they lacked a clear path for advancement; however, Hewlett's study did not compare women's experiences to men's. Taken together, these results suggest that pay and promotion opportunities are important reasons that women leave engineering, but that they are no more important for women than for men.

Family-related constraints. Frehill (2008) found that 17.8% of women who left engineering identified time and family-related issues as causal in their decision, compared to 2.7% of men. In a later study, Frehill (2012) found that among those who left engineering for a different field, women were 3.3 times as likely as men to identify family-related reasons as the primary factor in their decision. Among those who moved from engineering out of the labor force entirely, women were 6 times more likely than men to identify family issues as a factor (Frehill, 2012). Frehill's study used a single cross-sectional approach that accounted for age but not for cohort. For example, she found that the retention rate in engineering is 80% for women who earned bachelor's degrees between 2001-2004 but 50% for women who earned bachelor's degrees between 1976 and 1980. However, the effect of age cannot be separated from the effect of cohort. In order to account for cohort, the study would have to use a time-lag design and examine different cohorts when they were the same age.

Using SESTAT data concerning male and female engineers, Kahn and Ginther (2015) found that the "majority of the gender retention gap is due to women leaving the labor force entirely and that this exit is highly correlated with child bearing" (p. 1).

Morgan (2000) found that women engineers are less likely than men to work full time, and that half of these women identify family constraints as the reason they do not work full time.

While most researchers acknowledge the importance of family-related factors, some assert that the influence of family-related factors is overestimated, particularly in the popular literature. Regarding female exits from engineering as measured by SESTAT, Hunt (2012) states, “Family-related constraints are not a factor: while many more women than men cite family issues as the reason for leaving engineering, the gender gap is as large in non-science and engineering fields” (p. 3). Based on the results of the SWE Retention Study, Frehill (2008) determined that there was no difference between women who remained in engineering and those who left regarding number of children. However, Frehill did not distinguish between field exits to other professions versus field exits out of the workforce. This may have obscured the relationship between the presence of children and field exits out of the workforce. The varying ways in which researchers present data also highlights the controversial nature of the effect of family factors on retention and the differing perspectives from which researchers approach the subject.

Overall, these results suggest that while changes in career and professional interests and concerns about advancement are important for women’s decisions to leave engineering, these reasons are no more prominent for women than for men. Family concerns, however, are much more prominent for women than for men. Further, these results suggest that family factors are more influential in women’s decisions to leave the workforce entirely than in their decisions to leave engineering for other fields.

The Influence of Generation on Work

The Sociological Concept of Generations. A discussion of the construct of *generation* should begin with an explanation of terms. Generation has two different possible meanings in the context of sociology; first, as a kinship structure, and second, as a social structure. Generation as a kinship structure refers to biological and familial relationships, such as grandparent to parent to child. Generation as a social structure refers to membership in a birth cohort. According to Pilcher (1994), “A 'cohort' is defined as people within a delineated population who experience the same significant event within a given period of time” (p. 483). Although the words *cohort* and generation are often used interchangeably in other disciplines, cohort carries a more specific meaning and is better accepted in the sociology literature than the more nebulous popular terminology of generation. However, since cohorts can be defined by significant life events other than birth, for example marriage cohorts or graduation cohorts, the term *generational cohort* will be used for clarity and precision. A generational cohort refers to a group of individuals born within a delimited time period.

In his seminal work on the sociological concept of generation, Mannheim (1952) compares generational cohort to socioeconomic status, in that it serves to locate individuals within a larger social whole. Both class and generational cohort:

> endow the individuals sharing in them with a common location in the social and historical process, and thereby limit them to a specific range of potential experience, predisposing them for a certain characteristic mode of thought and experience, and a characteristic type of historically relevant action. (Mannheim, 1952, p. 168)

In a sense, generational cohort can function as a construct that encompasses all the social factors that affect a population in a defined period of time. The attitudes and behaviors of a cohort can be said to differ from its neighboring cohorts in response to these social forces. Ryder (1965) compares generational cohort to ethnic group in that "membership is determined at birth, and often has considerable capacity to explain variance, but need not imply that the category is an organized group" (p. 847).

However, Mannheim (1952) asserts that simply being born at the same time does not imply membership in a generational cohort. To speak of sharing a common location requires "participation in the same historical and social circumstances" (p. 176). For example, a Chinese peasant coming of age during the Cultural Revolution can hardly be said to belong to the same generation as an American born in the same year.

Further, despite experiencing common historical and social events, generations do not always coalesce. Transformation from a generational location into a generational *actuality* or identity occurs only when "a concrete bond is created between members of a generation by their being exposed to the social and intellectual symptoms of a process of dynamic destabilization" (Mannheim, 1952, p. 182). In other words, where there is no social change, there is no border between groups. In Mannheim's words, "Not every generation location—not even every age group—creates new collective impulses and formative principles original to itself and adequate to its particular situation" (p. 189).

The importance of social and historical events in the formation of generational cohorts as an actuality also means that generations cannot have arbitrary boundaries. Grouping individuals into five-year birth cohorts is a common approach in demography, but without communal experience of formative events, such a grouping is unlikely to be meaningful in terms of understanding social change (Parry & Urwin, 2011).

One of the mechanisms through which generational location coalesces into generation as an actuality is through the formation of collective memories, particularly during youth. Mannheim (1952) proposed that youth is a critical time in the formation of generation as an actuality because it is during this period that each generation makes fresh contact with the world. In their study, Schuman and Scott (1989) asked a random sample of Americans to recall significant historical events and changes that had occurred over the past fifty years. Respondents disproportionately identified events from their teens and early twenties. Further, events that occurred outside this time period were frequently interpreted through experiences that occurred within this time period. For example, individuals who experienced the Vietnam War during their teens and twenties were more likely to describe World War II as a “good war” than those who personally experienced World War II in their teens and twenties (Schuman & Scott, 1989, p. 374).

The concept of generational cohort as a meaningful social construct is not without its critics. In particular, the recent spate of popular books and articles describing broad generational stereotypes and advocating solutions to the problem of intergenerational conflict in the workplace has drawn criticism from the academic world. Costanza and Finkelstein (2015) argue that only minimal evidence exists for group differences between generations in the workplace, and that alternate explanations can account for any differences. The authors acknowledge that changes have occurred over time in job satisfaction, organizational commitment, turnover, social dominance, and narcissism, but state that these changes should not be ascribed to membership in a generational cohort.

Other explanatory factors, such as individual differences, time period effects, and changes in technology can account for these changes without resorting to the concept of generational cohort. Costanza and Finkelstein also assert that no theoretical basis exists for any group differences based on generational cohort. Finally, they caution that much research on generation is fraught with methodological weaknesses.

A detailed reading of Costanza and Finkelstein's work suggests that their real objection is that employers might fall prey to an ecological fallacy and ascribe attributes to individuals based on their group membership. The authors state that:

> Generalizations based on group membership are long-standing phenomena that usually end up being disproven and debunked, and if these generalizations continue to be used by managers and organizations, this can lead to legal problems as well as raise fairness issues and damage productivity. (Costanza & Finkelstein, 2015, p. 315)

While this is certainly a valid concern, in the words of Campbell, Campbell, Siedor, and Twenge (2015), "The goal of all research is to help explain phenomena. If we do not attempt to make meaningful distinctions between people and predict behavior, we may as well resign from research entirely" (p. 330). In other words, the potential for misunderstanding and misuse of differences between generational cohorts does not impact the existence of generational cohort as a meaningful sociological construct.

Responding to Costanza and Finkelstein's assertion of a lack of documented differences between generational cohorts, Lyons, Urick, Kuron, and Schweitzer (2015) cite numerous studies that have in fact shown differences in outcomes based on generational cohort. Lyons et al. (2015) specifically mention differences in "personality, work values, work-life balance, leadership styles and preferences, and career experiences" (p. 347) as well as perceptions of generational characteristics.

Regarding the other explanatory factors that might account for apparent differences between generations, Brink, Zondag, and Crenshaw (2015) contend that if generational cohort empirically "accounts for variance beyond individual differences, then it is a relevant construct" (p. 336). The existence of individual differences within a generational cohort does not obviate the possibility of group level differences based upon cohort membership.

Concerning Costanza and Finkelstein's statement that the construct of generational cohort is not based on theory, Lyons et al. (2015) cite theories developed by Mannheim (1952); Joshi, Dencker, and Franz (2011); and Parry and Urwin (2011). Lyons et al. (2015) contend that there is a "rich body of theory concerning generations as a social phenomenon" (p. 349).

Costanza and Finkelstein's discussion of methodological problems in much of the literature involving generational cohort, however, is echoed by Lyons et al. (2015), Brink et al. (2015), and Campbell et al. (2015), among others. All of these authors advise greater methodological rigor, including precision of terminology and use of research designs and data analysis methodologies that facilitate separation of the effects of age, period, and cohort.

The Age-Period-Cohort (APC) Dilemma. One of Costanza and Finkelstein's objections, that observed differences between generations can be accounted for by age or time period effects is often regarded as a major obstacle in cohort analysis. Three variables must be considered when studying change over time: age, period, and cohort (Glenn, 2005). Age effects involve differences between participants due to maturation over the life course. Period effects involve differences between participants due to events that all ages and cohorts experience simultaneously at the time of observation, such as war or economic depression. Cohort effects refer to differences between participants due to group membership in a generation. Since cohort membership + age = time period, each variable is linearly dependent on the other two, making it impossible to solve for all three variables simultaneously. Practically, this APC identification problem means that while an effect can be observed, it cannot irrefutably be ascribed to age or period or cohort.

While the APC identification problem has no "solution", its effects can be ameliorated by using appropriate research design and data analysis methods. Methodologically, four types of research designs are used when studying APC effects. Longitudinal designs, which measure outcomes for one cohort over the life course, are valuable when studying age effects, but since they only include one cohort, they are of limited value when studying cohort effects. Cross-sectional studies, which measure outcomes for all ages and multiple cohorts at a single point in time, are still relatively weak in terms of studying cohort effects, since the structure of the data makes it impossible to separate age effects from cohort effects (Joshi, Dencker, & Franz, 2011; Lyons & Kuron, 2013). Cross-temporal or time-lag studies measure outcomes for multiple cohorts when they are the same age by taking observations at different points in time, capturing cohort and period variance (Campbell et al., 2015). This design allows comparison of two or more generational cohorts when they were the same age. A more recent variant of the time-lag design is cross-temporal meta-analysis, in which meta-analysis is performed on published data gathered in past studies. The strongest design is a sequential longitudinal design, in which several cohorts are followed longitudinally, since this can capture age, period, and cohort effects (Lyons & Kuron, 2013).

Data analysis techniques can also ameliorate the APC identification problem. The earliest approach was to hold adjacent cells constant, but this assigned a value a priori to the very effect being investigated (Glenn, 2005). A more recent approach is to use cross-classified hierarchical linear models, also known as hierarchical age period cohort (HAPC) models. These models are used to "ascertain whether there are any clustering effects in survey responses by higher-level units – namely, the survey time period and birth cohort" (Yang & Land, 2006, p. 299). Like all hierarchical models, HAPC models require large sample sizes at each level of analysis. Therefore, HAPC models are useful when using birth cohorts based on narrow birth year boundaries, but less useful when studying broad generational cohorts.

Not all researchers in the field agree that the APC identification problem is really a problem at all. According to Campbell et al. (2015), each generation is formed in the socio-historical context created by an earlier generation. Therefore, the "problem" may not lie in separating the effects of period and cohort, but in the notion that period and cohort can meaningfully be separated at all. Age effects can be separated empirically by using a time-lag design, but "teasing apart period and cohort effects from each other, however, is more often than not impossible… and this teasing apart might not be necessary" (Campbell et al., 2015, p 327).

Operationalizing generations. One of the challenges common to all generational research is how to define the boundaries of each generational cohort. According to Campbell et al. (2015), “generations are fuzzy social constructs, just like race, gender, ethnicity, and life itself…As with any social construct, boundaries are debated” (p. 325). Some would argue that categorizing continuous data constitutes “data mutilation” (Vogt, Gardner, and Haeffele, 2012, p. 66). However, Vogt et al. (2012) continue, “Sometimes continuously measured data are naturally clustered; in that case, it can be appropriate to categorize them” (p. 66). Clearly, the literature supports the concept of generational cohort as an appropriate theoretical basis for aggregating data.

There is no clear consensus on the boundaries for generational cohorts. Popular literature is replete with different and apparently arbitrary boundaries. However, a review of the academic literature supports a three-generation model with the Baby Boom cohort including those born from 1945-1964, the Generation X cohort born from 1965-1980, and the Millennial cohort born from 1981-1997 (Twenge, Campbell, Hoffman, & Lance, 2010).

Generational Differences in the General Workforce

One of the few generational stereotypes actually supported by the literature is the increasing importance of life outside work across generational cohorts. In their time-lag study of high school seniors from the Baby Boom, Generation X, and Millennial cohorts, Twenge et al. (2010) found a linear increase in the importance of leisure time. Each successive generation valued leisure time significantly more than the preceding generation. This suggests that younger cohorts increasingly value their time outside work even before family formation. The difference between the Baby Boom and Millennial cohorts represented a moderate effect size. Wray-Lake, Syvertsen, Briddell, Osgood, and Flanagan (2011) also found a steady decrease in the centrality of work in young peoples' lives. These authors suggest that young people today have "lower expectations that employment will be a source of meaning and purpose in their adult lives" (p. 1133).

Closely related to the importance of activities outside of work is the desire to balance work and family. Recent cross-sectional research shows that compared to any other category, more members of the Millennial cohort consider work-life balance as very or extremely important in their consideration of career success (Harrington, Van Deusen, Fraone, & Morelock, 2015). However, the cross-sectional research design does not allow comparison with other generations.

The importance that young people place on job security has also declined over the past thirty years (Wray-Lake et al., 2011). While generational stereotypes would suggest this is due to disloyalty among Millennials, the authors view it either as an adaptation to market realities or resigned acceptance of their likely fate.

Evidence for generational changes in work-related attitudes such as organizational commitment and job satisfaction has been more equivocal. Using cross-temporal meta-analysis, Costanza, Badger, Fraser, Severt, and Gade (2012) found a very slight downward trend over time in both organizational commitment and job satisfaction.

The Interaction of Gender and Generation at Work

Using a time-lag design, Galinsky, Aumann, and Bond (2008) found that among workers under 29, the "desire to advance to jobs with greater responsibility" declined between 1992 and 2008. The decline in women's aspirations was less dramatic than the decline in men's, with the result that by 2008, the difference between women's and men's aspirations was no longer significant. Over the same period, the desire to move into a job of greater responsibility increased among young women with children and decreased among young women without children, so that by 2008, the difference between young women with and without children regarding career aspirations was no longer significant.

In time-lag data between 1977 and 2008, Galinsky et al. (2008) also found that among those under the age of 29, agreement with traditional gender roles (as defined by agreeing strongly or somewhat strongly with the statement, "It is better for all involved if the man earns the money and the woman takes care of the home and children") was significantly lower in the Millennial cohort than in the Baby Boom cohort. Interestingly, an even steeper decline was found in the older age groups, as shown in Figure 11. Pedulla and Thebaud (2015) also found that when free to choose, Millennial men and women preferred egalitarian relationship structures over traditional gender roles within the family. However, Pedulla and Thebaud's study did not include a time-lag component to compare generational cohorts.

