

Oral History Project of Underrepresented Leaders in Science, Technology, Engineering, and Mathematics (STEM)

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Abstract

This paper describes an Oral History Project that is intended to create a mentorship program to inspire the next generation of underrepresented young people in Science, Technology, Engineering, and Mathematics (STEM). There is a need to motivate underrepresented students to graduate with STEM degrees to increase female participation in STEM fields. There is also a need for capturing the oral histories of underrepresented distinguished STEM leaders because a survey of the National Academy of Engineering database and National Academy of Sciences database shows that many of these individuals' oral history interviews are not yet archived in oral history databases, and these interviews are key pieces of our societal history. The project provides unique mentorship to the students to motivate them to graduate in STEM fields by connecting them with leaders in STEM fields and giving them opportunities to interview and collect life stories of STEM leaders. This project is organized by a STEM faculty member at an institution of higher education in the United States and the Senior Director of the history center of the world's largest technology organization for the advancement of technology. The students are U.S. citizens, which is a desired demographic and can help increase the STEM workforce nationally. The oral histories are archived in perpetuity by the IEEE on the Engineering and Technology History Technology Wiki (<http://www.ethw.org>).

Introduction

It is well known that women “are more likely than men to ‘leak’ out of the pipeline in the sciences”¹. Women earn 20.2% of physics degrees, 43.9% of mathematics degrees, 17.7% of computer science degrees, and 17.5% of engineering degrees¹. To encourage female undergraduate students to graduate with STEM degrees, and thereby increase female participation in STEM fields, this paper describes an Oral History project that provided female students with unique mentorship with distinguished leaders whose careers align with the students' intended careers.

The project provided unique mentorship to the students so that the students are motivated to graduate in STEM fields, while simultaneously archiving original sources that are key pieces of our societal history. There is a need to capture the oral histories of underrepresented distinguished STEM leaders because a survey of the National Academy of Engineering database and National Academy of Sciences database shows that many of these individuals' oral histories

are not yet archived in oral history databases. At the same time, the one-on-one exposure of STEM students to some of the world's leading science and engineering pioneers is designed to be a life-changing and career-building experience for female students, since an oral history consists of a recorded conversation of a "well-informed interviewer questioning an interviewee."

Interviews generated by this project are important additions to the Oral History Collection of IEEE. They 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. 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. Furthermore, the strength of women's stories in the IEEE oral history collection is complemented by the presence on the ETHW of the oral history collection of the Society of Women Engineers, one of the members of the ETHW consortium. Oral histories are conducted in accordance with the best practices of the Oral History Association. This 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.

Research Questions

The two research questions that the students answered with the information collected in the oral histories are "What are the factors that led to the success of these distinguished female leaders?" and "What are the most crucial skills that enabled their success?" These questions are answered by the students in the **Findings** section below.

Partners and Research Design

IEEE is the world's largest professional association whose technical interests are rooted in electrical and computer sciences, engineering, and related disciplines.² 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.³ The IEEE History Center is located on the campus of Stevens Institute of Technology in Hoboken, New Jersey. The Center's historical material is made available through

a wiki-based portal known as the Engineering and Technology History Wiki (ETHW).³ 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.

The IEEE collection includes 52 oral histories of females in computing collected by Dr. Janet Abbate Virginia Tech University.^{4,5} Dr. Abbate's 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.ieeeghn.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.ieeeghn.org>) as part of its broader, important oral history collection which contains over 575 interviews, approximately 57 of whose subjects are female. As described in our previous paper published at 2014 ASEE,⁹

*One of the most interesting and important, and the most relevant for the project ..., 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....³ 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.⁴*

In our STEM Oral History Project, the IEEE Historians provide training to the students in oral history, a technique to record recollections of interviewees for posterity.⁶⁻⁹ The procedures in this project follow the best practices established by the Oral History Association.⁸ We use the methodology of oral history because 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."⁹ As the oldest type of historical inquiry, predating the written word, oral history is also the most modern current career path flowchart that is being continuously informed by exposure to today's distinguished underrepresented leaders in science and engineering. since today it is implemented with 21st century technologies.

The American Institute of Physics (AIP) is a federation of physical science societies.¹⁰ AIP's mission is to advance, promote, and serve the physical sciences for the benefit of humanity. Their products and services promote the advancement of physical science through collaborative efforts and distribution of knowledge. AIP also offers student programs and promotes physics education and promotion. The Grants-in-Aid program of the AIP Center for the History of Physics supports historical research of the physical sciences. This effort supports the current oral history project.

