Oral Histories of Distinguished Female Leaders: Inspiring the Next Generation of Young People in Science, Technology, Engineering, and Mathematics (STEM)

Ms. Kelsey Morgan Irvin

Kelsey Irvin is currently an undergraduate sophomore at Washington University in St. Louis. She is majoring in the Cognitive Neuroscience Track of Philosophy-Neuroscience-Psychology and hopes to pursue a career in social work or a related psychological field. She is currently working in a Cognition and Development Lab at Washington University in St. Louis studying child preferences.

Ms. Elizabeth Hiteshue, University of Pennsylvania

Elizabeth Hiteshue is a junior at the University of Pennsylvania. She is studying Systems Science and Engineering and Nutrition. She is originally from Medina, Ohio and worked at the Air Force Institute of Technology under Dr. Lanzerotti as a Summer Research Intern in 2013.

Dr. Mary Yvonne Lanzerotti, Air Force Institute of Technology

Dr. Lanzerotti is an Associate Professor of Computer Engineering at the Air Force Institute of Technology.

Dr. Sheldon Hochheiser, IEEE History Center

Dr. Sheldon Hochheiser is Archivist and Institutional Historian at the IEEE History Center in New Brunswick, New Jersey and Adjunct Professor of History at Rutgers University. Prior to joining IEEE, he spent sixteen years as corporate historian for AT&T, acting as both subject matter expert on AT&T history and manager of the corporate archives. While at AT&T, Dr. Hochheiser curated historical exhibits, completed oral histories with company executives, and studied every aspect of the history of the telephone in the United States. He has been conducting oral histories for over thirty years. Hochheiser earned a Ph.D. in the History of Science at the University of Wisconsin–Madison, and a B.A. in Chemistry-History at Reed College.

Prof. Michael Geselowitz, Rutgers, The State University of New Jersey

Michael N. Geselowitz is Senior Director of the IEEE History Center, a joint program of IEEE, Inc., and Rutgers, the State University of New Jersey. Through the arrangement between IEEE and Rutgers, he is also Adjunct Professor of History of Technology and of Science, Technology and Society at Rutgers. Geselowitz holds S.B. degrees in electrical engineering and in anthropology from the Massachusetts Institute of Technology, and M.A. and Ph.D. degrees in anthropology from Harvard University.

His focus has been on the role of history and social relations of engineering and technology at all levels. He has worked as an electronics engineer for the Department of Defense, and he has held teaching and research positions relating to the social study of technology at M.I.T., Harvard, and Yale University, including a stint as Assistant Collections Manager/Curator at Harvard’s Peabody Museum of Archaeology and Ethnology. Immediately prior to joining IEEE in 1997, Geselowitz was Group Manager at Eric Marder Associates, a New York market research firm, where he supervised Ph.D. scientists and social scientists undertaking market analyses for Fortune 500 high-tech companies. He is also a registered Patent Agent.
Oral Histories of Distinguished Female Leaders:
Inspiring the Next Generation of Young People in Science, Technology, Engineering, and Mathematics (STEM)

Abstract

This paper describes a new collaboration between a DOD government institution of higher education in the United States and the History Center of the Institute of Electrical and Electronics Engineers (IEEE), the world’s largest technology organization for the advancement of technology, to create a workforce development and one-on-one career-building and life-changing mentorship program for female undergraduate students in science, technology, engineering, and mathematics (STEM). This project provides the students with hands-on STEM research in the government institution and one-on-one exposure to some of the world’s leading female science and engineering pioneers. In this project, participating female undergraduate students pursue leading-edge STEM research. At the same time, the students identify, select, contact, interview, and transcribe a new oral history for the entire career of female distinguished leaders, whose research and career align with the students’ goals. Through this process, the students are simultaneously participating actively as researchers in a government institution, receiving one-on-one mentorship with distinguished female leaders, and preserving a critical part of the historic record (the oral histories) at IEEE. One desired outcome is that the students are motivated by these experiences to graduate with STEM degrees, which thereby increases the retention of women professionals with STEM degrees. A second outcome is that the oral history transcripts of the distinguished female leaders will be archived in perpetuity at the IEEE. Another outcome is to motivate female undergraduate students to complete their STEM degrees, thereby increasing female participation in STEM. To date, students have identified leaders who are CEOs at science and technology companies and members of the National Academy of Engineering and National Academy of Sciences. Four full-length, two-hour, oral history interviews have been researched and conducted for these individuals, and three additional interviews are being scheduled.