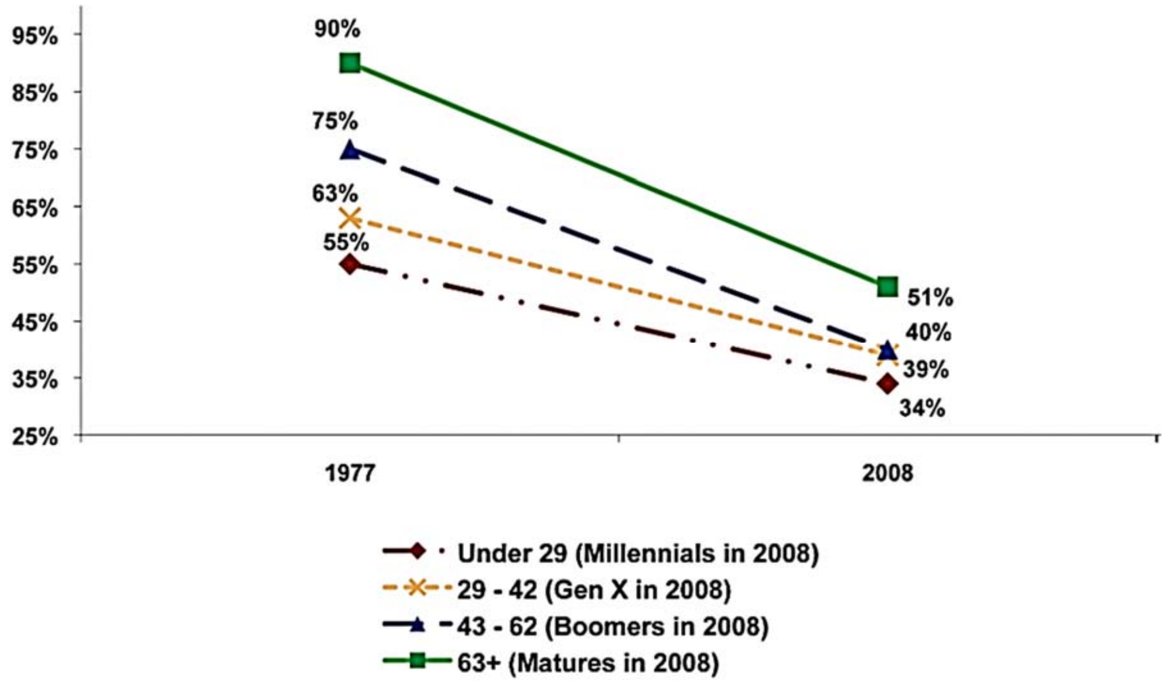

Figure 11. Employees of different generations who agree (strongly or somewhat) with traditional gender roles (1977–2008).

Galinsky's study also showed that the percentage of employed women who said their husbands take or share responsibility for child care increased from 21% in 1992 to 30% in 2008. Over the same period, the percentage of women who reported that their husbands share in cooking also increased, though not as steeply as the percentage of men who report that they shared in cooking. Finally, Galinsky found that the amount of time fathers under the age of 29 spent with their children on workdays increased from 2.4 hours for fathers in the Baby Boom cohort to 4.1 hours for fathers in the Millennial cohort.

Taken together, this research suggests that gender-specific changes have occurred over time in work-life issues. These changes appear to be influencing how different generations arrange their working lives.

Gap in the Literature

Morgan (2000) states that understanding "how family and children (the gender division of labor in the private sphere) affect women's career decisions are a key part of the puzzle" (p. 320) of the broader issue of women's progress in the professions. Morgan continues, "Other areas suggested for further study include variations in participation patterns across cohorts and professions" (p. 320). Lyons et al. (2015) state that "a better understanding of perceptions of intergenerational differences and their sources is an important element of diversity management and offers excellent potential for learning" (p. 354). Parry and Urwin (2011) assert that "important questions such as 'How has the impact of gender in the workplace changed through the decades?' would fall within a definition of generational studies that brings together the concerns of Mannheim, with a more modern-day focus on empirical validation" (p. 94). Finally, Lyons et al. (2015) call for greater use of time-lag designs in order to improve the methodological rigor of generational research.

The aim of this research is to fill this gap in the literature by using a time-lag design in order to address changes over time in the importance of family factors leading to field exits among women engineers. Further, this study will model field exits separately depending on whether the exit is to another field or out of the workforce entirely. This approach will separate two phenomena that are often treated together in the literature, despite evidence that they are different processes.

Summary

Gender interacts with generational cohort to influence workforce participation. Throughout history, the activities of and attitudes toward women in the labor force have changed. In pre-industrial times, before wage labor became the norm, women contributed to the subsistence of the household in equal measure with men. Particularly in colonial America, all able-bodied members of the community needed to work in order to assure the colonies' survival. With the rise of industrial capitalism, the locus of work shifted from the home to the factory, and, for the most part, women remained in the home, outside the wage labor structure. During the late 20th century, social and economic forces combined to propel ever larger numbers of women into the workforce. Wage labor for women, once thought of as a necessary evil for some, became the expectation for most.

The late 20th century also saw a dramatic increase in women's participation in engineering, with the representation of women increasing from 1% of the engineering workforce in the 1960s to 11% by the turn of the century. However, even into the 21st century, women leave engineering at a significantly higher rate than men. Most women leave engineering for the same reasons as men, specifically, changes in career interests and concerns about pay and promotion. The higher rate of female exits from engineering appears to be primarily related to family concerns.

The construct of generational cohort can be used to understand these social changes. The current workforce can be divided into the Baby Boom cohort, the Generation X cohort, and the Millennial cohort. Each of these generations has had formative experiences in their youth that affect the way they view and experience later events. While popular literature abounds in generational stereotypes that have little basis in fact, sound research suggests that there are gradual shifts in attitudes and behaviors that result in changes between generations along numerous dimensions, including work values and work-life balance. Compared to members of the Baby Boom and Generation X cohorts, members of the Millennial cohort place higher value on their time outside work, an effect that can be observed even before family formation. Members of the Millennial cohort derive much of their identity from their lives outside the workplace. In particular, Millennials with spouses and children report placing great emphasis on incorporating their family's needs into their career plans.

The reasons that today's young women cite for leaving engineering may reflect the importance that members of the Millennial generation ascribe to family issues and life outside the workplace. Understanding changes in the role of family factors on women's field exits from engineering will enable targeted intervention strategies.

CHAPTER III

METHODOLOGY

Research Approach and Design

The purpose of the research was to investigate how the relationship between family factors and field exits among women engineers changed over successive generational cohorts. An archival approach was used because the study involved change over time, and therefore required data to have been collected in the past (Vogt, Gardner, & Haeffele, 2012). A time-lag design was used in which data was collected at different points in time in order to observe participants when they were the same age. The time-lag design allowed examination of period and cohort effects without the confounding influence of age effects. Because age effects are generally larger than period or cohort effects, controlling for age effects is critical when exploring cohort and period effects. Therefore, time-lag designs, also known as cross-temporal designs, are considered one of the strongest approaches for studying period and cohort effects (Campbell et al., 2015).

Research Procedures

Data from the National Science Foundation's National Survey of College Graduates (NSCG) was used from four different periods. At least one generational cohort was represented in each period of observation. This design allowed comparisons between cohorts when they were the same age, thus controlling for age effects. The structure of the data is shown in Table 4.

Table 4

Structure of the Data, Showing Data Availability for each Cohort and Period

	Period			
Cohort	1982	1993	2003	2013
Baby Boom cohort	X	X	X	X
Generation X cohort		X	X	X
Millennial cohort				X

Sources of Data

The NSCG has been conducted by the United States Census Bureau on behalf of the National Science Foundation periodically since the 1970s (National Science Foundation, 2013). The NSCG has existed in its current form since 1993. Prior to 1993, the NSCG was known as the Survey of Natural and Social Scientists and Engineers (SSE). As one of the most complete, nationally representative data sets covering scientists and engineers, the NSCG is often used to study women in STEM fields (Frehill, 2012; Hunt, 2012; Kahn & Ginther, 2015; Miller & Wai, 2015). Relevant information collected in the NSCG is shown in Table 5.

Table 5

Relevant Information Collected and Variable Types for NSCG

Marital Status (Nominal: Married, Divorced, Separated, Widowed, Never married)	Sector of Employment (Nominal: For profit, non-profit, government, self-employed)
Family Status (Nominal: Children < 18, no children < 18)	Number of Children < 18 (Ordinal: 0, 1, 2, etc.)
Race/Ethnicity (Nominal: Caucasian, African-American, Asian, Native American, Hispanic, Other)	Sub-discipline (Nominal: Mechanical, Civil, Electrical, Environmental, Aeronautical, Other)
Salary (Continuous)	Country of Birth (Nominal: United States, Other)
Degree Level (Ordinal: Bachelor, Master, Ph.D.)	Age (Continuous)
Reasons for exiting engineering to another field (Nominal: pay/promotion, working conditions, job location, change in professional interests, family-related reasons, job not available)	Reasons for exiting engineering to out of labor force entirely (Nominal: on layoff, student, family responsibilities, disability, suitable job not available, did not need or want to work)

Population and Sample

The target population for the NSCG was individuals less than 76 years of age who had earned bachelor’s degrees, were living in the United States, and were not living in institutions. The 1982 SSE sample was drawn via stratified random sampling from respondents to the 1980 census who were trained as scientists or engineers. The 1993 NSCG sample was drawn randomly from respondents to the 1990 census long form who were college graduates. Similarly, the 2003 NSCG sample was drawn randomly from respondents to the 2000 census long form who were college graduates. The 2013 NSCG sample was drawn from the 2009 and 2011 American Community Surveys, plus a sample from the 2010 National Survey of Recent College Graduates.

The Census Bureau computed weights for each participant in the SSE and NSCG to compensate for over or under sampling. However, due to issues in the calculation of sample weights, the Census Bureau no longer recommends using the sampling weights for the 1982 SSE.

The target population for this study was all women who met the NSCG criteria and who held a Bachelor of Science or higher degree in engineering. The sample included all engineering sub-disciplines, rather than focusing exclusively on aerospace engineers, because the aerospace industry employs a variety of engineers. In fact, while aerospace engineers account for 6.0% of the aerospace manufacturing workforce, civil, electrical, environmental, industrial, materials, mechanical, and other sub-disciplines account for 11.2% of the aerospace manufacturing workforce (National Academy of Science, 2012). In 2013, the engineering specialties most in demand were actually systems and computer software engineering (Aerospace Industries Association, 2013).

Ideally, only engineers working in the aerospace industry would have been selected. However, the NSCG only recorded the type of employer for women currently in the workforce. Therefore, women who left aerospace or the workforce would have been excluded, seriously biasing the results.

Where all three generational cohorts were compared, the target population consisted of those women who were between the ages of 20 and 32, inclusive, at the time of observation. This age restriction was necessary because at the time of the most recent NSCG survey in 2013, the oldest member of the Millennial cohort was 32. The age restriction ensured that cohorts were compared when they were the same age. Where only Baby Boom and Generation X cohorts were compared, the target population consisted of those women between the ages of 33 and 48, inclusive, at the time of the observation. Once again, the age restriction was necessary since in 2013, the oldest member of the Generation X cohort was 48. The sample consisted of all female respondents to the NSCG who held a Bachelor of Science or higher degree in engineering who met the age restrictions. The random sampling techniques employed by the Census Bureau and the size of the dataset allowed generalization to the population of women engineers who were in the same age brackets.

Data Collection

Survey data from 1993 to the present were available from an online National Science Foundation (NSF) database. Data from 1982 were archived at the Interuniversity Consortium for Political and Social Research (ICPSR) at the University of Michigan. This data was available by application for a nominal fee. Data was imported into SPSS.

Descriptive Statistics

Descriptive statistics for each generational cohort at each age group were gathered for each of the variables. Sample size, frequency counts, and bar charts were determined for each categorical variable. Sample size, mean, median, and standard deviation were calculated for each continuous variable.

Research Questions and Hypothesis Testing

The overriding research question posed in this study was: Has the relationship between family factors and field exits among women engineers changed over successive generations? In order to answer this broad question, several more specific questions were posed. Where the literature was sufficient to guide an expectation of the answer, a hypothesis was included.

1. RQ1: Has retention of women in engineering changed over successive generations?

    Hypothesis 1: The retention of women in engineering has increased over successive generations.

2. RQ2: Have family formation decisions among women engineers changed over successive generations?

    Hypothesis 2a: The proportion of women engineers who are married has decreased significantly over successive generations.

    Hypothesis 2b: The proportion of women engineers who have children has decreased significantly over successive generations.

    Hypothesis 2c: The average number of children per woman engineer has decreased significantly over successive generations.

3. RQ3: Is having children associated with field exits?

    Hypothesis 3a: Having children significantly increases the probability of field exits out of the labor force.

    Hypothesis 3b: Having children does not have a significant effect on exits to other fields.

Hypothesis 3c: The probability of field exits out of the labor force increases quadratically with each additional child.

4. RQ4: Does generation influence the effect of having children on field exits?
5. RQ5: Among women who have left engineering for another field, have their reasons for leaving changed over successive generations?
6. RQ6: Among women who have left engineering to exit the workforce entirely, have their reasons for leaving changed over successive generations?
7. RQ7: Among women engineers with children, does generation affect the percentage of women who leave the workforce for family reasons?

Hypothesis testing was conducted with the alpha level set at $p < .05$ to establish significance. In addition, effect sizes were calculated for chi-square and *t*-tests according to the guidelines shown in Table 6 (Field, 2009; Sullivan & Feinn, 2012). Pseudo R^2 was used to assess effect size for multinomial logistic regression.

Table 6

Index and Associated Magnitudes Used in Determining Effect Sizes

Index	Effect Size
Pearson's r	Small 0.2
	Medium 0.5
	Large 0.8
Odds Ratio	Small 1.5
	Medium 2.0
	Large 3.0

Treatment of the Data

RQ1, including hypothesis 1 and RQ2, including hypotheses 2a and 2b were tested using chi-square tests (Agresti, 2013). Chi-square tests require independence of observations, with expected frequencies in each category of at least five (Field, 2009). Independence of observations was assured by the sampling design of the NSCG survey. Where the expected frequencies for each category were not at least five, Fisher's exact test was used.

Hypothesis 2c was tested using an independent *t*-test. The *t*-test requires independence of observations, normal distribution of error, and homogeneity of variance. Normal distribution of the error was assumed based on sample size (Field, 2009). Levene's test was used to assess homogeneity of variance.

RQ3, including hypotheses 3a, 3b, and 3c was addressed using multinomial logistic regression. The following variables that have been shown to influence retention were included as covariates: race/ethnicity, engineering subfield, and degree level (Hunt, 2012; Kahn & Ginther, 2015). The predictor and outcome variables and their levels are shown in Table 7. Age was controlled by restricting the analysis to ages 20-32. Hypothesis 3c was addressed only for the Generation X and Millennial cohorts, since the 1982 SSE identified only the presence or absence of children, not how many children were in the home.

Table 7

Multinomial Logistic Regression Model for Research Question 3

Predictor Variables		Outcome Variable
Degree Level (Ordinal: Bachelor, Master, Ph.D.)	Generational Cohort (Baby Boom, Generation X, Millennial)	Workforce status: (Nominal: In engineering, Out of engineering to another professional field, Out of engineering to exit workforce entirely)
Ethnicity (Nominal: Caucasian, African-American, Asian, Hispanic, Native American, Other)	Sub-discipline of engineering degree (Nominal: Mechanical, Civil, Electrical, Environmental, Aeronautical, Other)	
Children < 18 (Nominal: Yes/No)		

RQ4 was answered by including the interaction of generational cohort x presence of children in the model. Logistic regression requires independence of observations, linearity of the relationship between continuous predictors and the log transformation of the outcome variable, and limited multicollinearity of the predictor variables. Linearity of the logit transformation was evaluated, and collinearity diagnostics were analyzed.