The first step was for each student to identify distinguished female leaders. To identify key female leaders in their desired career fields, Ms. Irvin and Ms. Hiteshue searched through the National Academy of Engineering (NAE) website,¹¹ National Academy of Sciences (NAS) website,¹² the Harvard Business School faculty website,¹³ a STEMconnector publication provided by the STEMconnector, 'the one stop shop for STEM information,'¹⁴ and the Girls in Information and Communication Technology (ICT) Portal.¹⁵ Through these searches as well as references from STEM researchers at the DOD government institution, Ms. Irvin and Ms. Hiteshue obtained contact information and sent invitations to potential interviewees. After some correspondence, both in-person interviews and teleconferences were arranged.

Prior to each oral history interview, Ms. Irvin and Ms. Hiteshue conducted background research and requested the interviewee's Curriculum Vitae (CV) in order to present more thorough and individualized questions during the oral history interview. Next, interview questions were drafted, reviewed, and finalized. The questions were personalized for each interviewee and reviewed by the IEEE Historian. Following changes, the participating students sent the oral history questions to the interviewee prior to the interview.

A standard set of interview components included 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 are personalized for each interviewee. Questions in the Early Life/Education section covered family background, early interests, early role models, and elementary through doctorate education. Questions in the Career section covered the general path of the interviewee's career and the projects and accomplishments in each role. Questions in the Awards/Honors section focused on specific honors and memberships in esteemed professional societies. Questions in the Gender section focused on challenges and differences that the interviewee faced due to her gender in STEM fields. Questions in the Reflection section focused on advice pertaining to the original five personal research questions and general advice that the interviewee wished to share.

Table I. Structure of a Oral History Interview

Interview Section	Typical Questions
Early Life and Education	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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?

Data Collection

Ms. Irvin and Ms. Hiteshue obtained a signed consent form from each interviewee and conducted the oral history interviews. Oral histories were collected over the telephone with three participants; one interview was collected in person at the Air Force Institute of Technology. Five of the interviews were conducted via telephone in a quiet space. The oral history conducted in-person was conducted in a quiet conference room and lasted approximately two hours. The audio portion of all of the oral history interviews was digitally recorded.

After completing each oral history interview, a follow-up email message was sent to each interviewee, thanked them for their participation, and explained future steps. Ms. Irvin and Ms. Hiteshue transcribed the oral history interviews to be sent to the interviewee for edits. The next steps were to obtain a second IEEE consent form and obtain institution IRB approval. Following these steps, the finalized transcriptions were posted on the Engineering Technology and History Wiki (ETHW). Table 2 lists the six interviewees, their roles, and the interview dates.

Table 2. Interviewees¹⁶⁻²⁰ with archived interviews on the Engineering and Technology History Wiki.

#	Name	ETHW Categories	Interview Date
1	M. Dresselhaus,¹⁶ Professor at MIT	Computing and Electronics, Electronic components, Engineering and Society, Education, Home & Family, Profession, Diversity, Workplace	July 2013
2	D. Anderson,¹⁷ Daughter of J. Desch	Military Applications	July 2013
3	J. Hwang,¹⁸ CEO of H-Technologies	Computing and Electronics, Electronic equipment manufacture, Environmentally friendly manufacturing techniques, Education, Business, Professional Training and Development, Mentoring	July 2013
4	E. Pate-Cornell,¹⁹ Professor at Stanford	Risk assessment, Risk analysis, Women	January 2015
5	H. Ries,²⁰ Dean for Research at Air Force Institute of Technology	Education, Resonance, Optics, Physics, Materials, Research and development Labs	March 2015

Ms. Irvin now describes her descriptions of the importance of each interviewee to her in the project.

Dr. Mildred Dresselhaus is a professor at MIT. Raised in an impoverished household, she overcame the odds and received a high quality education, becoming a pioneer in the field of solid-state electronics. As a student, Dresselhaus showed a keen interest in mathematics and music. It was during her graduate school years in Chicago that she began to study superconductors, a subject that became the focus of her doctoral thesis. At that time, superconductors were one of the “hottest” fields in solid-state physics. In the late 1970s she made important contributions to understanding the structure of graphite intercalation compounds. The work of her group on fullerenes and carbon nanotubes began in the early 1990s before these structures were well known. She also demonstrated the symmetry of single-wall nanotubes and how one could calculate their electronic structure. Her work on nanotubes continues today, including the important contribution of the measurement of Raman spectroscopy on isolated single-wall carbon nanotubes. Her recent work on the semi-conductive properties of carbon nanotubes opens new possibilities in nanotechnology, and other recent research holds exciting promise for energy-related applications.