This paper presents key factors in the career development of the distinguished female leaders that led to their success. Common themes that might explain the reasons that the distinguished female leaders have been successful will also be presented. Second, this paper will present first-hand descriptions of the impact on the career outlooks of the participating undergraduates who are conducting all aspects of the project. Participating students are U.S. citizens, which is a desired demographic in the DOD workforce and in addition can help increase the STEM
workforce nationally. Training in oral history technique is provided by the IEEE History Center.

Oral history is the methodology selected in this project because oral history is a recognized “field of study and a method of gathering, preserving, and interpreting the voices and memories of people, communities, and participants in past events.” Oral history is the oldest type of historical inquiry, predating the written word, and is also the most modern, initiated with tape recorders in the 1940s and now implemented with 21st century technologies. The IEEE History Center will post the oral history transcripts in perpetuity on the IEEE Global History Network. The project draws on best practices from other oral history projects, such as those collected in 2001-2003 through the “Oral History of Women in Computing Project” of Dr. Janet Abbate, who is Associate Professor of Science and Technology in Society, at the Northern Virginia campus of Virginia Tech University. Her work became a major source for her book entitled, “Recoding Gender: Women’s Changing Participation in Computing.” (MIT Press, 2012) and 52 oral histories that are now available on the IEEE Global History Network (http://www.ieeeeghn.org/wiki/index.php/Oral-History:Women_in_Computing). The transcripts of these interviews are housed by the IEEE History Center on its IEEE Global History Network site (http://www.ieeeeghn.org) as part of its broader, important oral history collection which contains over 575 interviews, approximately 55 of whose subjects are female.

The views expressed in this document are those of the authors and do not reflect the official policy or position of the United States Air Force, Department of Defense, or the U.S. Government.
Introduction

This paper presents initial results of a STEM Education Project to create a workforce development and one-on-one career-building and life-changing mentorship program for female undergraduate students in science, technology, engineering, and mathematics (STEM). Our Project is a new collaboration between a DOD government institution of higher education in the United States and the History Center of the Institute of Electrical and Electronics Engineers (IEEE), the world’s largest technology organization for the advancement of technology. The STEM Education Project provides the students with hands-on STEM research in the government institution and simultaneous one-on-one exposure to some of the world’s leading female science and engineering pioneers. The students conduct all aspects of the project: They identify, select, contact, interview, and transcribe a new oral history for the entire career of the female distinguished leaders, each of whom are specifically selected by the students because the leaders’ research and career align with the students’ goals. This alignment provides unique mentorship for each student. Through this process, the students are simultaneously participating actively as researchers in a government institution, receiving one-on-one mentorship with distinguished female leaders, and preserving a critical part of the historic record (the oral histories) at IEEE. At the same time, the female undergraduate students are motivated to complete their STEM degrees, thereby increasing female participation in STEM.

The STEM Education Project combines hands-on STEM research with unique mentoring with distinguished STEM leaders to provide an environment that is supportive of both the research and career for the participating female undergraduate students. As background, in 2012, Yale University research showed that “science’s subtle gender biases favor male students.”\(^1\) As recently as July, 2013, three members of the U.S. House of Representatives wrote to the Government Accountability Office to express concern about the state of female participation in STEM fields, since “federal money supports about 60 percent of the research performed at universities, at a cost of $36.6 billion in 2011, in addition to more than $40 billion in intramural research and research at federally funded research development centers.”\(^2\) These Representatives cite research “that girls who grow up in an atmosphere supportive of women in the sciences will often go on to participate and succeed in STEM.”\(^2\)

DOD Government Institution

The Air Force Institute of Technology (AFIT) is a DOD government institution and engineering graduate school with 900 graduate students.\(^3\) The institution mission is to advance air, space, and cyberspace power for the Nation, its partners, and the U.S. armed forces by providing relevant defense-focused technical graduate and continuing education, research, and consultation. There are approximately 130 faculty (50% civilian, 50% military) with 4 tenured female faculty and 3 tenure-track female faculty. Each summer, the institution employs approximately 40-50 undergraduate student contractors; the program is four to five times larger than a typical NSF Research Experiences for Undergraduates (REU) program. All participating undergraduate students are required to be U.S. citizens, and over 10% are female.
IEEE History Center and Oral History Interviews

IEEE is the world’s largest professional association whose technical interests are rooted in electrical and computer sciences, engineering, and related disciplines. The IEEE History Center is the staff arm responsible for promoting the preservation of, research into and dissemination of information about the history of IEEE, its members, their professions, and the related technologies. The IEEE History Center is located on the campus of Rutgers, the State University of New Jersey, which serves as a cosponsor. The Center carries out several historical programs under the guidance of the IEEE History Committee, a standing committee of the IEEE Board of Directors: Maintenance of the IEEE institutional archives; a biennial conference to bring together engineers and historians; outreach activities such as publication, web articles, exhibits, reference services, a newsletter, and a “milestones” recognition program; undergraduate teaching in history of technology and related activities; support of IEEE’s pre-university STEM initiatives; pre-university social studies education; and, most importantly, an oral history program.