RQ5, RQ6, and RQ7 were evaluated using chi-square tests (Agresti, 2013). Chi-square tests require independence of observations, with expected frequencies in each category of at least five (Field, 2009). Independence of observations was assured by the sampling design of the NSCG survey. When the expected frequencies for each category were not at least five, Fisher's exact test was used.

CHAPTER IV

RESULTS

The purpose of this research was to determine the relationship between generational cohort and the influence of family factors on retention among women engineers in the United States. The population of women engineers was used as a proxy for the population of women engineers in the aerospace industry because the sample size of women in aerospace engineering was insufficient, and because the aerospace industry employs a variety of engineering sub-disciplines in addition to aerospace engineering. A time-lag design was used, allowing comparisons between generational cohorts while holding age constant. Retention rates, family formation decisions, workforce participation decisions, reasons for leaving engineering, and reasons for leaving the workforce were examined.

Preparation of the Data

The sources of data were the 1982, 1993, 2003, and 2013 iterations of the NSCG. Microdata from the 1982 NSCG was archived at ICPSR as a text file under the heading *Survey of Natural and Social Scientists and Engineers (SSE), 1984 (ICPSR 8538).* The year was identified as 1984 because the file contained data from the initial 1982 survey as well as the follow up survey in 1984. The dataset did not have associated syntax to read the file into SPSS. Therefore, the text file was imported into SPSS as a fixed width dataset, with the column width manually adjusted for each question based on information available in the codebook. Microdata from the 1993, 2003, and 2013 NSCG were stored at NSF and downloaded from the NSF website and imported into SPSS.

For each of the four NSCG datasets (1982, 1993, 2003, and 2013), cases were first selected based on gender, reducing the datasets to women only. Next, cases were selected based on field of major, reducing the datasets to only those women who had earned bachelor's degrees or higher in engineering disciplines. Finally, cases were selected based on place of birth, reducing the datasets to only those women with engineering degrees who were born in the United States.

Preparation of the 1982 Dataset. Several variables and their categories required recoding to match the format of the later datasets. The 1982 variable for race did not include a category for Hispanic. Therefore, a new variable (RACENEW) was computed that coded as *Hispanic* anyone identified as *white* for race and *yes* for the variable *Hispanic origin*. The dataset also did not have a binary response variable for children living in the home. Therefore, a new variable (CHLVIN2) was computed with a response category of *yes* for any respondent who had children under five or children between the ages of 6 and 17.

The 1982 dataset included degree type for each of the four most recent degrees, but not for the highest degree. Therefore, a new variable (HDRecode) was computed that allowed calculation of the type of degree (Bachelor's, Master's, or Ph.D.) for the respondent's highest degree. A new variable (SUBDIS) was also computed from the four most recent degrees to show the engineering sub-discipline of the respondent's first degree in engineering.

Preparation of the 1993, 2003, and 2013 Datasets. The 1993, 2003, and 2013 datasets included sub-discipline for each of the highest, second highest, third highest, and fourth highest degrees, but not for the first degree. Therefore, a new variable (SUBDIS) was computed from the highest degrees to show the engineering sub-discipline of the respondent's first degree in engineering. For the 1993, 2003, and 2013 datasets, the total number of children in the home (CHTOTHOME) was calculated from the number of children in various age categories. The total number of children in the home was not calculated for the 1982 dataset because only the presence of children in the home was recorded, not the number.

New Variables Computed for All Four Datasets. For all four datasets, new variables had to be computed from existing variables in order to address the research questions. A new variable (EngEmpStat2) was computed that allowed determination of engineering labor force status. Respondents were identified as being employed full time in engineering if they were employed full time and they identified their occupation as engineering. Respondents were identified as being employed full time out of engineering if they were employed full time and they identified their occupation as anything other than engineering. Part time employment in or out of engineering was calculated in a similar fashion. The final two categories, unemployed and out of the workforce, were copied directly from the original employment variables.

For all four datasets, a new variable (GENERATION) was computed to determine membership in generational cohort. Birth years from 1945 to 1964 were coded as the Baby Boom cohort, 1965 to 1980 as the Generation X cohort, and 1981 to 1997 as the Millennial cohort.

Once all of the relevant variables had been inspected to ensure consistency of coding across the four periods, the four datasets were merged into one consolidated dataset. In order to address Hypothesis 3a, *Having children significantly increases the probability of field exits out of the labor force*, a new variable (EngEmpStat3a) was created which collapsed the engineering employment categories into *employed full time, employed part time, unemployed,* and *out of labor force*. In order to address Hypothesis 3b, *Having children does not have a significant effect on exits to other fields*, a new variable (EngEmpStat3b) was created which collapsed the categories into *employed in engineering, employed out of engineering, unemployed,* and *out of the labor force*.

Weighting. All NSCG data included weights for individual cases generated by the NSF to reflect the proportion of the population represented by the case. The weights were generated based upon the probability of selection, plus adjustments for under-coverage of certain characteristics. Use of the sample weights makes it possible to "derive survey estimates that reflect the NSCG target population" (National Science Foundation, 2013, para. 2d). The WTSURVEY variable was used to weight the cases, as is recommended when the NSCG is used in isolation from the other SESTAT surveys such as the Survey of Doctoral Recipients or the National Survey of Recent College Graduates.

Using raw weights in SPSS inflates the sample size and therefore artificially reduces the standard error (Hahs-Vaughn, 2005). Normalizing weights by dividing the raw weight by the mean weight for the survey year preserves both the weight and the sample size (Hahs-Vaughn, 2005). Normalized weights were used for all analyses requiring weights.

Whether weighted or unweighted data should be used depends upon the type of analysis being performed. Descriptive statistics should be generated using weighted data to ensure that the sample statistics accurately reflect population parameters (Wissoker, 1999). However, regression analysis should use unweighted data "if sampling probabilities vary only on the basis of explanatory variables," (Solon, Haider, and Wooldridge, 2013, p. 16) as is the case in this study. The stratified sampling used in the NSCG was based on factors that are accounted for in the regression equation. As recommended by Solon et al. (2013), both weighted and unweighted estimates were generated when possible and examined for consistency. There was no difference between parameter estimates or model fit between weighted and unweighted data.

The NSF determined that weights for the 1982 SSE were not reliable (Citro & Kalton, 1989). Therefore, descriptive statistics using weighted data excluded the 1982 dataset.

Descriptive Statistics

The final dataset contained 6,842 records. The unweighted sample sizes in each survey period for each generation are shown in Table 8. The sample size for the 2013 period was much larger because women scientists and engineers were oversampled relative to their proportions in the population in order to have sufficient sample size for women in various STEM disciplines.

Table 8

Unweighted Sample Size for Each Cohort During Each Period

	Period				
Cohort	1982	1993	2003	2013	Total
Baby Boom cohort	1284 (20-39)	1055 (29-48)	657 (39-58)	402 (49-68)	3398
Generation X cohort		192 (20-28)	728 (23-38)	872 (33-48)	1792
Millennial cohort				1652 (20-32)	1652
Total	1284	1247	1385	2926	6842

Note. Numbers in parentheses indicate the age range of respondents for each cohort during each period.

Weighted sample sizes, counts, and descriptive statistics for variables of interest are shown in Table 9. The 1982 iteration of the NSCG was not included because the weights were not reliable, as determined by the NSCG during a review of the SSE design and methodology (Citro & Kalton, 1989). Several research questions depended upon comparing generational cohorts when respondents were the same age. Therefore, descriptive statistics for respondents from age 20-32 and age 33-48 are presented.

Table 9

Counts and Descriptive Statistics for Respondents to the 1993, 2003, and 2013 NSCG

	Baby Boom		Generation X			Millennial	
	All	33-48	All	20-32	33-48	All	20-32
Sample Size	2539	1277	2199	469	1730	773	773
Age							
Mean	43.26	39.68	37.18	28.50	39.53	28.01	28.01
Median	42.00	40.00	37.00	28.00	39.00	28.00	28.00
SD	9.26	4.28	6.17	1.795	4.63	2.80	2.80
Marital Status							
Married	1809	933	1552	279	1273	331	331
Mar-like Rel.	59	27	72	16	55	64	64
Not Married	671	317	575	174	402	379	379
Children							
Yes	1393	843	1318	117	1201	143	143
No	1145	434	881	352	529	630	630
Highest Degree Type							
Bachelor's	1436	740	1279	334	945	523	523
Master's	949	457	769	120	650	208	208
Ph.D.	77	44	70	10	60	24	24
Other	77	36	81	5	75	18	18
Race							
African-Amer	152	93	172	43	129	42	42
Asian/Pac Isl	70	41	122	41	81	57	57
Caucasian	2205	1080	1709	349	1360	590	590
Hispanic	89	47	144	27	117	54	54
Other	23	15	52	9	43	31	31
Subdiscipline							
Chemical	365	177	332	65	266	70	70
Civil	319	164	330	89	241	124	124
Electrical	470	233	370	74	296	102	102
Mechanical	366	203	315	57	257	120	120
Other	1018	500	852	183	669	357	357

Research Questions and Hypothesis Testing

Assumptions. The assumptions inherent in the data analysis techniques were tested. For the chi-square tests used to test Hypotheses 1, 2a, 2b, and to address RQ5, RQ6, and RQ7, the assumption of independence was met by the sampling strategy used for the NSCG. The expected frequency in each cell was at least five.

For the independent *t*-test used to test Hypothesis 2c, the assumption of independence was met by the sampling strategy used for the NSCG. The sample size was large enough to ensure normal distribution of the sampling error (Field, 2009). Levene's test and Hartley's F_{max} were used to test for homogeneity of variance. Where Levene's test and Hartley's F_{max} were significant, the results were stated and values for *equal variances not assumed* were presented.

For the multinomial logistic regression used to address RQ3 and RQ4, multicollinearity was assessed using tolerance and VIF statistics. Tolerance and VIF values for all predictors were near 1.00, indicating that multicollinearity among predictors did not exist.

RQ1: Has retention of women in engineering changed over successive generations? First, the retention rate was calculated using the following formula to give an overall understanding of the relationship between generation and retention (Frehill, 2012):

$$1 - \frac{\#\ in\ jobs\ not\ related\ to\ engineering + \#\ not\ in\ labor\ force}{\#\ of\ respondents}$$

The retention rate was calculated separately for women ages 20-32 and women ages 33-48 to permit comparison between generations while holding age constant. The retention rate for 20-32 year olds in the Generation X cohort was 50.74%. The retention rate for 20-32 year olds in the Millennial cohort was 51.88%. The retention rate for 33-48 year olds in the Baby Boom cohort was 32.58%. The retention rate for 33-48 year olds in the Generation X cohort was 31.10%.

Hypothesis 1: The retention of women in engineering has increased over successive generations. Retention was measured by the count of women who were employed full time or part time in engineering compared to those who were not. The contingency table is shown in Table 10. There was no significant association between generation and retention among 20-32 year old respondents from the Generation X and Millennial cohorts, $\chi^2(1)=.149$, $p=.699$.

Table 10

Contingency Table for Generation by Employment in Engineering Among All Women Engineers, Ages 20-32

		In Engineering	Out of Engineering	Total
Generation X	Count	238	231	469
	Expected Count	241.3	227.7	469.0
	Std. Residual	-.2	.2	
Millennial	Count	401	372	773
	Expected Count	397.7	375.3	773.0
	Std. Residual	.2	-.2	
Total	Count	639	603	1242
	Expected Count	639.0	603.0	1242.0

The contingency table for 33-48 year olds is shown in Table 11. There was no significant association between generation and retention rate among 33 to 48 year old respondents from the Baby Boom and Generation X cohorts, $\chi^2(1)=.761$, $p=.383$. Hypothesis 1 was not supported.

Table 11

Contingency Table for Generation by Employment in Engineering Among All Women Engineers, Ages 33-48

		In Engineering	Out of Engineering	Total
Baby Boom	Count	417	860	1277
	Expected Count	406.0	871.0	1277.0
	Std. Residual	.5	-.4	
Generation X	Count	539	1191	1730
	Expected Count	550.0	1180.0	1730.0
	Std. Residual	-.5	.3	
Total	Count	956	2051	3007
	Expected Count	956.0	2051.0	3007.0

RQ2: Have family formation decisions among women engineers changed over successive generations? Family formation decisions were broken down into marriage, presence of children, and mean number of children.

Hypothesis 2a: The proportion of women engineers who are married has decreased significantly over successive generations. There was a significant association between generation and marital status among 20-32 year old respondents from the Generation X and Millennial cohorts, $\chi^2(2)=36.591$, $p=0.00$. The contingency table is shown in Table 12.

Table 12

Contingency Table for Generation by Marital Status Among All Women Engineers, Ages 20-32

		Married	Marriage-like Relationship	Not Married	Total
Generation X	Count	279	16	174	469
	Expected Count	230.2	30.2	208.7	469.0
	Std. Residual	3.2	-2.6	-2.4	
Millennial	Count	331	64	378	773
	Expected Count	379.8	49.8	343.3	773.0
	Std. Residual	-2.5	2.0	1.9	
Total	Count	610	80	553	1243
	Expected Count	610.0	80.0	553.0	1243.0

The odds of a Generation X respondent being married were 1.60, while the odds of a Millennial respondent being married were .88. The odds of young women engineers being married were 1.88 times higher if they were in the Generation X cohort than if they were in the Millennial cohort, which represents a small effect size (Sullivan & Feinn, 2012).

There was no significant association between generation and marital status among 33-48 year old respondents from the Baby Boom and Generation X, $\chi^2(2)=3.856$, $p=0.145$. The contingency table is shown in Table 13.

Table 13

Contingency Table for Generation by Marital Status Among All Women Engineers, Ages 33-48

		Married	Marriage-like Relationship	Not Married	Total
Baby Boom	Count	933	27	317	1277
	Expected Count	936.8	34.8	305.3	1277.0
	Std. Residual	-.1	-1.3	.7	
Generation X	Count	1273	55	402	1730
	Expected Count	1269.2	47.2	413.7	1730.0
	Std. Residual	.1	1.1	-.6	
Total	Count	2206	82	719	3007
	Expected Count	2206.0	82.0	719.0	3007.0

Hypothesis 2a was partially supported. The proportion of 20-32 year old women engineers who were married decreased significantly from the Generation X cohort to the Millennial cohort. However, the proportion of 33-48 year old women engineers who were married did not change significantly from the Baby Boom cohort to the Generation X cohort.

Hypothesis 2b: The proportion of women engineers who have children has decreased significantly over successive generations. There was a significant association between generation and presence of children among 20-32 year old respondents from the Generation X and Millennial cohorts, $\chi^2(1)=7.331$, $p=0.007$. The contingency table is shown in Table 14.

Table 14

Contingency Table for Generation by Presence of Children in the Home Among All Women Engineers, Ages 20-32

		Children	No Children	Total
Generation X	Count	117	352	469
	Expected Count	98.2	370.8	469.0
	Std. Residual	1.9	-1.0	
Millennial	Count	143	630	773
	Expected Count	161.8	611.2	773.0
	Std. Residual	-1.5	.8	
Total	Count	260	982	1242
	Expected Count	260.0	982.0	1242.0

The odds of a Generation X respondent having children were 0.33, while the odds of a Millennial respondent having children were 0.23. The odds of young women engineers having children were 1.43 times higher if they were in the Generation X cohort than if they were in the Millennial cohort, which represents a small effect size. Hypothesis 2b was supported.