Dr. Dresselhaus’ public advocacy for women in engineering and science began in the mid-1970s, when the number of American women seeking undergraduate degrees in engineering began to rise. Recognizing this as an issue of great importance for the profession, Dr. Dresselhaus began actively speaking out in favor of women’s access to careers in technology and science. Her unquestioned accomplishments in the laboratory and classroom gave her an unparalleled credibility in this national dialogue. Her 1975 article “Some Personal Views on Engineering Education for Women” (IEEE Transactions on Education) remains an immensely valuable and accurate account of the psychological and social challenges facing women in a male-dominated field. The article also stressed the critical importance of role models for women engineering students, which Dr. Dresselhaus herself has certainly served as through mentoring, formally and informally, countless young women across the United States and around the world.

The oral history interview is posted at this URL: http://ethw.org/Oral-History:Mildred_Dresselhaus (See Fig. 1).¹⁶

In this interview, Anderson discusses her life and career, such as the difficulties of being a woman in the STEM fields. Although not of a STEM profession, she provides encouragement to continue pursuing the movement of STEM education, to keep moving beyond mistakes and obstacles, and to keep contributing to the world. Additionally, she reflects and gives an inside perspective on her father's career and how it affected her own choices and the research projects she later pursued, namely on the Dayton Code Breaking project.

The oral history interview is posted at this URL: http://ethw.org/Oral-History:Deborah_Anderson (See Fig. 2).¹⁷



Figure 2. Word cloud of Oral History of Ms. Anderson conducted by Ms. Irvin.¹⁷

Dr. Jennie S. Hwang was born on May 21st, 1949 in China, and raised in Taiwan. She studied Chemistry at some of the best schools in Taiwan before continuing her higher education at Columbia University studying Chemistry and at Kent University studying the pioneering field of Liquid Crystal Science, before earning her Ph.D. at Case Western Reserve University's Materials Science and Engineering School, becoming the first woman to do so. Hwang's professional career included executive positions at both Lockheed Martin and Sherwood Williams, and serving as Engineering Advisor to the United States Defense Department's Army Material Command. Her achievements included induction into the Ohio Women's Hall of Fame and the Women in Technology International Hall of Fame. She was the first woman from Ohio and first Asian-American woman to be elected to the National Academy of Engineering (NAE) and the first national woman president of Surface Mount Technology Association.

In this interview, Hwang discusses her long and successful career in the science and technology industry. She emphasizes the need both for an enriching education in early childhood and the desire to excel, in spite of challenges, in order to succeed. Addressing the challenges and obstacles of women in STEM fields, Hwang provides encouragement to women to strive, to excel, and to gain confidence in a male-dominated world, as well as to understand the commitment and demand that such environments require. Being Asian, being a woman, and wanting a career and a family, proved to be challenges to Hwang, but despite obstacles and difficulties that she was able to succeed. Serving as an example, she challenges everyone, especially women, to educate themselves, to strive for excellence in their career and with their family, and to contribute their knowledge and experiences to the world.

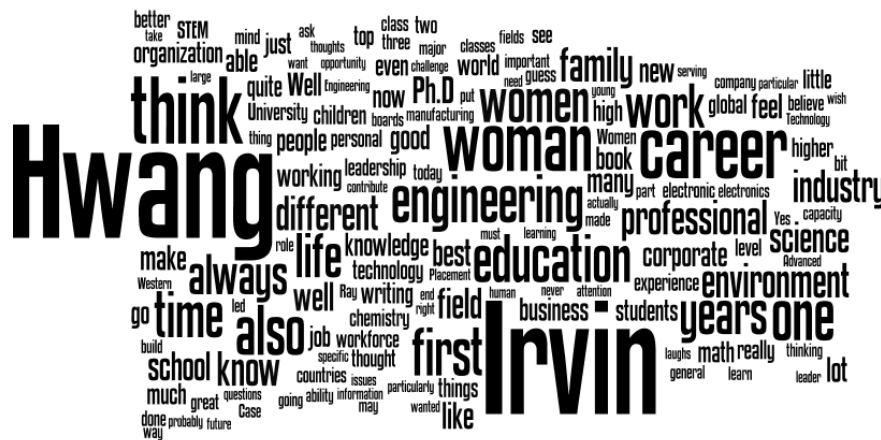


Figure 3. Oral history of Dr. Hwang conducted by Ms. Irvin.¹⁸

After completing her degrees, she accepted a faculty position at MIT in the Department of Civil Engineering, where she initiated several research projects on risk analysis and seismic engineering and activity. She later returned to Stanford University in 1981 to be