The Center’s historical material is made available through a wiki-based portal known as the IEEE Global History Network (GHN). The flexibility of the portal’s architecture allows it to host a wide array of historical preservation activities including an opportunity for engineers to tell their own stories both through a direct “First-Hand History” section and through the more formal posting of oral history transcripts.

The oral history collection of almost 600 interviews of prominent engineers and scientists in IEEE’s fields of interest is one of the most important in the world. It is comprised of a number of distinct collections obtained through a series of initiatives.

Collaboration with the IEEE History Center

One of the most interesting and important, and the most relevant for the project described in this paper, is the Women in Computing Oral History Collection. In 1996-1998, Dr. Janet Abbate (now Associate Professor of Science and Technology in Society at the Northern Virginia campus of Virginia Tech University) served as a post-doctoral fellow at the IEEE History Center. Her chief focus during her initial fellowship period was the completion of the manuscript for her book *Inventing the Internet* (MIT Press, 1999). She then chose as her next project a study of female participation in computer science and technology, with the goal of writing a book on the subject. A major part of her research for the project in 2001-2003 was conducting fifty-two oral histories with American and British women in computing. She contacted the Center to see if it was interested in the project and if it would be willing to work with her and preserve the finished oral histories. It was agreed that the Center would be the ultimate repository for the interviews. The book, *Recoding Gender: Women’s Changing Participation in Computing* (MIT Press, 2012) has been published and the transcripts are now available on the GHN. The interviews and the book are focused on some of the same issues raised in the current project discussed in this paper, understanding the pathways and barriers for women pursuing careers in engineering, and serve as complementary material.
The oral history interviews collected in the STEM Education Project discussed in this paper will be posted at the IEEE History Center at the conclusion of the project.

Training of Undergraduates in Oral History Technique

Oral History is a well-established historical technique to collect the stories and recollections of individuals and make those recollections part of the historical record for posterity. Oral Histories consist of recorded interviews between a well-prepared interviewer and a subject. The recording is then typically processed into a written transcript, and then both the original recording and the transcript are preserved in an archive or library for future use. Oral History enables the preservation of material beyond that which is found in the written record. An oral history is a first cousin to autobiography, in that it preserves an individual’s story as recalled by that individual. In that sense, it is a finished product. But as one person’s story, it is simultaneously a raw document that historians use along with other documents and evidence to create an historical narrative.9,10

Dr. Sheldon Hochheiser, IEEE Historian, trained the participating undergraduates and project PI in oral history technique in June 2013. Both students and project PI were provided with training certificates provided by the IEEE History Center following the completion of the training. Dr. Hochheiser also reviews the oral history questions prepared by the undergraduate students in this project. Dr. Hochheiser has conducted and processed approximately 100 oral histories over the course of his career since the early 1980s. In addition, since joining IEEE in 2008, he has trained, both in person and via webinar, over 35 individuals in the process of how to do and collect oral histories. Oral History has particular protocols, techniques and legal requirements; the basics can be explained and taught in a single session, where the students have opportunities for questions.

Training undergraduates in oral history technique is not different than training anyone else. The training is designed to create an understanding of what oral history is, what sort of historical issues it is particularly apt for documenting, and to teach how to design question sets based on research into the interview subject’s career. The training also provides an understanding of the logistics of conducting a technically satisfactory interview, the post interview processing of the tape into a finished transcript, and the legal requirements for transfer of intellectual property rights. These procedures follow the best practices established by the Oral History Association.11

Reviewing student-generated questions is much like reviewing a first draft of any student work. Read carefully, and give constructive criticism, not only offering suggestions for improvement, but more importantly explaining why. A good set of questions is a prerequisite for a quality interview. These questions must strike a balance between questions specific to the subject, based on understanding of the subject’s life and career, and more general questions designed to further the more general aims of a study to be based on a group of related interviews.

Training of Undergraduates in Human Subjects Training

Both Ms. Irvin, Ms. Hiteshue, as well as the PI, Dr. Lanzerotti, completed Human Subjects Training through the institution’s Institutional Review Board (IRB) prior to conducting the oral
history interviews of the distinguished leaders. This course is “suitable for investigators and staff conducting research with human subjects at the Air Force Research Laboratory (AFRL) and for investigators and staff at other sites conducting Research, Development, Testing, and Evaluation (RDT&E) activities with human subjects.”