Hypothesis 2c: The average number of children per woman engineer has decreased significantly over successive generations. An independent *t*-test was used to compare the mean number of children per woman engineer. Levene's test for homogeneity of variance was significant, $F(1, 1240)=38.9$, $p=0.00$, and Hartley's F_{max} was 1.82, so equal variances were not assumed. The Generation X cohort had a significantly higher mean number of children ($M=.3574$, $SE=.03366$) than the Millennial cohort ($M=.2332$, $SE=.01944$), $t(779)=3.20$, $p=.001$. This represents a small effect size, $r=.123$.

To further explore whether the lower mean number of children in the Millennial cohort was due to fewer children among those choosing to have children or simply fewer women choosing to have children at all, the analysis was repeated with only women who had children included. The same pattern held, with women engineers in the Generation X cohort having a significantly higher mean number of children (*M*=1.432, *SE*=.071) than women in the Millennial cohort (*M*=1.264, *SE*=.044), *t*(199)=2.11, *p*=.013. This represents a small effect size, *r*=.148. This finding was not due to differences in age, since the mean age of women engineers with children did not differ significantly between the Generation X cohort and the Millennial cohort.

RQ3: Is having children associated with field exits? Multinomial logistic regression was used with unweighted data to address RQ3. Factors that have been shown to influence retention were included in the regression equations.

Hypothesis 3a: Having children significantly increases the probability of field exits out of the labor force.

The logistic regression equation is shown below.

$$P(WorkforceStatus) = \frac{1}{1 + e^{-(b_0 + b_1 SubDis + b_2 Child + b_3 Gen + b_4 HD + b_5 Race + b_6 Child * Gen)}}$$

The predictor and outcome variables and their levels are shown in Table 15.

Table 15

Multinomial Logistic Regression Model for RQ3, Hypothesis 3a

Predictor Variables		Outcome Variable
Generation (Nominal: Baby Boom, Generation X, Millennial)	Highest Degree (Ordinal: Bachelor, Master, Ph.D., Other)	Workforce status (Nominal: Employed full time, Employed part time, Unemployed, Out of labor force)
Race (Nominal: Asian or Pacific Islander, African-American, Caucasian, Hispanic, Other)	Sub-discipline of engineering degree (Nominal: Chemical, Civil, Electrical, Mechanical, Other)	
Children < 18 (Nominal: Yes/No)	Generation*Children	

Significant results are shown in Table 16. The full table of results can be found in Appendix C. Having children significantly increased the probability of working part time, being unemployed, and being out of the labor force compared to working full time. The likelihood of working part time versus full time was 2.76 times higher among women engineers with children than without. The likelihood of being unemployed versus working full time was 2.31 times higher among women engineers with children than without. Finally, the likelihood of being out of the labor force versus working full time was 5.1 times higher for women engineers with children than without. Hypothesis 3a was supported.

Table 16

Multinomial Logistic Regression Predicting Workforce Status from Generation, Children, Highest Degree, Race, Sub-discipline, and the Interaction Between Generation and Children Among All Women Engineers

				95% Confidence Interval for Odds Ratio		
		B	Sig.	Lower Bound	Odds Ratio	Upper Bound
Part time vs Full time	Intercept	-3.037	.000			
	Generation					
	Baby Boom Cohort	-.601	.012	.343	.549	.877
	Generation X Cohort	-.227	.447	.445	.797	1.429
	Millennial Cohort	0^b	.	.	.	.
	Children in Home					
	Yes	1.016	.000	1.722	2.762	4.433
	No	0^b	.	.	.	.
	Interactions					
	Baby Boom*Yes Children	.952	.007	1.297	2.592	5.181
	Generation X*Yes Children	.438	.318	.656	1.549	3.661
	Millennial *Yes Children	0^b	.	.	.	.
Unemployed vs Full Time	Intercept	-4.536	.000			
	Generation					
	Baby Boom Cohort	.856	.002	1.353	2.353	4.091
	Generation X Cohort	.127	.761	.501	1.136	2.574
	Millennial Cohort	0^b	.	.	.	.
	Children in Home					
	Yes	.838	.045	1.019	2.312	5.249
	No	0^b	.	.	.	.
	Interactions					
	Baby Boom*Yes Children	-.134	.797	.315	.875	2.431
	Generation X*Yes Children	-.471	.558	.129	.625	3.015
	Millennial *Yes Children	0^b	.	.	.	.
Out of Labor Force vs Full Time	Intercept	-3.650	.000			
	Generation					
	Baby Boom Cohort	.020	.932	.649	1.020	1.601
	Generation X Cohort	-.438	.238	.312	.646	1.336
	Millennial Cohort	0^b	.	.	.	.
	Children in Home					
	Yes	1.632	.000	3.226	5.113	8.103
	No	0^b	.	.	.	.
	Interactions					
	Baby Boom*Yes Children	.661	.038	1.038	1.937	3.616
	Generation X*Yes Children	.893	.052	.992	2.443	6.018
	Millennial *Yes Children	0^b	.	.	.	.

Note. Full results can be found in Appendix C. Main effects were entered as forced terms; interactions were entered as stepwise terms. R^2=.090 (Cox & Snell), .133 (Naglekerke). Model χ^2 (48)=347.99, p=0.00.

Hypothesis 3b: Having children does not have a significant effect on exits to other fields.

The logistic regression equation is shown below.

$$P(EngWkfcStat) = \frac{1}{1 + e^{-(b_0 + b_1 SubDis + b_2 Child + b_3 Gen + b_4 HD + b_5 Race + b_6 Child*Gen)}}$$

The predictor and outcome variables and their levels are shown in Table 17.

Table 17

Multinomial Logistic Regression Model for RQ3, Hypothesis 3b

Predictor Variables		Outcome Variable
Generation (Nominal: Baby Boom, Generation X, Millennial)	Degree Level (Ordinal: Bachelor, Master, Ph.D., Other)	Engineering workforce status: (Nominal: Working in engineering, Working out of engineering, Unemployed, Out of labor force)
Race (Nominal: Asian or Pacific Islander, African-American, Caucasian, Hispanic, Other)	Sub-discipline of engineering degree (Nominal: Chemical, Civil, Electrical, Mechanical, Other)	
Children < 18 (Nominal: Yes/No)	Generation*Children	

Relevant significant results are shown in Table 18. The full table of results can be found in Appendix C. Among 20-32 year olds, having children did not significantly increase the probability of working out of engineering versus working in engineering or of being unemployed versus working in engineering. Hypothesis 3b was supported.

Table 18

Multinomial Logistic Regression Predicting Engineering Workforce Participation from Generation, Children, Highest Degree, Race, Sub-discipline, and the Interaction Between Generation and Children Among All Women Engineers

				95% Confidence Interval for Odds Ratio		
		B	Sig.	Lower Bound	Odds Ratio	Upper Bound
Out of Engineering but In Labor Force vs In Engineering Labor Force	Intercept	1.374	.000			
	Generation					
	Baby Boom Cohort	-.690	.000	.407	.502	.618
	Generation X Cohort	.161	.211	.913	1.175	1.513
	Millennial Cohort	0^b	.	.	.	.
	Children in Home					
	Yes	-.039	.811	.698	.962	1.324
	No	0^b	.	.	.	.
	Interactions					
	Baby Boom*Yes Children	.612	.008	1.17	1.845	2.909
	Generation X*Yes Children	.266	.334	.761	1.305	2.237
	Millennial *Yes Children	0^b	.	.	.	.
Unemployed vs In Engineering Labor Force	Intercept	-3.295	.010			
	Generation					
	Baby Boom Cohort	.687	.015	1.143	1.988	3.459
	Generation X Cohort	.189	.653	.530	1.208	2.752
	Millennial Cohort	0^b	.	.	.	.
	Children in Home					
	Yes	.727	.084	.907	2.068	4.717
	No	0^b	.	.	.	.
	Interactions					
	Baby Boom*Yes Children	-.032	.951	.346	.968	2.706
	Generation X*Yes Children	-.415	.608	.136	.661	3.217
	Millennial *Yes Children	0^b	.	.	.	.
Out of Labor Force vs In Engineering Labor Force	Intercept	-2.357	.007			
	Generation					
	Baby Boom Cohort	-.142	.538	.551	.867	1.365
	Generation X Cohort	-.375	.316	.330	.687	1.430
	Millennial Cohort	0^b	.	.	.	.
	Children in Home					
	Yes	1.531	.000	2.892	4.622	7.389
	No	0^b	.	.	.	.
	Interactions					
	Baby Boom*Yes Children	.754	.020	1.128	2.126	4.007
	Generation X*Yes Children	.948	.043	1.031	2.579	6.453
	Millennial *Yes Children	0^b	.	.	.	.

Note. Full results can be found in Appendix C. Main effects were entered as forced terms; interactions were entered as stepwise terms. R^2=.139 (Cox & Snell), .166 (Naglekerke). Model χ^2 (48)=551.654, *p*=0.00.

Hypothesis 3c: The probability of field exits out of the labor force increases quadratically with each additional child.

The contingency table for weighted counts for all respondents to the 1993, 2003, and 2013 NSCG for number of children by labor force status is shown in Table 19. Respondents with more than five children were not included because the observed cell counts were very low.

Table 19

Contingency Table for Number of Children by Labor Force Status Among Women Engineers from the 1993, 2003, and 2013 NSCG

Number of Children		In Labor Force	Out of Labor Force	Total	Odds of Being Out of Labor Force
0	Count	2442	215	2657	.0880
	Expected Count	2303.3	353.7	2657.0	
	Std. Residual	2.9	-7.4		
1	Count	826	130	956	.1574
	Expected Count	828.7	127.3	956.0	
	Std. Residual	-.1	.2		
2	Count	1073	232	1305	.2162
	Expected Count	1131.3	173.7	1305.0	
	Std. Residual	-1.7	4.4		
3	Count	345	117	462	.3391
	Expected Count	400.5	61.5	462.0	
	Std. Residual	-2.8	7.1		
4	Count	73	36	109	.4932
	Expected Count	94.5	14.5	109.0	
	Std. Residual	-2.2	5.6		
5	Count	14	3	17	.2143
	Expected Count	14.7	2.3	17.0	
	Std. Residual	-.2	.5		
Total	Count	4773	733	5506	.1536
	Expected Count	4773.0	733.0	5506.0	

The values for the odds of being out of the labor force were fitted to linear, quadratic, exponential, and growth models. The quadratic model had the best fit *F*(2, 2)=300.837, *p*=.003. The quadratic equation is shown below.

$$F(x) = .032x^2 + .017x + .094$$

Where *F*(x) is the probability of being out of the workforce based on the number of children in the home. The observed and predicted relationships are shown in Figure 12.

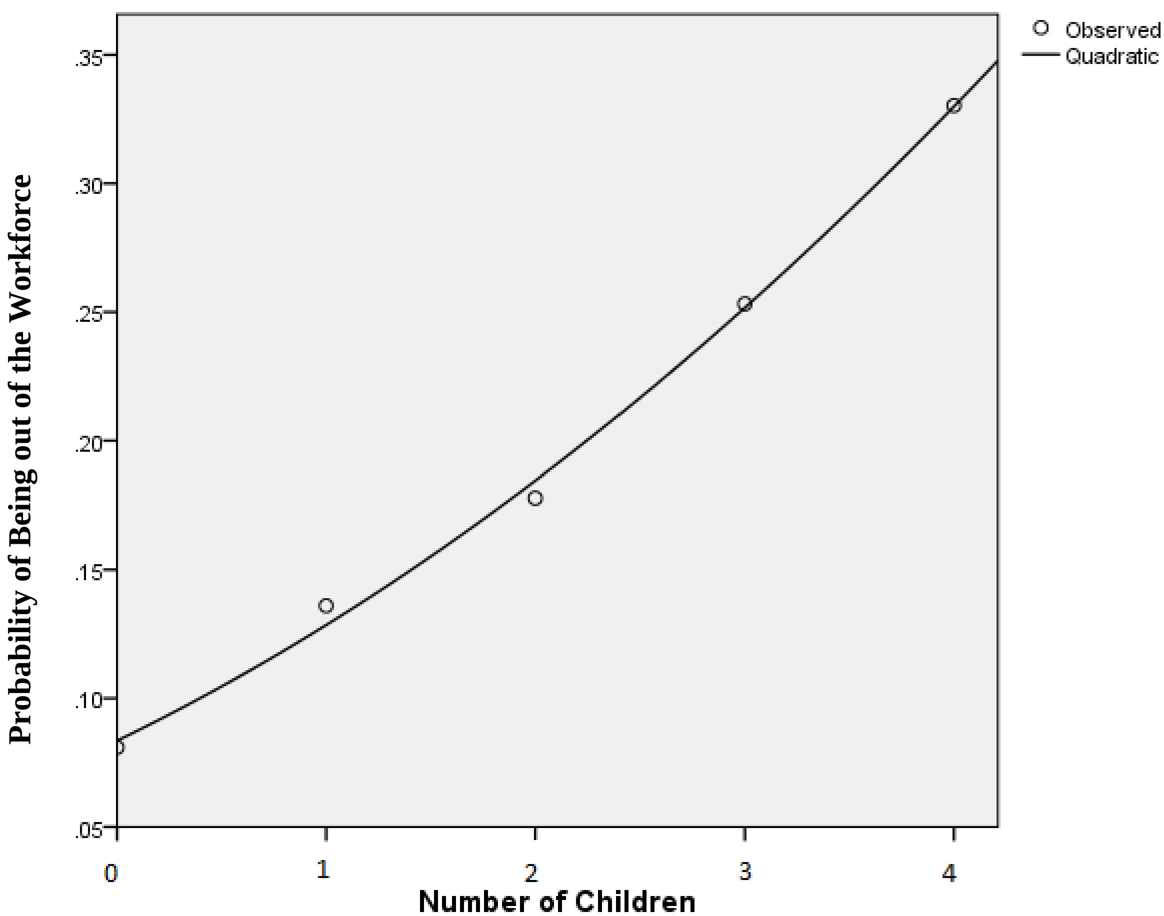

Figure 12. Quadratic model of relationship between number of children and probability of being out of the workforce.

This relationship breaks down when the number of children is five or higher. The probability of being out of the workforce with five children is .1331, which clearly does not fit the quadratic curve shown in Figure 12. Although the number of respondents with five children was low, it was not negligible. Further study is necessary to understand why the relationship between the probability of being out of the workforce and number of children only holds true for four children or less. Hypothesis 3c was partially supported.

RQ4: Does generation influence the effect of having children on field exits? Field exits out of the labor force were modeled separately from field exits out of engineering. The interaction of generation and children had a significant influence on field exits out of the labor force when comparing the Baby Boom cohort to the Millennial cohort, as shown in Table 16. Among 20-32 year old women engineers with children, women in the Baby Boom cohort were 1.9 times more likely than women in the Millennial cohort to be out of the labor force. However, the interaction of generation and children had no significant influence on field exits out of the labor force when comparing the Generation X cohort to the Millennial cohort.

The interaction of generation and children had a significant influence on field exits out of engineering to other fields when comparing the Baby Boom cohort to the Millennial cohort, as shown in Table 18. Among 20-32 year old women engineers with children, women in the Baby Boom cohort were 1.85 times more likely than women in the Millennial cohort to be out of engineering but in the labor force. However, the interaction of generation and children had no significant influence on field exits out of engineering to other fields when comparing the Generation X cohort to the Millennial cohort.

RQ5: Among women who have left engineering for another field, have their reasons for leaving changed over successive generations? Among women age 20-32, there were no significant differences between the Generation X and Millennial cohorts regarding *no job available,* or *other*. However, women in the Generation X cohort were significantly more likely than women in the Millennial cohort to cite *change in career or professional interests, family factors, and working conditions,* while women in the Millennial cohort were significantly more likely than women in the Generation X cohort to cite *job location* and *pay and promotion opportunities*. The results are shown in Table 20, with the contingency tables shown in Table 21. The odds ratio for the difference in working conditions represents a small effect size, while the other differences represent moderate effect sizes.