an Assistant Professor of Industrial Engineering and Engineering Management (IEEM) before becoming Professor in 1991 and the Department Chair in 1997. She also accepted a visiting professor position at Georgia Institute of Technology during her sabbatical year, and one at New York University in the Department of Finance and Risk Analysis. Currently she holds the position of Professor and former department Chair (from 2000-2011), of the Department of Management Science and Engineering at Stanford University. She is also Senior Fellow of the Stanford for International Studies.

A world leader in engineering risk analysis, risk management, and decision analysis under uncertainty research, her contributions to the scientific community have led her to be recognized through several distinguished positions and awards. Most recently she received the Ramsey Award for the Decision Analysis Society and the Distinguished Achievement Award from the Society of Risk Analysis, and Teaching Award from the Stanford Department of Management Science and Engineering, in 2002, and served as consultant to NASA in 1999-2000 as Chair of the Review Panel for the Quantitative Risk Analyses of the Space Shuttle. Additionally she has held several other positions and roles, such as Chair of the Decision Analysis Society of the Institute for Operations Research and the Management Sciences (INFORMS), President of the Society for Risk Analysis, the Academie des Technologies Conseiller since 2001, and a member of the (US) National Academy of Engineering since 1995, the French National Academy of Engineering, and Board of Directors of WingTech and Energy Recovery Inc. (ERI) in California since 2004 and 2009, respectively, as well as several government, editorial, and advisory boards.

In this interview, Paté-Cornell discusses her education, career, and contributions to the field of risk analysis and engineering. She recounts her student days, and her research projects and work at MIT and Stanford. She reflects on the decisions, difficulties, and successes of her career, her involvement with several groups and organizations, and on the role and challenges faced by women entering STEM fields. Additionally, she discusses the evolution of STEM education and provides advice to individuals interested in the STEM fields.

The oral history interview is posted at this URL: http://ethw.org/Oral-History:Elisabeth_Pat%C3%A9-Cornell.¹⁹

Discussion

The oral history interviews impacted Ms. Irvin's outlook as she pursues a doctorate degree in a STEM field and hopes to have a career in academia. She learned the challenges of being a woman in a STEM field, but also has learned the importance of addressing discrimination. She also learned that some of the key skills which are important in a STEM field, such as confidence, focus, and interpersonal skills, and continuously attempts to improve these skills in herself for her present and future career.

The oral history interviews impacted Ms. Hiteshue's outlook as she begins her professional career as a management consultant and hopes to eventually combine technology and business later in her career. She learned that there is a balance women must find when juggling both a professional career and being a mother. Additionally, she learned the importance of women professionals finding a specialty, or niche, where they can make a passionate impact and have enough self-confidence along the way that they will be able to make that impact.

In summary, this paper presents five oral histories of distinguished female leaders in STEM fields that are now archived at the IEEE. The IEEE Oral History Collection is an important component of the activity to preserve, research, and promote the historical role of women in engineering, and the Center intends to continue to cooperate in efforts such as the one presented here.

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The authors thank the oral history interviewees: Dr. Mildred Dresselhaus,¹⁶ Ms. Deborah Anderson,¹⁷ Dr. Jennie S. Hwang,¹⁸ Dr. Elizabeth Pate-Cornell,¹⁹ and Dr. Heidi Ries.²⁰ Dr. Dresselhaus¹⁶ is a Professor of Physics at Massachusetts Institute of Technology in Boston, Massachusetts, and was awarded the 2014 Presidential Medal of Freedom from President Obama. Dr. Dresselhaus is a member of the National Academy of Engineering and National Academy of Sciences. Ms. Anderson¹⁷ is the daughter of Joseph Desch, of the U.S. Navy version of the bombe in World War II produced by National Cash Register. Dr. Jennie Hwang¹⁸ is CEO of H-Technologies in Akron, Ohio, and is the first female from Ohio to be elected to the

National Academy of Engineering. Dr. Elizabeth Pate-Cornell¹⁹ is the Burton J. and Deedee McMurtry Professor in the School of Engineering at Stanford University and is a member of the National Academy of Engineering. Dr. Heidi Ries²⁰ is Professor of Physics and Dean for Research at the Air Force Institute of Technology, Wright-Patterson Air Force Base, Ohio.

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