Following completion of the Human Subjects Training, these undergraduates and the PI were issued certificates of completion. The Common Rule, at 45 CFR 46,102 defines what constitutes ‘research’ and what constitutes ‘human subjects.’ According to this section of the Code of Federal Regulations, research is defined as the "systematic investigation, including research development, testing and evaluation, designed to develop or contribute to generalizable knowledge. Activities which meet this definition constitute research for purposes of this policy [45 CFR 46], whether or not they are conducted or supported under a program which is considered research for other purposes. For example, some demonstration and service programs may include research activities."

The term human subject is defined as "a living individual about whom an investigator (whether professional or student) conducting research, obtains (1) data through intervention with the individual, or (2) identifiable private information."

**Participating Female Undergraduates and Their Career Goals**

Ms. Irvin (the first author on this paper) is a sophomore majoring in Philosophy, Neuroscience, and Psychology at Washington University in St. Louis, and Ms. Hiteshue (the second author on this paper) is a junior majoring in Systems Engineering at University of Pennsylvania. Ms. Irvin’s criteria for identifying potential interviewees include female gender, STEM background, successful career, and preferably residing in Ohio or the surrounding states to allow for the possibility of in-person interviews. Ms. Hiteshue’s criteria included female gender, engineering or mathematics background, and an executive position in career field that is atypical of the engineering/mathematics path (specifically business or food production).

Before starting the STEM Education Project, the participating female undergraduate students, Ms. Irvin and Ms. Hiteshue, each identified five questions that they individually want to answer through the collection of oral histories. These questions are the driving force behind which women are identified for the project, with the hope that the oral history responses will in fact provide the anticipated mentorship portion of the research by answering the five questions.

Ms. Irvin’s questions are:
(1) How did you first get into your profession?
(2) What were the key decisions or paths you took that affected your career?
(3) Was there any additional pressure to balance your professional and personal/family life? If so, how did you handle it?
(4) What do you feel were the most vital skills in your field?
(5) How has your field changed since you entered it?
Ms. Hiteshue’s questions are:
(1) What moments in your early life stand out as critical moments for your future career choice?
(2) What issues have you experienced in STEM fields because of your gender?
(3) Did your work ever interfere with your ability to maintain a family life?
(4) How have you seen the role of women in STEM fields change over the years?
(5) How could your experiences help someone just entering a STEM field?

Identification of Distinguished Leaders by the Participating Students

The first step in the STEM Education Project is the identification of distinguished female leaders by each student. To identify key female leaders in their desired career fields, Ms. Irvin and Ms. Hiteshue search through the National Academy of Engineering (NAE) website, National Academy of Sciences (NAS) website, the Harvard Business School faculty website, a STEMconnector publication provided by the STEMconnector, ‘the one stop shop for STEM information,’ and the Girls in Information and Communication Technology (ICT) Portal. Through these searches as well as references from STEM researchers at the DOD government institution, Ms. Irvin and Ms. Hiteshue obtain contact information and send invitations to potential interviewees. After some correspondence, both in-person interviews and teleconferences are set up to conduct the oral history.

Oral History Interview Process and Structure

Prior to each oral history interview, Ms. Irvin and Ms. Hiteshue conduct background research and request the interviewee’s Curriculum Vitae (CV) in order to present more thorough and individualized questions during the oral history interview. Next, interview questions are drafted, reviewed, and finalized. The questions are personalized for each interviewee and reviewed by Dr. Hochheiser, the IEEE Historian. Following changes, the oral history questions are sent to the interviewee before the interview by the participating students.

A standard set of interview components includes the following sections: Introduction, Early Life/Education, Career, Awards/Honors, Gender-Related Questions, Reflection/Advice, and Conclusion. Table I (shown on the next page) shows the structure of a typical oral history interview. Excluding an introduction and conclusion, the five general sections covered in the interview are Early Life/Education, Career, Awards/Honors, Gender, and Reflection/Advice. Questions in the Early Life/Education section cover family background, early interests, early role models, and elementary through doctorate education. Questions in the Career section cover the general path of the interviewee’s career and the projects and accomplishments she has at each. Questions in the Awards/Honors section focus on specific honors the interviewee has and also memberships to esteemed professional societies. Questions in the Gender section focus on challenges and differences that the interviewee faced due to her gender in STEM fields. Questions in the Reflection section focus on advice pertaining to the original five personal research questions and general advice that the interviewee wishes to share.