Table 20

Chi-square Test of Association Between Generation and Reasons for Leaving Field of Highest Degree for Job Not Closely Related to Engineering Among Women Who Have Left Engineering for Another Field, Age 20-32

				Odds ratios	
	χ^2	df	*p*	Gen X	Millennial
Change in career or professional interests	6.69	1	.010	2.97	
Family-related reasons	5.51	1	.019	3.12	
Job location	8.99	1	.003		3.13
Pay, promotion opportunities	12.52	1	.000		3.90
Working conditions	4.00	1	.045	2.14	

Table 21

Contingency Tables for Reasons for Leaving Field of Highest Degree for Job Not Closely Related to Engineering by Generation Among Women Who Have Left Engineering for Another Field, Ages 20-32

			Generation X	Millennial	Total
Change in career or professional interests	No	Count	29	66	95
		Expected Count	35	60	95
		Std. Residual	-1.0	.8	
	Yes	Count	17	13	30
		Expected Count	11	19	30
		Std. Residual	1.8	-1.4	
		Odds of yes answer	.586	.197	
Family-related reasons	No	Count	34	71	105
		Expected Count	38.6	66.4	105.0
		Std. Residual	-.7	.6	
	Yes	Count	12	8	20
		Expected Count	7.4	12.6	20.0
		Std. Residual	1.7	-1.3	
		Odds of yes answer	.353	.113	
Job location	No	Count	30	30	60
		Expected Count	21.9	38.1	60.0
		Std. Residual	1.7	-1.3	
	Yes	Count	16	50	66
		Expected Count	24.1	41.9	66.0
		Std. Residual	-1.6	1.3	
		Odds of yes answer	.533	1.67	
Pay, promotion opportunities	No	Count	26	20	46
		Expected Count	16.8	29.2	46.0
		Std. Residual	2.2	-1.7	
	Yes	Count	20	60	80
		Expected Count	29.2	50.8	80.0
		Std. Residual	-1.7	1.3	
		Odds of yes answer	.769	3.00	
Working conditions	No	Count	24	56	80
		Expected Count	29.2	50.8	80.0
		Std. Residual	-1.0	.7	
	Yes	Count	22	24	46
		Expected Count	16.8	29.2	46.0
		Std. Residual	1.3	-1.0	
		Odds of yes answer	.917	.429	

Among women age 33-48, there were no significant differences between the Baby Boom and Generation X cohorts regarding *change in career or professional interests, location, other,* or *pay and promotion opportunities.* However, women in the Baby Boom cohort were significantly more likely than women in the Generation X cohort to cite *family factors,* while women in the Generation X cohort were significantly more likely than women in the Baby Boom cohort to cite *no job available* and *working conditions,* as shown in Table 22. The contingency tables are shown in Table 23. All of these differences represent small effect sizes.

Table 22

Chi-square Test of Association Between Generation and Reasons for Leaving Field of Highest Degree for Job Not Closely Related to Engineering Among Women Who Have Left Engineering for Another Field, Age 33-48

				Odds ratio	
	χ^2	df	*p*	Baby Boom	Generation X
Family factors	13.09	1	.000	2.19	
No job available	6.42	1	.011		1.98
Working conditions	6.03	1	.014		1.70

Table 23

Contingency Tables for Reasons for Leaving Field of Highest Degree for Job Not Closely Related to Engineering by Generation Among Women Who Have Left Engineering for Another Field, Ages 33-48

			Baby Boom	Generation X	Total
Family-related reasons	No	Count	55	123	178
		Expected Count	72.0	106.0	178.0
		Std. Residual	-2.0	1.6	
	Yes	Count	93	95	188
		Expected Count	76.0	112.0	188.0
		Std. Residual	1.9	-1.6	
		Odds of yes answer	1.691	.772	
No job available	No	Count	126	160	286
		Expected Count	116.1	169.9	286.0
		Std. Residual	.9	-.8	
	Yes	Count	23	58	81
		Expected Count	32.9	48.1	81.0
		Std. Residual	-1.7	1.4	
		Odds of yes answer	.183	.363	
Working conditions	No	Count	71	76	147
		Expected Count	59.7	87.3	147.0
		Std. Residual	1.5	-1.2	
	Yes	Count	78	142	220
		Expected Count	89.3	130.7	220.0
		Std. Residual	-1.2	1.0	
		Odds of yes answer	1.10	1.86	

RQ6: Among women who have left engineering to exit the workforce entirely, have their reasons for leaving changed over successive generations? Among women age 20-32 who have left the workforce, there were no significant differences between Generation X and Millennial cohorts regarding *suitable job not available, other reasons,* or *student*. However, there was a significant difference between Generation X and Millennial cohorts regarding *family responsibilities*. Women in the

Generation X cohort were 8.90 times more likely than women in the Millennial cohort to identify *family responsibilities* as a reason for leaving the workforce.

There was also a significant difference between Generation X and Millennial cohorts regarding *did not need or want to work*. Women in the Millennial cohort were 7.97 times more likely than women in the Generation X cohort to identify *did not need or want to work* as a reason for leaving the workforce. The results are shown in Table 24. The contingency tables are shown in Table 25. Both odds ratios represent large effect sizes.

Table 24

Chi-square Test of Association Between Generation and Reasons for Leaving Workforce Among Women Engineers Who Have Left the Workforce, Age 20-32

				Odds ratio	
	χ^2	df	*p*	Generation X	Millennial
Family responsibilities	23.20	1	.000	8.90	
Did not need or want to work	20.78	1	.000		7.97

Table 25

Contingency Tables for Reasons for Leaving Workforce by Generation Among Women Engineers Who Have Left the Workforce, Age 20-32

			Generation X	Millennial	Total
Family responsibilities	No	Count	8	52	60
		Expected Count	19.4	40.6	60.0
		Std. Residual	-2.6	1.8	
	Yes	Count	26	19	45
		Expected Count	14.6	30.4	45.0
		Std. Residual	3.0	-2.1	
		Odds of yes answer	3.25	.365	
Did not need or want to work	No	Count	25	20	45
		Expected Count	14.3	30.7	45.0
		Std. Residual	2.8	-1.9	
	Yes	Count	8	51	59
		Expected Count	18.7	40.3	59.0
		Std. Residual	-2.5	1.7	
		Odds of yes answer	.320	2.55	

Among women age 33-48, there was no significant difference between Baby Boom and Generation X cohorts regarding *suitable job not available*. However, women in the Baby Boom cohort were significantly more likely than women in the Generation X cohort to cite *family factors,* while women in the Generation X cohort were significantly more likely than women in the Baby Boom cohort to cite *did not need or want to work* and *student.* The results are shown in Table 26. The contingency tables are shown in Table 27. All of the odds ratios represent small effect sizes.

Table 26

Chi-square Test of Association Between Generation and Reasons for Leaving Workforce Among Women Engineers Who Have Left the Workforce, Age 33-48

				Odds ratio	
	χ^2	df	*p*	Baby Boom	Generation X
Family responsibilities	8.61	1	.003	1.80	
Did not need or want to work	20.28	1	.000		2.44
Student	6.65	1	.010		2.75

Table 27

Contingency Tables for Reasons for Leaving Workforce by Generation Among Women Engineers Who Have Left the Workforce, Ages 33-48

			Baby Boom	Generation X	Total
Family responsibilities	No	Count	60	93	153
		Expected Count	74.5	78.5	153.0
		Std. Residual	-1.7	1.6	
	Yes	Count	148	126	274
		Expected Count	133.5	140.5	274.0
		Std. Residual	1.3	-1.2	
		Odds of yes answer	2.467	1.355	
Did not need or want to work	No	Count	133	93	226
		Expected Count	109.8	116.2	226.0
		Std. Residual	2.2	-2.2	
	Yes	Count	74	126	200
		Expected Count	97.2	102.8	200.0
		Std. Residual	-2.4	2.3	
		Odds of yes answer	.556	1.355	
Student	No	Count	199	194	393
		Expected Count	191.9	201.1	393.0
		Std. Residual	.5	-.5	
	Yes	Count	9	24	33
		Expected Count	16.1	16.9	33.0
		Std. Residual	-1.8	1.7	
		Odds of yes answer	.045	.124	

RQ7: Among women engineers with children, does generation affect the percentage of women who leave the workforce for family reasons? Among 20-32 year old women with children in the Generation X and Millennial cohorts, there was a significant association between generation and identification of family responsibilities as a reason for leaving the workforce, $\chi^2(1)=4.725$, $p=0.030$. The contingency table is shown in Table 24. Women in the Generation X cohort were 2.1 times more likely to have left the workforce for family reasons than women in the Millennial cohort, which represents a small effect size.

Table 28

Contingency Table for Generation by Identification of Family Responsibilities as a Reason for Not Working Among Women Engineers with Children, Ages 20-32

		Family Responsibilities as Reason for Not Working		
		Yes	No	Total
Generation X	Count	25	91	116
	Expected Count	18.7	97.3	116.0
	Std. Residual	1.5	-.6	
Millennial	Count	16	123	139
	Expected Count	22.3	116.7	139.0
	Std. Residual	-1.3	.6	
Total	Count	41	214	255
	Expected Count	41.0	214.0	255.0

Among the subset of women with children who were out of the labor force, there was a significant difference between the Generation X cohort and the Millennial cohort in the percentage of women who identified family responsibilities as a reason for leaving the workforce, $\chi^2(1)=23.793$, $p=0.000$. Among non-working mothers, 93% of Generation

X women cited family reasons, while only 34% of Millennial women cited family reasons. The odds of a non-working mother in the Generation X cohort citing family responsibilities as a reason for leaving the workforce were 12.5, while the odds of a non-working mother in the Millennial cohort citing family responsibilities were .52. Therefore, non-working mothers in the Generation X cohort were 24.2 times more likely to identify family responsibilities as a reason for leaving the workforce than women in the Millennial cohort. The odds ratio among the subset of mothers who left the workforce is much higher than among all mothers because many Millennial women were out of the workforce for reasons other than family. The contingency table is shown in Table 29.

Table 29

Contingency Tables for Leaving the Workforce Due to Family Responsibilities by Generation Among Mothers Who Are Out of the Workforce, Ages 20-32

		Family Responsibilities as Reason for Not Working		
		Yes	No	Total
Generation X	Count	25	2	27
	Expected Count	15.0	12.0	27.0
	Std. Residual	2.6	-2.9	
Millennial	Count	16	31	47
	Expected Count	26.0	21.0	47.0
	Std. Residual	-2.0	2.2	
Total	Count	41	33	74
	Expected Count	41.0	33.0	74.0

Summary of Results

Retention of women in engineering has not changed significantly with generational cohort. Among women age 20-32, women in the Millennial cohort were less likely to be married and have children than women in the Generation X cohort. Among women age 20-32, mothers in the Millennial cohort had fewer children than mothers in the Generation X cohort. Using pooled data for all three generations, having children significantly increased the odds of being out of the labor force. The odds of being out of the labor force increased quadratically with each additional child, up to four children. Having children had no significant effect on the odds of leaving engineering for another discipline.

Mothers in the Baby Boom cohort were significantly more likely to leave the workforce than mothers in the Millennial cohort. Mothers in the Baby Boom cohort were also significantly more likely to be out of engineering but in the workforce than mothers in the Millennial cohort.

Among women age 20-32 who have left engineering for another field, women in the Generation X cohort were more likely than women in the Millennial cohort to cite *change in career or professional interests, family-related reasons,* and *working conditions* as reasons for leaving engineering for another discipline. Women in the Millennial cohort were more likely than women in the Generation X cohort to cite *job location* and *pay and promotion opportunities* as reasons for leaving engineering for another discipline.

Among women age 33-48 who have left engineering for another field, women in the Baby Boom cohort were more likely than women in the Generation X cohort to cite *family-related reasons* as reasons for leaving engineering for another discipline. Women in the Generation X cohort were more likely than women in the Baby Boom cohort to cite *no job available* and *working conditions*.

Among women age 20-32 who have left the workforce, women in the Generation X cohort were far more likely than women in the Millennial cohort to cite *family responsibilities* as a reason for leaving the workforce. Women in the Millennial cohort were far more likely than women in the Generation X cohort to cite *did not need or want to work* as a reason for leaving the workforce.

Among women age 33-48 who have left the workforce, women in the Baby Boom cohort were more likely than women in the Generation X cohort to cite *family responsibilities* as a reason for leaving the workforce. Women in Generation X cohort were more likely than women in the Baby Boom cohort to cite *did not need or want to work* and *student* as reasons for leaving the workforce.

Among women with children age 20-32, women in the Generation X cohort were more likely than women in the Millennial cohort to be out of the workforce for family reasons. Among mothers who were out of the workforce, mothers in the Generation X cohort were far more likely than mothers in the Millennial cohort to cite *family responsibilities* as a reason for being out of the workforce.

These results have implications for the aerospace industry. The effects, consequences, and meaning of these results for aviation and aerospace will be discussed in Chapter V.

Chapter V

DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

This research used data from the NSCG in a time-lag design to explore the effect of generational cohort on factors affecting retention among women engineers in the United States, with a focus on the aerospace industry. The sample was representative of all women trained as engineers who were born and living in the United States. All women engineers were studied as a proxy for women engineers working in aerospace.

The results of this study may extend the body of knowledge in several ways. First, the use of a nationally representative database combined with a time-lag design allowed valid conclusions to be made about generational change among all women engineers. Second, this study is original in applying the time-lag design to workforce issues in the aerospace industry. Finally, the results showed that there were statistically and practically significant differences between generations regarding family formation and workforce participation decisions that have implications for the aerospace industry.

Population and Sample: Advantages and Limitations

The use of women engineers as a proxy for women engineers in the aerospace industry was made necessary by the time-lag design of the study. The time-lag design in turn was critical to addressing generational change. One of the major weaknesses in research on generational change is the lack of methodological rigor (Brink et al., 2015; Campbell et al., 2015; Costanza & Finkelstein, 2015; Lyons et al., 2015). Cross sectional designs cannot separate the effects of age and cohort. Confounding the effects of age and cohort can lead to faulty conclusions about the effects of generational change, attributing to generational change effects that may be due to maturational changes during the life course. The time-lag design is one of the strongest research designs when studying generational change (Campbell et al., 2015). However, as with any archival design, the time-lag approach restricts the data to that which has already been collected. The NSCG, while the best available nationally representative survey of scientists and engineers in the United States, did not collect information that would make it possible to select only women engineers who worked in, or departed from, the aerospace industry. However, the data collected did make it possible to analyze women engineers who made up the larger pool from which the aerospace industry draws its workforce.

Instead of using all women engineers, another option would have been to draw only from the population of aerospace engineers. Operationalizing this would be straightforward, because the sample could have been restricted only to women who majored in aerospace engineering. However, this was rejected for two reasons. First, only about one-third of engineers employed in the aerospace and defense industry are aerospace engineers (National Academy of Engineering, 2012). Therefore, restricting the analysis to only aerospace engineers would fail to capture many of the engineers who work in the industry. Second, the sample size of women aeronautical engineers was inadequate for the types of statistical analyses performed, which depended on adequate sub-samples, for example women aeronautical engineers who had left the workforce.

