
AC 2011-1325: THE ENGINEERING "PIPELINE" METAPHOR AND THE CAREERS OF FEMALE DEANS OF ENGINEERING

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Myths of Race and Gender: The Engineering “Pipeline” Metaphor and the Careers of Female Deans of Engineering

Introduction

Who does engineering is important, since engineers are key contributors to the design of technologies that shape our world.¹ While women have made significant gains in their proportion of degrees earned and their representation in the professoriate in the past 30 years, they remain significantly underrepresented in engineering.² In 2009, women earned just 17.8% of the 74,387 bachelor’s degrees awarded in engineering in the United States, 23% of master’s degrees, and 21.3% of doctoral degrees. Women currently comprise 12.7% of full-time, tenured or tenure-track engineering faculty, and 7.7% of “full” professors.³ Understanding the career progression of women who have reached a high level of accomplishment in academic engineering careers will inform institutional change strategies aimed at increasing women in STEM.

The metaphor of the “pipeline” is often used to describe the progression of individuals through engineering education and careers, with a student entering the pipeline in middle or high school by taking appropriate math and science courses, proceeding to major in engineering in college, and entering the workforce upon graduation. In the case of faculty members, the pipeline extends through graduate school, an academic appointment, and promotion through the ranks of assistant, associate, and “full” professor. Interviews of women engineering deans illustrate the limitations of the pipeline metaphor for describing the careers of female engineering academics.

Background

The pipeline metaphor reinforces the myth of linearity in education and career progression. Flow through the pipeline is linear, with no provision for changes of direction or speed, and no reentry once one exits, or “leaks” out of the pipe. While not overtly gendered, the unidirectional, constant flow image of fluid in a pipe is similar to that of the (male) ideal worker who gives full attention to his job, without distraction or other demands on his time, and moves through a career with no breaks or changes of direction.^{4,5} The material within the pipe is always moving towards the ultimate goal, without pause or detour.

The National Science Foundation (NSF) institutionalized the pipeline metaphor in the 1980s when it developed a mathematical model to predict the supply of engineers in the United States. The model provided a useful framework for identifying various input streams, such as women and people of color, who differed from the traditional raw material of engineers, and helped to identify particular points at which individuals “leaked” from the system, thereby helping to justify programs for recruitment and retention designed to “plug the leaks.”⁶ The NSF model came under severe criticism in the early 1990s, however, for predicting massive shortages of engineers and scientists that never materialized.^{7,8}

Adelman⁹ critiqued the pipeline metaphor as inaccurate and too restrictive in his analysis of the educational experiences of engineering students. His in-depth review of college transcripts showed that women and men take many routes to completion of an engineering degree, and he

proposed an alternative metaphor of the path or pathway as more realistically portraying human experience in higher education:

“A ‘path’ is a story-line created by a central actor... It is not a paved roadway with exit ramps at set intervals, rather a trail that one constructs along contours of the terrain. One can wander away from a rough trail marked by the footsteps of predecessors, finding another pathway that may fit one’s proclivities and changing values better. One may detour and return, and, in the detour, establish an alternative way to get there from here.”⁹

Tyson and Borman’s interviews with tenured women faculty in chemistry and engineering also found the pipeline metaphor too limited to describe the women’s circuitous career paths. They reject the pipeline’s emphasis on increased throughput as the way to get more women and minorities into science and engineering, as well as the assumption that men and women follow the same pattern in their careers. The pipeline model’s focus on inputs, in this case more young women taking math and science classes in middle and high school and choosing science and engineering majors in college in order to prepare for future careers, deflects attention from the culture and climate of academic departments and workplaces and their impact on women’s career choices.¹⁰

In reality, women and men follow many routes to and through education and career. For women especially, family formation can present challenges to advancement in engineering careers, leading to “pipeline leaks”, particularly for academics. Married women and women with children are less likely than men to enter a tenure-track position upon completion of the Ph.D., and women are less likely than their male colleagues to achieve tenure. Single women who enter tenure-track positions are less likely than their male peers to marry, and women who are married when they obtain their first tenure-track job are more likely than their male peers to divorce. Women faculty are also more likely than men faculty to say that they had fewer children than they wanted.^{11, 12, 13, 14} The pipeline model of the standard academic career does not accommodate time out for care-giving responsibilities. Women engineering academics employ a variety of strategies to accommodate and resist the combined demands of motherhood and a workplace designed for men.