Oral history interviews are conducted by Ms. Irvin, who obtains a signed consent form from each interviewee. Oral histories are collected over the telephone with three participants; one interview is collected in person at the Air Force Institute of Technology. The three telephone
interviews are conducted for approximately two hours in a quiet office provided by the institute library. The oral history conducted in-person is conducted in a quiet conference room and also lasted approximately two hours. The audio portion of all of the oral history interviews is digitally recorded.

After completing each oral history interview, a follow-up email message is sent to each interviewee thanking them for their participation and explaining future steps. The oral history interviews are transcribed by Ms. Irvin and Ms. Hiteshue to be sent to the interviewee for edits. The next steps are to obtain a second consent form of the IEEE and receive institution IRB approval. Following these steps, the finalized transcriptions will be posted on the IEEE Global History Network.

**Distinguished Female Leaders Interviewed in this Project to Date**

Interviewee #1 is the daughter of an engineer whose efforts were crucial to the war effort in World War II. Gifted from a young age, she originally studied biology in her high school education. She enrolled at university and initially studied chemistry and math, but was somewhat discouraged in her academic pursuits by her university, and switched to an English major. She believes library research was a crucial skill learned in university. She believes that self-confidence was not only her biggest struggle, but also an important skill in any field and in life. She thinks that STEM fields are more accepting of women now than when she was growing up, reflecting a cultural change of more openness.

Interviewee #2 is a full professor at an R1 institution. She had always been interested in science, technology, and engineering. She was always top of her class, and her family was extremely supportive of this and encouraged her schoolwork. Her grandfather was especially mentoring to her because he advocated for the importance of hard work during their times together. She shifted from science to engineering when she changed from having one major in her undergraduate school to another major in her graduate degree. Another key decision was when she finished schooling and chose to go into industry instead of academia. For her, there was an ever-present pressure to balance professional and family life. One of her greatest prides is her ability to balance these aspects of her life, and to make sacrifices necessary to be there for her children. She believes the ability to use time effectively, to focus, and to prioritize are key skills in any field, but especially in STEM fields. She also asserted the importance of interpersonal skills, which she learned continuously and gradually throughout her career. She also stressed the value of her confidence and her drive to demonstrate effective leadership. The skill of leadership, she believes, can also be taught. One thing she also attributed her success to was her drive to finish and focus on education, always working as hard as she could and being a full-time student, never working until after her education. She thinks that there are still more challenges in the industry for women than for men; however, she believes there is a trend moving away from that.
<table>
<thead>
<tr>
<th>Interview Section</th>
<th>Typical Questions</th>
</tr>
</thead>
</table>
| Early Life and Education | • Can you tell me a little about your childhood?  
• Were you interested in technology as a youth?  
• How did you become interested in technology and engineering?  
• Did you have a role model who inspired your technical interests?  
• What types of activities were you involved in during these years that motivated your interest in STEM fields?  
• Did you family encourage your technical interests?  
• What led you to X University?  
• Were there any teachers who mentored you?  
• What part of your education was most beneficial to your career?  
• What moments in your younger life stand out as life-changing or critical moments in your career? |
| Career                | • What led you to your first job?  
• What projects did you work on there?  
• What kinds of things did you find most satisfying in a job? |
| Awards/Honors         | • For what did you earn X Award?  
• What professional organizations are you a member of?  
• What have you done as a member of this organization?  
• What have you gained from being a member of this organization? |
| Gender                | • Have you ever experienced discrimination based upon your gender in your career?  
• Was there any time when you doubted yourself and/or your work?  
• Did gender play a role in this doubt?  
• How have you overcome these issues?  
• Did you feel any additional pressure to balance your professional and personal/family life?  
• Do you have any advice for a woman in a demanding career that wishes to start or maintain a family life?  
• How have you seen women’s role in STEM fields change? |
| Reflection/Advice      | • What was your favorite job you held? Why?  
• Have you seen any notable trends in education in general or in STEM education?  
• How could your experiences help someone just entering or contemplating entering a STEM field?  
• How do you define success?  
• What are the steps that young people can take to prepare themselves for their first job?  
• If you could go back and change one thing, what would it be?  
• Overall, what are you most proud of in your career or in your life?  
• Eleanor Roosevelt once said that “the future belongs to those who believe in the beauty of their dreams.” What are your goals that you will be releasing in the coming years? |
Interviewee #3 is a CEO at a consulting company. She considered high school to be a transformative experience as she moved to a top tier school. She was exposed to physics at her high school and decided she wanted to do physics as a career at her university. It was a popular major at the time because of its influence in WWII. This experience launched her into a graduate program, where she “really learned physics.” The biggest change for her was when she changed from public schools to a private high school. She felt a pressure to balance her career with family life and came up with a personalized “formula” to take care of her family. She thinks that everyone has to find a formula that works for them. She believes that the most crucial skill in a career is knowledge of the field and “being able to do the work that has to be done is the first criteria.” She thinks that the number of women in STEM fields is slowly rising, but physics still doesn’t have a lot of women in it. She thinks that technology has changed a lot of the education system, however.