Given the importance of the time-lag design, and the problems with restricting the analysis to only aeronautical engineers, the most favorable way to assess generational change among women engineers in the aerospace industry was to assume that there were no significant differences between women engineers in the aerospace industry and women engineers in other industries. The representation of women engineers in aerospace compared to the overall engineering workforce provided support for this assumption. Women represent 14.6% of the engineering workforce in aerospace (Hedden, 2015), compared to 15% of the overall engineering workforce (National Science Foundation, 2015).

While equal representation lends support to the assumption that no significant differences exist between women engineers in the overall engineering workforce and women in the aerospace industry workforce, it does not preclude other differences. This possibility must be kept in mind when considering the results of this study.

Discussion and Conclusions

The results of this study showed that generational cohort significantly affected family formation decisions of women engineers. Having children had a significant impact on retention in the labor force, but not retention in engineering compared to other fields. Each additional child had an increasing effect on field exits out of the labor force. Generational cohort had a small, non-linear, significant effect on the relationship between family formation and retention both in the workforce and in engineering.

Generational cohort also had a significant effect on the reasons women left engineering for other fields and the reasons women left the workforce entirely. The effect sizes ranged from small to large. Generational cohort had a significant, small effect on the proportion of women who left the workforce for family reasons. Among mothers who had left the workforce, there was a significant and large association between generation and identification of *family responsibilities* and *did not need or want to work* as reasons for leaving the workforce.

In this section, the results presented in Chapter IV are integrated to give a complete picture of generational changes among women engineers. The theoretical and practical implications for the aerospace industry will be examined, and recommendations for future study and action will be presented.

The effect of generation on retention. Retention of women engineers ages 20-32 did not change significantly from the Generation X cohort to the Millennial cohort. Retention of women engineers ages 33-48 did not change significantly from the Baby Boom cohort to the Generation X cohort. While consistent with other research findings (Kahn & Ginther, 2015), this result is surprising given the improvements in workplace climate that have taken place in the last twenty years. According to the National Survey About Engineering conducted by the Society of Women Engineers (Frehill, 2007), the proportion of women who reported believing that *female and male employees performing the same job are always treated equally* increased from 25% in 1993 to 39% in 2005. Similarly, the proportion of women who reported that they were *not personally aware of any instances where women have been overlooked with regard to career opportunities* increased from 42% in 1993 to 61% in 2005. The fact that improvements in workplace climate have not translated into increased retention suggests that retention problems may be due to other factors.

According to the 2015 Aviation Week Workforce Study, the overall voluntary attrition rate in aerospace and defense (A&D) is low, at 5.2% (Hedden, 2015). However, 67.3% of this attrition occurs in the first five years. Furthermore, 41% of those who voluntarily left their organizations within the first five years were women or under-represented groups. When interpreting these results, two factors should be kept in mind. First, young members of the Millennial cohort change jobs more often than their predecessors (Lyons, et al., 2012). Second, the individuals in the Aviation Week study left their jobs but not necessarily the A&D workforce. However, the disproportionate departure of women from A&D jobs in the early years of their careers is cause for concern.

The effect of generation on family formation decisions. Family formation decisions were broken down into marriage, presence of children, and mean number of children.

The effect of generation on marriage. Among women engineers ages 20-32, generation had a significant influence on the proportion of women engineers who were married, with 59% of Generation X women being married, compared to only 43% of Millennial women. Among women engineers ages 33-48, there was no significant influence of generation on the proportion of women engineers who were married, with 73% of Baby Boom women being married, compared to 74% of Generation X women.

The mean age at first marriage has been rising among women in the general population, increasing from 23 in 1990 to 27 in 2011 (Cohn, Passel, Wang, & Livingston, 2011). At the same time, the proportion of Americans who are married has been declining, particularly among young people. In 2011, only 20% of young people age 18-29 were married, compared to 59% in 1960 (Cohn et al., 2011).

At 43%, the proportion of young women engineers in the Millennial cohort who were married was much higher than the 20% of young people in the general populace in the Millennial cohort who were married. This is consistent with data that shows that the decline in marriage has been more significant among those without a college education than among those with a bachelor's degree (Cohn et al., 2011).

Whether the declining proportion of married young people is due to deferred marriage or choosing not to marry at all is not yet known. However, the results of this study suggest that among women engineers, deferred marriage is a more likely scenario. The linear increase in mean age at first marriage, combined with the absence of a difference between the proportions of married women in the 33-48 age bracket suggests that women engineers are delaying marriage rather than foregoing it altogether. Future research on the Millennial cohort when they reach the older age group could test this hypothesis.

Marriage has not been shown to have a consistent effect on women's exits out of the labor force or out of engineering (Kahn & Ginther, 2015). Therefore, the main relevance of marriage to the aerospace industry is as an indicator of other relevant factors.

Delayed marriage may be indicative of the extended period of young adulthood now known as *emerging adulthood* (Arnett, 2000). During this period, identity exploration is a chief concern, both in personal and career spheres. Questions such as *What kind of work am I good at?* or *What kind of work would I find satisfying for the long* *term?* are asked (Arnett, 2000, p. 474). The search for work identity may in turn involve switching jobs often, as young people seek a good fit. The finding that 67.3% of voluntary attrition in A&D occurs in the first five years on the job supports this theory (Hedden, 2015).

The aerospace industry can leverage this period of *emerging adulthood* to its advantage to retain both young men and women. Although Millennial workers change jobs more often than their predecessors, most would actually prefer to stay with one or two employers throughout their careers (Goux, 2012; Wray-Lake et al., 2010). Helping newly hired young women and men address the questions facing emerging adults may offer one path to improving retention.

The effect of generation on the choice to have children. Among women ages 20-32, 25.0% of Generation X women had children in the home, compared to 18.5% of Millennial women. This represented a small effect size. The smaller proportion of mothers among young Millennial women engineers did not, however, translate into a higher retention rate in engineering. This suggests that there are other reasons driving engineering workforce participation decisions among Millennial women beyond family factors.

In the population of college educated women, the mean age for first births has risen along with the age for first marriage, reaching 30 years old in 2010 (Cohn et al., 2011). The lower proportion of Millennial women engineers with children could be due to delayed childbearing, or to foregoing childbearing altogether. Future research will be able to isolate the cause as Millennial women get older.

Among women in the Millennial cohort who were working mothers, 51% agreed with the statement that *being a working parent makes it harder to advance in a job or career* (Pew Research Center, 2013). Working women in the Millennial cohort also often experienced career interruptions such as working reduced hours (34%) or taking time off work to care for a child (33%). Women who delay motherhood also delay these career interruptions. By the time Millennial women face these career interruptions, they may be more experienced and of more value to their employers. However, Hewlett et al. (2008) described the possibility of a *fight or flight* moment in which women reach a critical point for advancement in their careers at the same point they encounter the needs of young children.

When queried about the factors that contribute to job satisfaction, women in A&D cited *independence in my work* and *flex time* as two of the most important factors (Hedden, 2015). Independence and flex time are often associated with family concerns, and specifically motherhood, but as Hedden's research shows, these job attributes are important to all women.

Along with deferring or foregoing childbearing, successive generations may be opting for smaller families. Among women engineers ages 20-32, members of the Millennial cohort had significantly fewer children than members of the Generation X cohort. The same pattern held true among women with children, supporting the idea that the smaller mean number of children was not due only to fewer women opting to have children at all. While the difference between generations was statistically significant, the effect sizes were small, indicating that the difference was of limited practical importance.

Among mothers in the general population, the lifetime number of children has not changed significantly from 1990 to 2014 (Monte & Ellis, 2014). If this trend persists and it applies to women engineers as well, it suggests that the lower mean number of children among young Millennial women may be due to delayed childbirth, and Millennial women will eventually have the same size families as their Generation X predecessors. Future research will be needed to determine whether Millennial women engineers are having smaller families or just shifting childbearing to later years.

Field exits out of the labor force. Field exits out of the labor force were examined separately from field exits out of engineering to other occupations.

The effect of children on field exits out of the labor force. Among women engineers ages 20-32 in all cohorts, women with children in the home were five times more likely than women without children to be voluntarily out of the workforce. However, this should not obscure the fact that the majority of women with children worked full time. Among women with children, 59.5% worked full time, 12.7% worked part time, 25.8% were out of the workforce, and 2.1% were unemployed. Overall, women with children who were out of the labor force accounted for only 6.9% of women engineers. This suggests that while few women left the workforce, among those who did, children were an important factor in their decisions to leave the workforce.

Having an additional child increased the probability that a woman engineer would leave the labor force. The relationship was quadratic for the first four children, meaning that the probability of leaving the labor force increased with the square of the number of children. Practically, this means that each additional child had an ever greater impact on the likelihood of a woman leaving the labor force. Beyond the first four children, the relationship broke down. Among the 17 women in the sample who had five children, 14 were in the workforce full time, a strong departure from the trend of women with up to four children. Examining the workforce status of their husbands or partners would be worthwhile, as this group may represent women with stay at home husbands.

While most women engineers with children worked full time, the gender gap in retention in engineering is still largely due to women leaving the workforce entirely, which is strongly correlated with child-bearing (Kahn & Ginther, 2015). Therefore, an obvious place to begin in attempting to keep more women in the engineering workforce is to explore the factors that influence mothers to stay or go. Since women engineers with children appear to exit the workforce at the same rate as women in other professions with children (Glass et al., 2013), programs and incentives that have been successful in other professions may prove beneficial in retaining women engineers as well.

The aerospace industry may be able to lead the way in developing job structures and supports that would encourage women with children to stay in the workforce. Professional women with children often seek part-time employment (Hewlett, 2007), but Kahn and Ginther (2015) suggested that there may be fewer part-time engineering jobs available than women want. In addition, Hewlett (2007) found that 93% of women who leave the workforce eventually want to come back. Aerospace companies that provide part-time opportunities may fulfill unmet demand. In addition, part-time work can serve as an on-ramp back into the full time aerospace workforce.

The ability to move in and out of the workforce appears valuable to the Millennial cohort. In a study of 1,000 college-educated Millennials, the Bentley University Center for Women and Business found that 56% of mothers cited the opportunity to take time off to raise their children and then re-enter the workforce as an important part of their ideal career path (Goux, 2012). Interestingly, almost 20% of fathers also cited the ability to exit and re-enter the workforce to care for children as part of their ideal career path (Goux, 2012). The implication for aerospace employers is that flexible, non-traditional career paths have value for both men and women in the Millennial generation.

The interaction of generation and children regarding field exits out of the labor force. Mothers in the Generation X and Millennial cohorts were less likely than mothers in the Baby Boom cohort to leave the labor force. The moderate effect size was more than could be accounted for by the small decrease in mean number of children, even considering the quadratic effect of each additional child on field exits. Research in the general population of American adults has shown that the workforce participation rate of mothers with children under the age of eighteen has risen dramatically, increasing from 47% in 1975 to 71% in 2007.

This result suggests that combining work and motherhood became easier, more desirable, or more necessary for recent generational cohorts of women engineers. Consequently, aerospace employers should expect to see more mothers with young children in the workforce. Given that later generations of fathers are taking an increasing role in child rearing (Galinsky et al., 2008), the industry may be able to improve retention of men and women by examining the needs of parents and providing an array of options that do not contain assumptions about the career choices of new parents.

The effect of generation on reasons for field exits out of the labor force among all women. Among women ages 20-32 who had left the labor force, the only significant generational changes in the reasons given for field exits out of the labor force concerned *family responsibilities* and *did not need or want to work.* Women in the Generation X cohort were almost nine times more likely to cite *family responsibilities* as a reason for leaving the workforce than women in the Millennial cohort. At the same time, women in the Millennial cohort were almost eight times more likely to cite *did not need or want to work*. This represented a large effect size.

Among women ages 33-48 who had left the workforce, the significant generational changes in the reasons given for field exits out of the labor force also concerned *family responsibilities* and *did not need or want to work,* and also *student,* meaning having left the workforce to return to school. Women in the Baby Boom cohort were twice as likely to identify *family factors* as a reason to be out of the workforce, and women in the Generation X cohort were roughly two and a half times more likely to identify *did not need or want to work* and *student*. Unlike the difference between young Generation X and Millennial women, the effect sizes were small.

The generational decline in *family responsibilities* and the increase in *did not need or want to work* occurred in both the younger and older groups. Given that family responsibilities are usually associated with parenthood, generational changes in the reasons for field exits among mothers were examined next.

The effect of generation on reasons for field exits out of the labor force among mothers. While the proportion of mothers who were out of the labor force did not differ significantly between the Generation X cohort and the Millennial cohort, the proportion of mothers who cited family responsibilities as a reason for leaving the labor force was much higher among Generation X mothers than among Millennial mothers, as can be seen in Figure 13. Mothers in the Generation X cohort were twice as likely to have left the workforce for family responsibilities than mothers in the Millennial cohort.

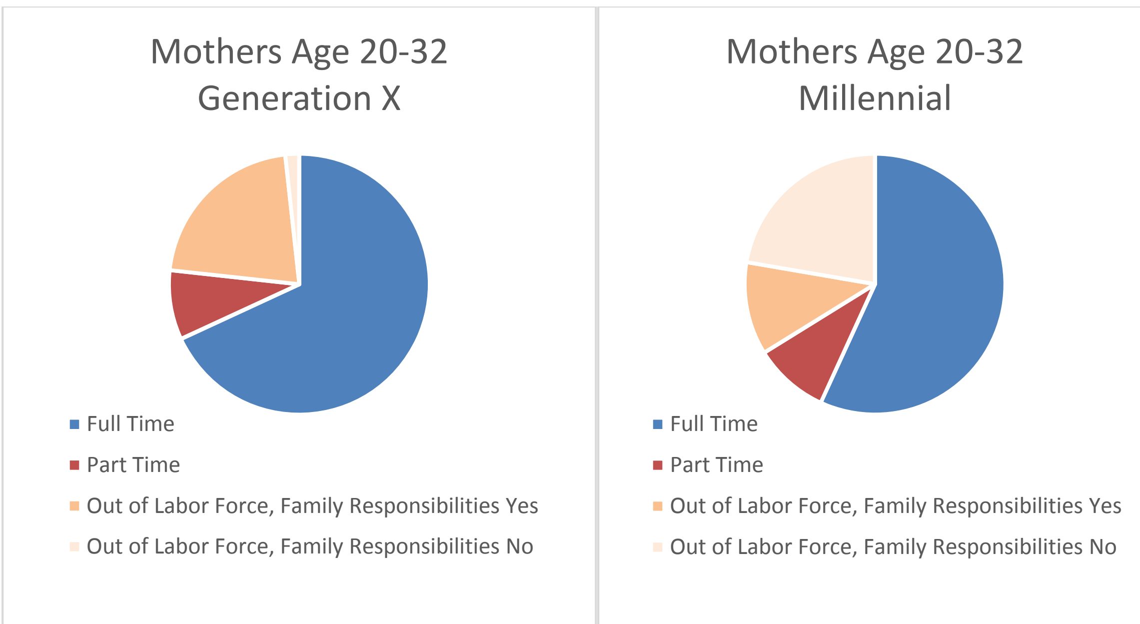

Figure 13. Comparison of Generation X and Millennial mothers regarding being out of the labor force due to family responsibilities.

Conversely, the proportion of mothers who cited *did not need or want to work* as a reason for leaving the labor force was significantly higher among Millennial mothers than among Generation X mothers, as shown in Figure 14.