The advancement of women into leadership roles in engineering education has the potential to make engineering as a career more attractive to young women and to encourage women currently pursuing academic careers in engineering to aspire to leadership positions themselves. Of the almost 400 institutions in the United States with engineering programs accredited by ABET, 38 had women in the role of dean of engineering or director of the engineering program in the spring of 2010. Thirty-one additional women have served as dean at some point in the past 20 years, for a total of 69 known women engineering deans (ASEE, personal communication). Deans play many important roles in universities, responsible for faculty recruitment, hiring, and development, as well as setting priorities and allocating resources for their college. The dean’s words and actions help to define the work environment and establish the climate for faculty as well as students. A deanship is also a common stepping-stone to higher academic leadership roles, such as provost or president.^{15, 16, 17} It is therefore important to understand the factors that

facilitate and inhibit female faculty members' aspirations for and ability to succeed in the role of dean.

Methodology

The author has interviewed 21 female engineering deans since 2002 for profiles published in *SWE, Magazine of the Society of Women Engineers*. Two or three women deans are profiled each year, with a goal of illustrating different types of institutions and engineering disciplines. Of the 21 deans profiled to date, 20 are white, one is Hispanic, and one is Asian-American. Five were born outside the U.S. and one in Puerto Rico. The current analysis does not attempt to investigate possible impacts of ethnicity and country of origin. The deans responded to a standard set of questions about their role as dean, their career path, the impact of their career on their personal life, and their perspectives on gender and leadership. Interviewees were given the option of responding to the questions by email or in a telephone interview, and in some cases email responses were supplemented with telephone conversations. The interviews were not recorded, but detailed notes were taken.

After the profiles were published, the author compiled all the responses and coded them to identify themes that emerged across the interviews. Other findings are presented elsewhere.^{18, 19} Since the interviews were explicitly for magazine profiles, there was no promise of confidentiality and no attempt to explore potentially sensitive topics in depth. Nevertheless, this somewhat unscientific sample of women who have achieved important leadership roles in engineering education can provide some insights into the many pathways possible in engineering careers and illustrate the limitations of the pipeline metaphor.

Findings

Several of the women deans profiled took circuitous paths to the deanship, spending time in industry, national labs, or federal agencies at some point in their career, gaining leadership experience through professional society activities and academic service work, overcoming professional setbacks, and balancing the demands of academic life with those of a spouse and children. Rather than proceeding in one direction at a constant rate like fluid in a pipe, their careers changed direction depending on the circumstance and moved at varying speeds according to their surroundings. They explored different forks in the road, took detours around obstacles, and navigated through sometimes difficult terrain, eventually arriving at the dean's office.

Candace Claiborne started out in the oil industry, but as her career progressed she decided to move to academe in order to stay focused on technical work:

"...I also worked in industry before getting my PhD. I wanted to solve the first energy crisis, so I worked in the oil industry, and really enjoyed it – great people to work with, a great boss, I got to do a lot of technical work. Then I had to decide on the next steps, and that would have meant going into management and moving around the country, so I decided to stay technical and work in a university setting." – Candace Claiborne, dean, Washington State University

Diane Dorland decided on an academic career because she thought it would allow her more flexibility to raise her children, and became an assistant professor at age 40:

“My personal path led me from a [university] BS/MS in 1969/70 to industry experience in [state]. After balancing family obligations and career motivation in the late 70’s and early 80’s, I returned to school and received my PhD from [different university] in 1985. My continued commitment to education led me to the newly created chemical engineering department at [another university] in 1986, where I started as an assistant professor just before turning 40.” – Diane Dorland, dean, Rowan University

Sally Ann Keller gained leadership experience at the National Science Foundation and Los Alamos National Laboratory before becoming dean:

“When I look back on my career, I can honestly say I did not spend much time planning any of it. However, what I did do was embrace new and interesting challenges, whether it was the opportunity to go to the National Science Foundation and direct a research program, go to Los Alamos National Laboratory and build a world-class statistical sciences group, or come to Rice and lead a top-ranked school of engineering.” – Sally Ann Keller, dean, Rice University

Three of the women deans did not embark on the pathway to an engineering career until after starting a family, then going back to school:

“I ended up at a small liberal arts school known for their investment in science, and had an extraordinary undergraduate education. I thought I would go to medical school, but got married and had three kids. I was geographically constrained, so I got certified to teach science and math, but I burned out after a couple of years of teaching, so I decided to go back to school. I was able to commute to [university] for bioengineering graduate work. I had to be very focused to juggle family and school – I dragged my kids back at night so I could do my lab work.” – Janie Fouke, former dean, Michigan State

“I was a late bloomer in terms of my career. I married in college and had two children by the time I was 24. I did not start graduate school until I was turning 32, but I finished both the MS and PhD in biomedical engineering at Duke University before my 36th birthday in spite of starting the program without an undergraduate degree in engineering.” – Susan Blanchard, dean, Florida Gulf Coast