Interviewee #4 is a CEO at a company. She also has over 40 years’ experience in teaching and research in academia, where she was a tenured faculty member in engineering. She had always been interested in mathematics, and her parents were very encouraging of her STEM interests. In fact, her mother pushed for her to be in the honors program at her high school. This experience was key to her education. While balancing her career and family life was not an added pressure, she believes that young women are still at a disadvantage because they are discouraged from getting into computing because computers are seen as male-oriented. The crucial skills to her career were her ability to keep her options open and to seize opportunities that were key to her success.

Themes that Emerge from the Oral Histories Collected to Date

After collecting the oral histories to date, two key themes have emerged. The first theme concerns a balance between a professional and personal life as it applies to women in STEM fields. Multiple interviewees in this project expressed that while sacrifice (whether it be social, personal, or professional) was necessary, the reward of achieving new heights in their career and breaking the glass ceiling for women in STEM was well worth personal or professional sacrifice. The ability of women in STEM fields to find this balance and propel their careers forward is vitally important for the continued increase of female success in STEM fields.

A second theme that emerged from the oral histories collected to date is that the role of women in STEM fields has progressed immensely over the years, but the interviewees noted that there is still progress to be made in order to reach complete equality of roles. This theme arose mainly as a result of asking the interviewees the following question, namely: “How have you seen women’s role in STEM fields change over the years?” during the oral history interview. One interviewee explained that very few of her fellow women classmates in high school were encouraged to take STEM-related classes or pursue STEM degrees in college. Another interviewee discussed how this situation has changed over time, as shown by the larger number of women pursuing STEM degrees and holding prominent positions in STEM fields.
Key Factors in the Career Development of Distinguished Female Leaders that Led to Their Success

Through oral history interviews conducted in this study, Ms. Irvin finds that according to these successful women in STEM fields, the most crucial skills in STEM fields are hard work, interpersonal skills, focus, leadership, confidence, drive, time efficiency, and prioritization. She also finds that these women all felt additional pressure to balance family and professional life. Further, they all agree that while more women are present in STEM fields than previously, the overwhelming majority of professionals in STEM fields are male, and that this fact is not changing quickly.

Ms. Hiteshue finds that all interviewees provide explanation of a clear, dynamic moment in their lives from between 15 to 25 years of age. The event is truly life-changing and is reflected in each of their careers, showing that choices that are made during those years of one’s life are crucial to building one’s future, but still does not inhibit one from breaking into a new area with hard, persistent effort. Ms. Hiteshue also finds that two of the interviewees discuss the balancing act that occurs when a woman with a successful career raises a family. The interviewees stress that it was a difficult period, but with the right formula and time management, it can be one of the most rewarding parts of life. Lastly, Ms. Hiteshue finds that one interviewee puts an interesting spin on success when she explains how failure is a part of the learning process because it makes a person reassess his or her situation.

First-Hand Description of the Impact on the Career Outlook of Ms. Irvin (First author)

This study created one-on-one exposure for STEM students to some of the world’s leading engineering pioneers, serving as a life-changing and career-building experience for both of us undergraduate students. To illustrate this experience, we both designed a flow chart of our lives at the various times throughout the summer internship. These charts include education, summer opportunities, research and our potential future careers. The goal was to show how the outputs of this oral history project are inputs to our future careers and life paths, visualizing the mentorship aspect.

My role as the lead undergraduate research assistant on the oral history project was the conduction of all aspects of the project. This included research potential interviewees, reaching out to those potential interviewees and corresponding with them to set up an interview, developing the oral history questions with Dr. Hochheiser’s feedback, obtaining the signed consent forms, conducting the interview, helping to transcribe the interviews, and assisting on the packets to submit to IRB with all required materials. I developed Word templates for all of these items (correspondence, interview questions, follow-up emails, and IRB packets). I also presented the project on several occasions at the conclusion of the summer.

I created one flow chart at the beginning of the summer and another updated chart at the end of the summer to include the three interviews. I entered this project as a rising sophomore majoring in the Cognitive Neuroscience track of Philosophy-Neuroscience-Psychology (PNP) at Washington University in St. Louis. My educational goals were to
finish my undergraduate degree in 2016 and enter into a graduate school for Social Work. My career goals were to become a psychologist and/or counselor. My experiences at AFIT this summer provided an opportunity to improve my technical and research skills, work effectively with a team of research professionals, and develop my abilities in communicating with subjects both in person and via phone. What I learned in this project is that to be a woman in STEM means understanding the additional challenges that it brings such as balancing professional and family life.