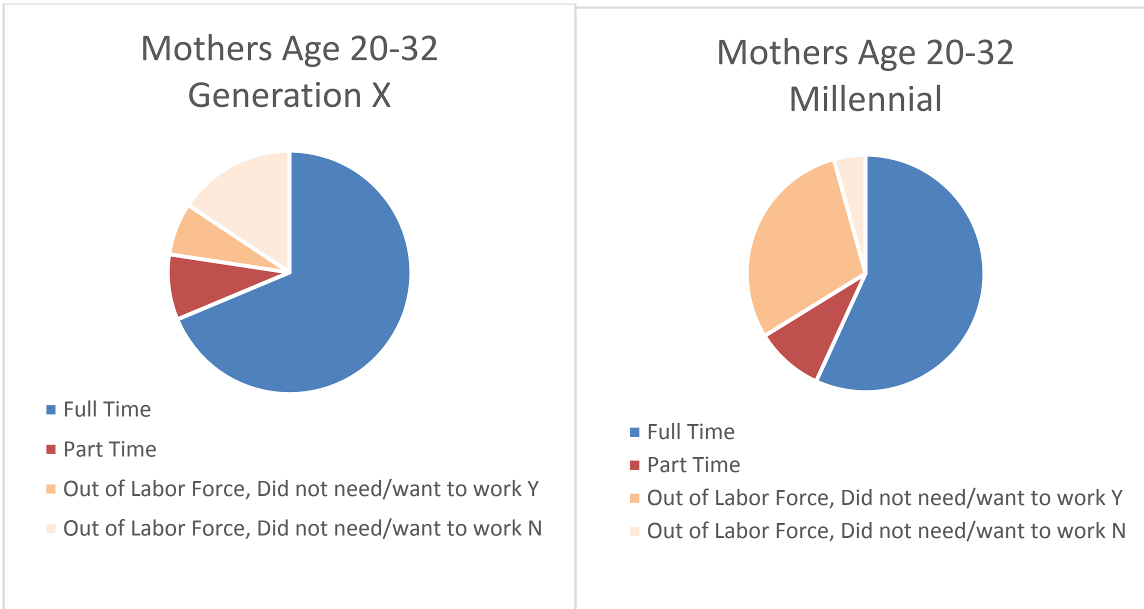

Figure 14. Comparison of Generation X and Millennial mothers regarding being out of the labor force due to not needing or wanting to work.

In the Generation X cohort, motherhood seemed to be associated with identifying *family responsibilities* as a reason for leaving the workforce. However, in the Millennial cohort, motherhood seemed to be associated with identifying *did not need or want to work* as a reason for leaving the workforce. Millennial mothers were three times more likely to cite *family responsibilities* as a reason for leaving the workforce than their peers without children. However, Millennial mothers were 24 times more likely to cite *did not need or want to work* as a reason for leaving the workforce than their peers without children. This suggests that the Millennial mother's conception of *did not need or want to work* was somehow associated with parenthood, to an even greater extent than *family responsibilities* was associated with parenthood.

The data did not contain a simple explanation for this result. The proportion of women with children who left the workforce was similar for the Generation X and

Millennial cohorts, yet the reasons mothers gave for leaving the workforce were strikingly different. One possibility is that mothers in the Generation X cohort viewed their departure from the workforce as a family responsibility, while mothers in the Millennial cohort viewed their departure as a choice. Similarly, Generation X women might have been reluctant to frame their departure from the workforce in terms of personal preference.

Another possible explanation is that members of the Millennial cohort felt less defined by their work than preceding generations and therefore more free to move in and out of the workforce without giving up their identity. Certainly, the centrality of work in the lives of young people has been declining with each successive generation (Twenge et al., 2010; Wray-Lake et al, 2011). Harrington et al. (2015) found that among young professionals age 22-35, life outside work was far more important to their self-definition than their careers, as shown in Figure 15. Harrington et al. (2105) found that this same pattern held regardless of parental status or gender. Unfortunately, the cross sectional nature of the study precluded comparisons with preceding generations.

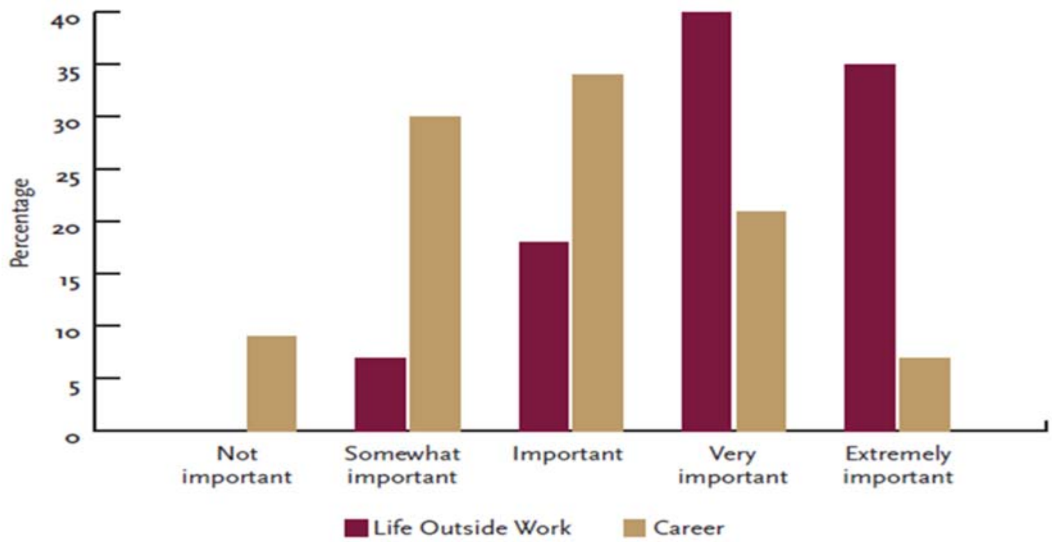

Figure 15. How important is your life outside of work to your identity, to how you define yourself? How important is your career to your identity, to how you define yourself? Adapted from "How Millennials Navigate Their Careers," by B. Harrington, F. Van Deusen, J. Fraone, and J. Morelock, 2015. Copyright 2008 by Boston College Center for Work and Family.

Millennial mothers also seem interested in redefining how to achieve success. In their study of 1,000 college-educated Millennial adults, the Center for Women and Business (Goux, 2012) found that 43% of mothers agreed with the statement *I hope to achieve the same level of success (as women who have leadership roles at my company) but I plan to follow a different path to get there.* Possibly their emphasis on being free to choose to enter or exit the workforce reflected their desire to depart from the career paths of their predecessors. However, all of these explanations are simply informed speculation. Further research is needed to determine both the causes and consequences of the shift in perspective between Generation X and Millennial mothers.

However, the aerospace industry need not wait until further research is conducted to make use of this information. Simply being aware of the difference may have benefits for the aerospace industry. First, the techniques and approaches that attach mothers to the workforce may differ between the Generation X and Millennial cohorts. For example, support for child care might be critical to a mother who frames her role in terms of responsibility for her family. Conversely, time to spend with her child might be more important to a mother who considers her role in terms of personal preference. Knowing that Millennial mothers view their roles and responsibilities differently than earlier generations can guide aerospace employers to ask their employees the right questions and provide them the right resources to keep them on the job.

Field exits to other occupations. Field exits out of engineering to other occupations were analyzed separately from field exits out of the labor force.

The effect of children on field exits to other occupations. The presence of children in the home did not have a significant influence on field exits out of engineering to other fields. This result suggested that women did not leave engineering for other fields due to family factors.

The interaction of generation and children regarding field exits to other occupations. Mothers in the Baby Boom cohort were more likely to leave engineering for another field than mothers in the other generations. This result was particularly interesting since overall, women in the Baby Boom cohort were significantly less likely than Millennial women to have left engineering for other occupations. This suggested that for young Baby Boom mothers, working in engineering was not compatible with motherhood. As suggested by Frehill (2007), the environment for women, and specifically for mothers, may be improving in engineering.

The effect of generation on reasons for field exits to other occupations. Among women ages 20-32, women in the Generation X cohort were more likely to identify *change in career or professional interests, family-related reasons,* and *working conditions* as reasons for leaving engineering for another occupation, while women in the Millennial cohort were more likely to identify *job location* or *pay and promotion opportunities*. Figure 16 shows the percentage of women who checked *yes* for each of the possible reasons.

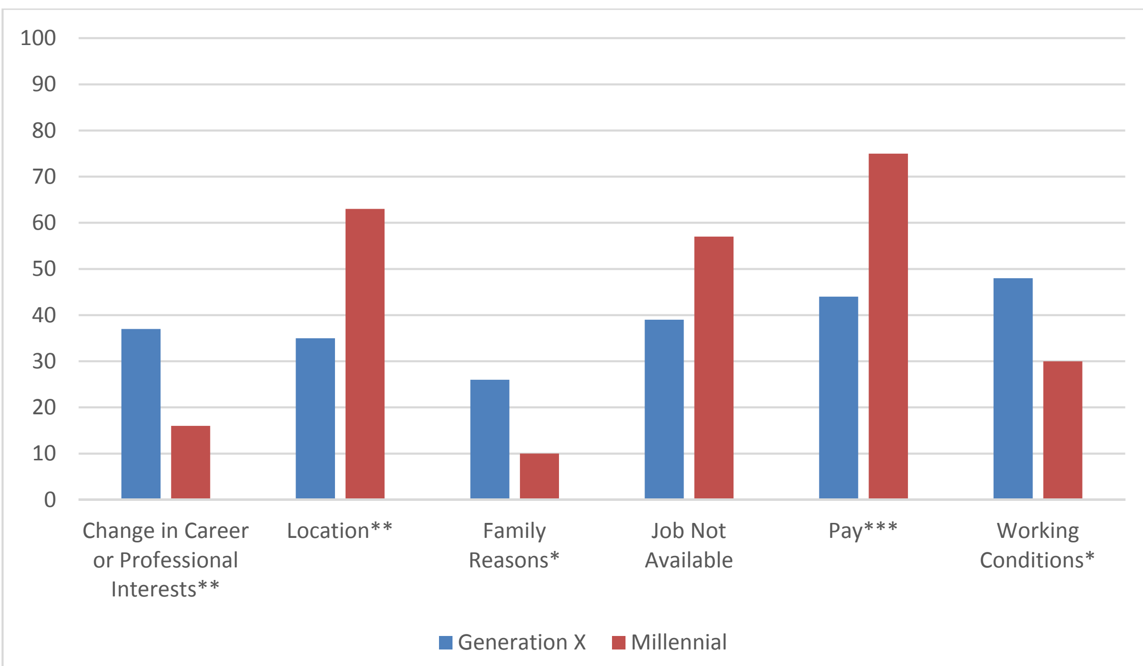

Figure 16. Differences between Generation X and Millennial women regarding reasons for leaving field of highest degree for an occupation outside engineering among 20-32 year old women engineers. More than one response allowed.
**p*<.05. ***p*<.01. ****p*<.001.

The decline in identification of *family-related reasons* was interesting, because in both the Generation X and Millennial cohorts the majority of women who cited *family-related reasons* for leaving engineering for other disciplines did not have children. This result highlighted the fact that family responsibilities extend beyond children and often include eldercare issues as well.

When respondents were allowed to check only the most important reason for leaving engineering for another occupation, there was no significant difference between women in the Generation X cohort and women in the Millennial cohort. In both cohorts, *change in career or professional interests* and *job not available* accounted for over 50% of the responses.

Among women ages 33-48, women in the Baby Boom cohort were more likely to cite *family-related reasons*, while women in the Generation X cohort were more likely to cite *job in highest degree field not available* and *working conditions.* Figure 17 shows the percentage of women who checked *yes* for each of the possible reasons.

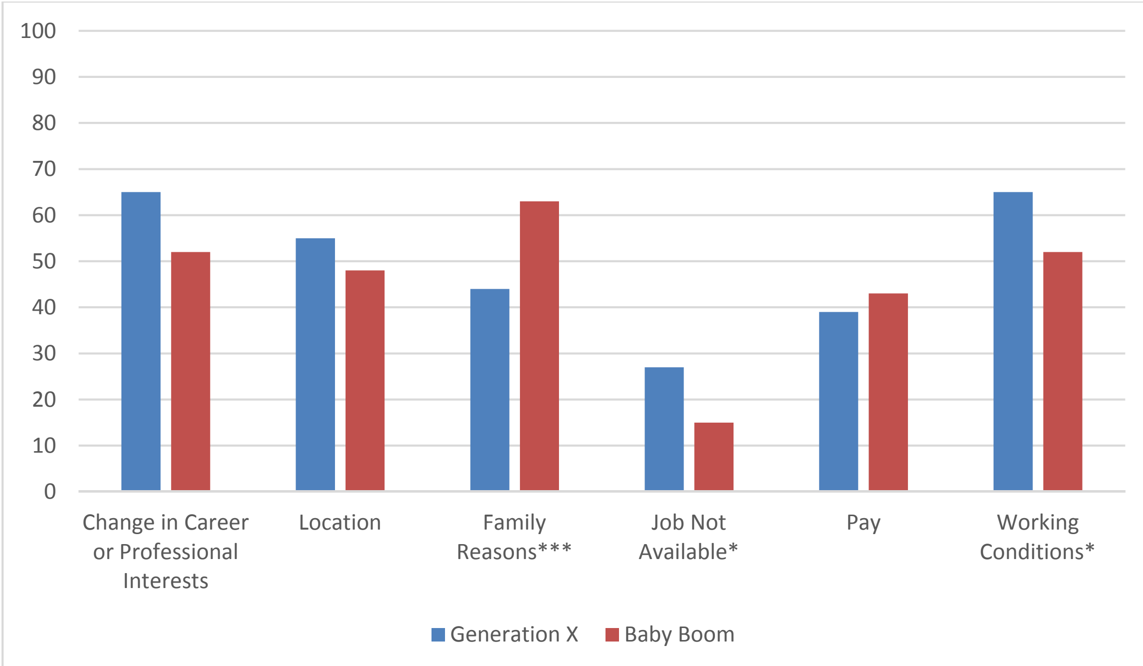

Figure 17. Differences between Generation X and Baby Boom women regarding reasons for leaving field of highest degree for an occupation outside engineering among 33-48 year old women engineers. More than one response allowed.
$^{*}p<.05$. $^{**}p<.01$. $^{***}p<.001$.

When respondents were allowed to check only the most important reason, women in the Baby Boom cohort were significantly more likely to cite *family-related reasons*, while women in the Generation X cohort were significantly more likely to cite *location*. In both cohorts, *change in career and professional interests* and *family-related reasons* were the most often cited reasons, accounting for over 50% of the responses.

Recommendations

The results of this study support that generational changes have occurred in family formation and workforce participation decisions among women engineers. Previous studies have compared women who were retained in engineering to women who were not (Fouad et al., 2012), female engineers to male engineers (Frehill, 2012; Kahn & Ginther, 2015), and women engineers to women in other professions (Glass et al., 2013). Each of these studies analyzed a particular aspect of the problem of retaining women in engineering. This study added the dimension of change over time, viewed through the construct of generational cohort. This study addressed the need for research on "generational differences and the potential impacts on the aerospace industry" (Department of Labor, 2008, p. 9) that was highlighted by the Interagency Aerospace Revitalization Task Force. In addition, the results of this study addressed the recommendations of the American Institute for Aeronautics and Astronautics to "create mechanisms to tap the largely underrepresented workforce pool of women" (American Institute for Aeronautics and Astronautics, 2009, p. 10).

Finally, understanding the choices of each generation of women engineers can equip aerospace employers with the means to retain experienced engineers. Reducing attrition among women engineers can save the aerospace industry money. Replacing workers lost to voluntary attrition costs employers between 90-200% of the employee's annual salary (Allen, 2008; O'Connell & Kung, 2007). The average turnover rate across all industries is 15% (Society for Human Resource Management, 2014), while the turnover rate among engineers in the A&D industry is 22%, with a disproportionate amount of that attrition occurring among women or under-represented groups (Hedden, 2015).