“I went back to engineering, I originally graduated in math and chemistry and worked in a medical research lab for a few years, then taught school – ninth grade and eighth grade for two years – then decided that I loved the math and science, and I felt like I could do the engineering, so I went back to school in my twenties and got a BS, MS, and PhD in engineering.” – Linda Lucas, dean, University of Alabama Birmingham

The deans who are mothers sometimes changed direction on their paths to leadership positions, moving to a different institution, cutting back on work hours, travelling at different speeds at different times in their career:

“It was very challenging to have two children a year and a half apart... I got tenure before having kids, and chose to leave [prestigious university] for a less pressured place to raise kids... my husband was willing to be the primary parent, and it was great for the kids...” – Pam Eibeck, former dean, Texas Tech

“...I also have made deliberate choices that have been less than ideal for my career, but were the right choices for my family. For example, I reduced my faculty appointment to half time for about six years so I would have more time to spend with our children when they were young. This delayed my promotion to full professor, but I have never regretted my decision to spend that time with our children.” – Sandra Woods, dean, Colorado State

Motherhood is not the only challenge that may lead to a detour along the path:

“Challenges in my professional life included not being promoted to full professor on the first attempt – a devastating occurrence since I thought that I was doing what I was supposed to do to achieve this goal. I used this as an opportunity to reassess my activities and did what I needed to do to get promoted, which happened without incidence two years later. One thing that surprised me was that a number of very successful male faculty, some of whom were administrators, told me that they, too, had not been successful on their first attempt. So, it is OK to fail, if you learn from the experience and keep moving forward.”- Susan Blanchard, dean, Florida Gulf Coast

Finding the right path for these women required planning, adaptation, compromise, and setting priorities:

“At this point the area I have to be very careful with is time. You can spend 110% doing this job. I’m married and have a son who is 14, so I have to be very careful that I don’t let it be 110%. I recently took my son to Antarctica for two weeks. You have to make those experiences happen. As a family, we have a commitment to getting away, vacations and holidays are important to us. I may get up early and do some emails, but my family is still asleep. I don’t combine business trips with vacations. We take several vacations a year to have absolute complete time together.” – Linda Lucas, dean, University of Alabama Birmingham

“I was committed to building a successful career AND having a rich, fulfilling personal life. I suppose one would say that I wanted to “have it all” in that I did not want to make sacrifices either in my professional development or in having a family. Now, there were compromises along the way, to be sure, but sacrifices? Not really. I feel that I have achieved a great deal professionally, and my life has been indescribably enriched by the experience of being a mother.” – Esin Gulari, dean, Clemson

“I decided that there is more to life than work. My life has been far richer for sharing it with a loving spouse, two wonderful daughters, a couple of dogs, and an assortment of friends and family. Life is hectic, complicated, fun, and always tiring, but never, never boring!” – Eileen Busch-Vishniac, former dean, Johns Hopkins University

Discussion

The careers of these pioneering women deans illustrate the limitations of the pipeline as a metaphor for the preparation and experiences of engineers. Rather than taking a direct route from high school to college, graduate school, tenure-track faculty position, and into administration, about half of the deans interviewed had some experience working in industry, a national laboratory, or a non-engineering field (pre-college teaching) at some point in their career. Two-thirds of the deans found ways to incorporate marriage and children into their lives, sometimes taking a detour from the academic fast-track in order to do so. These women were not being swept along in a pipeline or even driving along a well-marked highway towards the dean's office, but constructed their own pathways, making choices and changing directions as they went, perhaps leaving a trail for others to follow.

While the image of the pipeline can be useful in identifying potential points for intervention, increasing flows and patching leaks, it can be restrictive to view a career in engineering as limited to following a pre-determined course. It is important for young people, especially women, considering or beginning an engineering career to be aware of the multiplicity of pathways open to them in the engineering profession. Some paths may be straighter or more well-established than others, but many routes will eventually bring the traveller to their goal, whatever that goal may be.

Looking beyond the individual to an institutional perspective, employers of engineers need to recognize the potential variability of career paths and be prepared to accommodate rather than marginalize engineers who stray from the idealized model. Universities seeking to increase the number and success of women faculty can implement policies that enable women and men to combine career and family, such as provisions for tenure clock extension, modified duties, or part-time employment. More important than having such policies on the books is creating a culture that ensures faculty who take advantage of family friendly policies are not penalized or considered less serious about their careers.

As the lives of these women deans demonstrate, careers in engineering can be highly variable, not constrained by a pipeline but following a variety of paths, even breaking new trails across the landscape of the profession. In order to benefit from the diverse perspectives of women and other groups currently underrepresented in engineering, educators and employers of engineers must think outside the pipeline metaphor and embrace a broad array of possible engineering career paths.

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