Now, at this point in the project, my educational goals are still to finish my undergraduate education majoring in PNP but with the addition of a Children’s Studies minor. I plan to pursue a doctorate degree in Child Clinical and Developmental Psychology. Throughout my undergraduate and graduate education, I hope to participate is psychological research. In my career, I hope to be a Child Psychologist, providing counseling services to children and families. Because of my personal goal to have a family, I realize that to be successful in STEM, I will need to find a balance between professional and family life. I further hope to challenge the uneven ratio of men to women as STEM professionals.

After hearing the interviewees’ responses to my personal five questions, I feel I have a better grasp on what is important in terms of knowledge, skill, and drive to be successful in a STEM field.

The interviewees’ stress upon the importance of prioritization personally resonates with me both in regard to prioritizing duties within a career, but also in regard to prioritizing aspects of family life versus a profession life, especially as a woman. While the majority of professionals in STEM fields are male, I feel hopeful that STEM fields are becoming increasingly accepting to female professionals. This oral history project gave me the knowledge of what it means to be a woman in STEM fields and the confidence to dive into my education and prospective career in a STEM field.

In regard to the input to my life’s flow chart from the oral history project, learning about the importance of these skills may drive my decisions of what classes to take in the future. Further, the knowledge of what it means to be a woman in a STEM field, and the challenges that go along with it, will be present with me as I continue my undergraduate education and as a pursue a career.
First-Hand Description of the Impact on the Career Outlook of Ms. Hiteshue (Second author)

My role as an undergraduate research assistant on the oral history project was to assist Ms. Irvin in conducting all aspects of the project. I was able to research individuals who I felt would be personally beneficial in the mentoring component of the project. After Ms. Irvin completed the actual oral history interview, I assisted in transcribing the oral history interviews and organizing all the components for the IRB packets. Additionally, I presented this research with Ms. Irvin on several occasions at the conclusion of the summer and worked on submitting the research to CUR’s 2014 Posters on the Hill session.

As for the technology portion of the project, I read through a paper on the topology of integrated circuits as it was in review to spot any edits from an outside perspective. This gave me the opportunity to learn about a topic in which I had never had formal training. The basic concepts were touched on in my college math and engineering classes, but the discussions were never based on the combination of both topology and integrated circuits. This required me to do some of my own research on the topic in order to gain a background understanding. After reviewing the concepts in this paper, a new research goal was set to understand such topological constraints for circuits that have different connectivity but equivalent function.

Entering this project as a rising junior, I created a total of three flow charts throughout the summer: an original chart, an intermediate chart including Interviewee #1, and an updated chart with the first three interviewees. My first flow chart was arranged from top down, showing my most future goals at the bottom. This chart was very simple, containing my graduation from high school, entrance into college, my four years at college, and my three potential post-college career paths. However, the third flow chart, combining both flow chart #1 and chart #2, had many more components. Between the boxes for each of my four years of undergraduate education, I was able to add in outputs from this research project and other experiences that become inputs into my future career endeavors. For instance, this oral history project has given me the opportunity to receive advice from very successful women in STEM. This advice becomes inputs into my aspirations to have a family and possibly attend business school.

At the conclusion of the summer, I even noted that, “The interviewees were very encouraging of young women in STEM, giving me even more motivation to continue and eventually complete my STEM degree. More specifically, Interviewee #2 reassured me that a STEM degree can open up many opportunities in other fields, such as business or management. This supports my personal goal of attending business school after the completion of my undergraduate degree in engineering.”

Currently, my educational goals are still to complete my undergraduate degree with a degree in Systems Science and Engineering and a minor in Nutrition. Although my plans are not finalized, I do plan to enter the industry after graduation to gain experience in the field I choose. This research has forced me to realize that the work force of my choosing
may be male-dominated, but with diligent persistence, it is definitely possible for a woman to make an impact.

How the Key Themes are Encouraging the Further Work In STEM of Ms. Irvin and Ms. Hiteshue

Ms. Irvin will continue to pursue her undergraduate degree in Philosophy-Neuroscience-Psychology. She will keep in mind the various skills that the interviewees identified as particularly important to their careers as she does so and as she chooses classes. She will use the knowledge of what it means to be a woman in STEM fields and the challenges that go along with it as motivation to have a focused drive on her future career.