Recommendations for Industry

The aerospace industry should recognize where Millennial women are different from their predecessors and where they are the same. Overall, Millennial women engineers are leaving engineering at the same rate as earlier generations. Millennial women engineers are marrying and having children later than their predecessors, but when they do have children, the majority of them are staying in the workforce. Millennial and Generation X mothers are equally likely to leave the workforce, but they frame their decisions very differently. Millennial mothers are much more likely to think of leaving the workforce as a personal choice rather than a matter of family responsibility.

When Millennial women engineers leave engineering for other occupations, they are more likely than their predecessors to cite job location and pay and promotion opportunities, but their main reason for leaving engineering is the lack of available jobs. Millennial mothers are less likely to leave engineering for other occupations than their Baby Boom predecessors.

Aerospace companies can leverage this knowledge to their advantage. In the competition for talent, the ability to anticipate and meet employees' needs can be an important factor. As the 2015 Aviation Week Workforce Study noted, "A&D needs to do a better job of appealing to the hearts and minds of young professionals and the next generation if it intends to compete with other high technology sectors for top talent" (Hedden, 2015, p. 4).

Specifically, retaining Millennial women means understanding the determinants of their attachment to the workplace. Millennial women do not derive their identity from their work to the same extent as earlier generations. Further, Millennials do not regard work as the central feature of their lives. In this, Millennials may be moving away from the industrial capitalist notion of work as the driving force in shaping and defining their lives. Millennial women engineers show a willingness to leave the workforce due to their own preferences, though these preferences are strongly associated with having children. Helping Millennial mothers achieve both their career goals and their family goals may increase their attachment to their workplace. While this may have been equally true for Baby Boom and Generation X mothers, the difference is that Millennial women appear to feel free to make the choice to stay in or leave the workforce. This may give employers the opportunity to affect women's workforce participation decisions more than among women in the Generation X cohort, who viewed exiting the workforce as their responsibility.

Recommendations for Future Research

One of the more intriguing areas for future research is in comparing generational change among women to generational change among men. While time-lag studies of gender differences are rare, the studies that have been performed suggest that young men and women are converging on numerous measures, including ambition, labor force participation, responsibility for child care, responsibility for housekeeping, and work-life conflict (Galinsky, 2011), field exits from engineering out of the labor force entirely (Kahn & Ginther, 2015), and persistence in STEM Ph.D. attainment (Miller & Wai, 2015). In some cases, the gender gaps are closing because the behaviors and attitudes of men are drawing closer to the behaviors and attitudes of women, for example in family-related issues such as responsibility for child care and housekeeping and in work-life conflict. If this holds true in the aerospace setting, it would suggest that approaches designed to recruit and retain women would actually be successful in recruiting and retaining Millennial men as well. A time-lag design using NSCG data could help address generational changes among men in engineering compared to women in engineering.

The advantage of this study was in the validity and generalizability of its results. However, the study was limited to the data gathered by the NSCG. Future studies should focus on in-depth exploration of why these results were found. Specifically, future research should investigate why Millennial women engineers who left the workforce so frequently cited not needing or wanting to work, and why Millennial mothers who left the workforce framed their choices in terms of not needing or wanting to work rather than in terms of family responsibilities.

In conclusion, this study showed the existence of both statistically and practically significant differences between generations regarding family formation and workforce participation decisions. The aerospace industry can use this information to affect retention of women engineers. Future research should concentrate on extending this investigation to include men and on explaining the reasons behind the generational shifts.

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APPENDIX A

Permission to Conduct Research

Embry-Riddle Aeronautical University
Application for IRB Approval
Exempt Determination

Principle Investigator: Kristine M Kiernan **Other Investigators**: Dr. Tim Brady, Dr. Peggy Chabrian, Dr. Haydee Cuevas, Dr. Dave Esser **Role**: Student **Campus**: Daytona Beach
College: COAS

Project Title: Generation and family-driven field exits among women engineers
Submission Date: 3/1/2016 **Determination Date**: 3/11/2016

Review Board Use Only

Initial Reviewer: Teri Gabriel/M.B. McLatchey

Exempt: Yes

Approved: *Teri Gabriel* M.B. McLatchey
Pre-Reviewer Signature / Chair of the IRB Signature

Brief Description: Women are underrepresented in the engineering workforce in the United States, both because fewer women enter the engineering field, and because women leave the engineering workforce at a higher rate than men. The higher exit rate of women from engineering compared to men represents a loss of talent for employers and a loss of lifetime earning potential for women. Women cite family factors as influencing their decisions to leave the engineering workforce far more often than men. However, to date few studies have been done that examine changes in the role of family factors in field exits over time. The purpose of this study is to determine the nature and extent of the difference between generational cohorts regarding the effect of family factors on women's field exits from engineering.

This research falls under the **exempt** category as per 45 CFR 46.101(b) under:

☐(1) Research conducted in established or commonly accepted educational settings, involving normal educational practices, such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

☐(2) Research involving **only** the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures (of adults), interview procedures (of adults) or observation of public behavior. Participant information obtained will remain anonymous or confidential.

☐(3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) require(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

☒(4) Research involving the collection or study of **existing** data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available or if the information is recorded by the investigator in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects.

☐(5) Research and demonstration projects which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) Public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.

☐(6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the Food and Drug Administration or approved by the Environmental Protection Agency or the Food Safety and Inspection Service of the U.S. Department of Agriculture.

An exempt research project does not require ongoing review by the IRB, unless the project is amended in such a way that it no longer meets the exemption criteria.

Embry-Riddle Aeronautical University
Human Subject Protocol Application Form

Campus: World Wide **College:** Aeronautics - Worldwide

☐ Non-ERAU/Other Institution
Name & Address:

Applicant: Student **Degree Level:** Ph.D

Project Title: Generation and family-driven field exits among women engineers

Principal Investigator: Kristine M. Kiernan

(If undergraduate student, faculty advisor must be listed as the principal investigator.)

List all Other Investigators: Dr. Tim Brady, Dr. Peggy Chabrian, Dr. Haydee Cuevas, and Dr. Dave Esser

(If graduate student, list research advisor and all other investigators.)

Submission Date: 03/01/2016

Beginning Date: 03/15/2016 **Expected End Date:** 05/31/2016
(Approval is only good for one year.)

Type of Project: (Check ALL that apply.)

☐ Survey ☐ Interviews ☐ Classroom ☑ Use of Existing Data

☐ Comparison of instructional strategies ☐ Observation of public behavior

☐ Audio/Video recording ☐ Other Explain:

Type of Funding Support (if any):

☐ **Internal**

☐ Faculty Internal Award
☐ Student Internal Award
☐ IGNITE Funds
☐ CTLE Funds

☐ **External** If externally funded what agency?

☐ **Other** Explain:

☑ **Not Funded**

Please answer the following questions and provide a brief explanation of the answer for each.

1. **Background and Purpose: Briefly describe the background and purpose of the research including your hypothesis or primary objective and its rationale.**

Women are underrepresented in the engineering workforce in the United States, both because fewer women enter the engineering field, and because women leave the engineering workforce at a higher rate than men. The higher exit rate of women from engineering compared to men represents a loss of talent for employers and a loss of lifetime earning potential for women. Women cite family factors as influencing their decisions to leave the engineering workforce far more often than men. However, to date few studies have been done that examine changes in the role of family factors in field exits over time. The purpose of this study is to determine the nature and extent of the difference between generational cohorts regarding the effect of family factors on women's field exits from engineering.

Please describe briefly how this study will contribute to existing knowledge in the field

To date, research is lacking on how the influence of family factors on field exits among women engineers has changed over time. Cross-sectional studies have compared women engineers to women in other professional fields, or female engineers to male engineers, but few studies have compared women engineers today to women engineers from earlier generations. Understanding how the influence of family factors may have changed over time can help distinguish between continuing obstacles and those that are no longer relevant. Identifying persistent obstacles can help focus efforts to increase retention of women engineers, with the attendant benefits to industry and to women themselves.

2. **Design, Procedures, Materials and Methods: Describe the details of the procedure to be used and the type of data that will be collected.**

An archival approach will be used because the study involves change over time, and therefore requires data to have been collected in the past. A time lag design will be used, in which data is collected at different points in time in order to observe participants when they were the same age. Data from the National Science Foundation's (NSF) National Survey of College Graduates (NSCG) will be used from four different periods: 1984, 1993, 2003, and 2013. The NSCG is conducted by the United States Census Bureau on behalf of the NSF. The NSCG collects information from participants concerning education, work history, and demographic data.

3. **Measures and Observations: What measures or observations will be taken in the study? If any questionnaires, tests, or other instruments are used, provide a brief description <u>and</u> include a copy for review (computer programs may require demonstration at the request of the IRB).**

The NSCG is a written survey soliciting answers to multiple choice or short answer questions that pertain to educational background, employment status, work history, income, job satisfaction, and demographic information such as age, marital status, number of children, citizenship status, racial and ethnic background, gender, and disability status. A copy of the 2013 survey is attached with this package.

4. **Risks and Benefits: Describe any potential risks to the dignity, rights, health or welfare of the human subjects. Assess the potential benefits to be gained by the subjects as well as to society in general as a result of this project. Briefly assess the risk-benefit ratio.**

There is no risk to the participants. Participant anonymity is guaranteed by the Census Bureau. Consequently, no direct benefits of this project can accrue to the participants. However, their participation may contribute to an understanding of the changing impact of family factors on women's decisions to leave the engineering workforce, which in turn may help improve retention efforts.

5. **Informed Consent: Describe the procedures you will use to obtain informed consent of the subjects and the debrief/feedback that will be provided to participants. See Informed Consent Guidelines for more information on Informed Consent requirements. (The consent document must be submitted with this application for review.)**

Informed consent was obtained by the Census Bureau at the time the surveys were completed. Participants agreed that their participation was voluntary, that they understood that their information would be used for statistical purposes, and that their information would be kept anonymous.

6. **Anonymity: Will participant information be: (Check appropriate box.)**

- [x] **Anonymous (not even the researcher can match data with names)**
- [ ] **Confidential (names or any other identifying demographics can be matched, but only members of the research team will have access to that information. Publication of the data will not include any identifying information)**
- [ ] **Public (names and data will be matched and individuals outside of the research team will have either direct or indirect access. Publication of the data will allow either directly or indirectly, identification of the participants).**

Justify the classification and describe how privacy will be ensured/protected.

The Census Bureau provides only raw data that cannot be connected with identifying information.

7. **Privacy: Describe the safeguards (including confidentiality safeguards) you will use to minimize the risks. If video/audio recordings are part of the research, please describe how that data will be stored or destroyed.**

All the data that will be used in this project is publicly available on the NSF website, or archived in a database accessible to researchers. No identifying data is kept in these records.

8. **Participant Population and Recruitment Procedures: Who will be recruited to be participants and how will they be recruited. Note that participants must be at least 18 years of age to participate. Participants under 18 years of age must have a parent or guardian sign the informed consent document.**

Although the NSCG was completed by a nationwide sample of people involved in the fields of science, technology, engineering, and math (STEM), the participants for this study are only those people who completed the NSCG who were female engineers.

9. Economic Considerations: Are participants going to be paid for their participation? If yes, describe your policy for dealing with participants who 1) Show up for research, but refuse informed consent; 2) Start but fail to complete research.

No.

10. Time: Approximately how much time will be required of each participant?

The Census Bureau states that the survey took about 25 minutes per participant.

By signing below and returning this application, you are signing that as the Principal Investigator as well as any other investigators certify the following:

1) The information in this application is accurate and complete
2) All procedures performed during this project will be conducted by individuals legally and responsibly entitled to do so
3) I/we will comply with all federal, state, and institutional policies and procedures to protect human subjects in research
4) I/we will assure that the consent process and research procedures as described herein are followed with every participant in the research
5) That any significant systematic deviation from the submitted protocol (for example, a change in the principal investigator, sponsorship, research purposes, participant recruitment procedures, research methodology, risks and benefits, or consent procedures) will be submitted to the IRB for approval prior to its implementation
6) I/we will promptly report any adverse events to the IRB.

Signature of Principal Investigator Date

Signature of Faculty Advisor Date

APPENDIX B

Data Collection Device

NSCG

INFORMATION COPY
DO NOT USE TO REPORT

2013 National Survey of College Graduates

Conducted for
National Science Foundation
by

United States™ Census Bureau

U.S. Department of Commerce
Economics and Statistics Administration
U.S. CENSUS BUREAU

The information collected in this questionnaire is solicited under the authority of the National Science Foundation (NSF) Act of 1950, as amended. The U.S. Census Bureau is conducting this survey under the authority of Title 13, Section 8 of the United States Code. Title 13, Section 9 of the United States Code or the Confidentiality Information Protection and Statistical Efficiency Act of 2002 require the U.S. Census Bureau and the NSF keep all information about you strictly confidential. The information you provide will be used for statistical purposes only. Your response is voluntary and failure to provide some or all of the requested information will not in any way adversely affect you. Actual time to complete the questionnaire may vary depending on your circumstances but on the average, it will take about 25 minutes. If you have any comments on the time required for this survey, please send them to the National Science Foundation, 4201 Wilson Blvd., Suite 295, Arlington, VA 22230, Attn: NSF Reports Clearance Officer.

Please make any name/address changes below:

First Name M.I.

Last Name

Number and Street

City/Town

State ZIP Code

OMB No.: 3145-0141
Approval Expires: 11/30/2015

Form NSCG-21

2113975

Thank you for taking the time to complete this questionnaire.

Follow all appropriate skip instructions after marking a box. If no skip instruction is provided, you should continue to the next question.

If you have any questions or concerns, please call us toll-free at 1-888-262-5935 or email us at nscg@census.gov.

Part A - Employment Situation

A1. Were you working for pay or profit during the week of February 1, 2013?

Working includes being a student on paid work-study, self-employed, or on any type of paid or unpaid leave, including vacation.

Use an X to mark your answer.

1☐ Yes → ***Go to question A8***

2☐ No

A2. *(If No)* **Did you look for work during the four weeks preceding February 1, 2013? This would be between January 4th and February 1st.**

1☐ Yes

2☐ No

A3. What were your reasons for not working during the week of February 1, 2013?

Mark Yes or No for each item.

	Item	Yes	No
1	Retired	1☐	2☐
	If Yes → Year retired ☐☐☐☐		
2	On layoff from a job	1☐	2☐
3	Student	1☐	2☐
4	Family responsibilities	1☐	2☐
5	Chronic illness or permanent disability	1☐	2☐
6	Suitable job not available	1☐	2☐
7	Did not need or want to work	1☐	2☐
8	Other – *Specify*	1☐	2☐

A4. Prior to the week of February 1, 2013, when did you last work for pay or profit?

0☐ ← ***Mark this box if you never worked for pay or profit and then go to page 7, question D1***

LAST WORKED Month ☐☐ Year ☐☐☐☐

A5. What was the title of the last job you held prior to the week of February 1, 2013?

Example: Financial analyst

A6. What kind of work were you doing on this last job – that is, what were your duties and responsibilities on your last job? Please be as specific as possible, including any area of specialization.

Example: Analyzed financial information, prepared technical reports. Specialized in asset management.

A7. Using the JOB CATEGORY list on pages 18-19, choose the code that best describes the last job you held prior to the week of February 1, 2013.

CODE ☐☐☐ → ***Go to page 5, question A36***

NOTE: Job category codes range from 010 to 500

A8. Although you were working during the week of February 1, had you previously retired from any position?

Examples of retirement include mandatory retirement, early retirement, or voluntary retirement.

1☐ Yes → Year retired ☐☐☐☐

2☐ No