Ms. Irvin is especially encouraged to further her work in STEM after hearing about the importance of prioritization between professional and personal life for women. From the oral history interviews, she grasped a better understanding of the challenge that balance between both aspects of life. While she understands that a career in STEM fields can involve sacrifices in all parts of life, the rewards of such a sacrifice can be well worth it not only for her personal career, but also for the increasing role of women in STEM fields.

Ms. Hiteshue intends to continue supporting her vastly different interests and areas of study with the advice of the women already interviewed. She finds hope in the fact that many of the interviewees have taken advantage of industries and occupations that do not directly line-up with their degree or formally learned skill sets. She will use this mentorship as motivation and encouragement to dive into new areas of study and future career paths.

The second key theme of gender equality of roles in STEM fields from this research has encouraged Ms. Hiteshue to (1) be proud of her gender and (2) be an ambassador to the younger generation of females. She was reassured that there is nothing wrong with being proud of her gender and now confidently knows that she can bring unique perspectives to classes and work environments that are mainly comprised of men. Additionally, she hopes to continue the growth of women in STEM fields by being a source of encouragement to young girls through organized mentorship and personal interactions.

After initiating and making great progress on this research project throughout the summer and continuing researching throughout the academic school year, Ms. Irvin and Ms. Hiteshue began investigating possible presentation events and conferences. One poster session that stood out was the 2014 Council on Undergraduate Research (CUR) Posters on the Hill. This 18th annual poster session on Capitol Hill allows undergraduates to demonstrate how they have been impacted by research and education programs funded by the U.S. Congress. Since this research was funded by a National Science Foundation (NSF) grant and was conducted at an federal institution of higher education, this opportunity seemed ideal for both undergraduate students. Hoping to be able to present their findings and unique perspectives to members of Congress, Ms. Irvin and Ms. Hiteshue submitted their abstract to CUR Posters on the Hill in early November, and are anticipating notification of their potential selection in mid-February. If accepted, the CUR Posters on the Hill poster session will occur in April, 2014.
During the next seven months, Ms. Irvin and Ms. Hiteshue plan to conduct three more oral history interviews with distinguished female leaders in STEM in Taiwan. In addition, Ms. Irvin and Ms. Hiteshue will continue the previously-described process of conducting, transcribing and editing the oral history interviews in order to post the oral history transcriptions on the IEEE Global History Network website. In the longer term, as the repository of interviews increases, the participants will create a report synthesizing the common key experiences in the success of the distinguished female leaders. This report will be augmented with the increasing number of distinguished leaders.

**Summary and Conclusions**

This paper presents initial results of a STEM Education Project, a new collaboration between a DOD government institution of higher education in the United States and the History Center of the IEEE. Participating students conduct all aspects of the project and are provided with unique mentorship with leading female science and engineering pioneers during the duration of their STEM research project, which is undertaken simultaneously. Participating students are found to be motivated to continue their studies to graduate with STEM degrees.

The interviews generated by this project are important additions to the Oral History Collection of IEEE. They will serve as historical documents for future historians researching a range of important issues in the history of engineering and technology. More immediately, they fit into IEEE’s interests in recognizing women's outstanding achievements in IEEE fields and in facilitating the development of programs and activities that promote the entry into and retention of women in engineering programs. The IEEE History Center, the IEEE organization that curates the Oral History Collection supports these activities by preserving, researching and promoting the historical role of women in engineering. The Oral History Collection is an important component of this activity, and the Center intends to continue to cooperate in efforts such as the one presented here.

**Acknowledgements**

The authors wish to thank Dr. Charles Cerny, Technical Advisor, RF Systems Branch, Air Force Research Laboratory Sensors Directorate, for discussions. The authors also wish to thank Mr. Brad Paul, Chief of Integrated Circuits and Microsystems, Sensors Directorate, Air Force Research Laboratory, for discussions. The authors also thank Mr. John Reisner and Mr. David Pope of AFIT Extension Services for technical and administrative support. The authors thank Capt Derrick Langley, PhD, for discussions and comments on the paper. The authors thank Dr. Heidi Ries, Dean for Research at AFIT, for support and discussions at the initiation of this project.

Partial support for this work was provided by the National Science Foundation NSF ADVANCE under Award # 0810989. Any opinions, findings, conclusions, and recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.
Bibliography

gender biases favor male students,” Proc. National Academy of Sciences,
2. Letter dated 24 July 2013 to the Honorable Gene L. Dodaro, Comptroller General of the United State,
Government Accountability Office, 441 G. Street, N. W., Washington D.C., from Louise M. Slaughter,
Eddie Bernice Johnson, and Rosa DeLauro stating that the authors “are highly concerned that gender bias
is inhibiting women and girls from participating in STEM education and career fields.”
2012.
History:Women_in_Computing.