Women's Leadership in Science, Technology, Engineering & Mathematics: Barriers to Participation

Laura McCullough, Department Chair, Physics Department, University of Wisconsin-Stout

Abstract

Despite gains overall, women are still under-represented in leadership positions in science, technology, engineering, and mathematics (STEM) fields. Data in the US suggest around one-quarter of deans and department heads are women; in science this drops to nearly 1 in 20. Part of this problem of under-representation stems from the population pool: only 33% of science and engineering doctorate holders employed in academia are women. Other issues include well-known problems of women's participation in STEM fields: lack of role models, unconscious biases, discrimination, and unwelcoming climates.

This paper examines the primary barriers to women's participation in (1) STEM areas and (2) leadership arenas. Examination of the two suggests that women in STEM fields are particularly susceptible to the barriers and biases facing women who wish to move into leadership positions. The similarity in the barriers in these two areas could lead to an effective double jeopardy for women entering STEM leadership. A distinct lack of research in the area of women's leadership in STEM fields suggests that this is a major problem that is not currently understood and not being addressed.

Introduction

There is a great deal of research available on the lack of gender equality in the areas of science, technology, engineering, and mathematics (STEM). Similarly, there is a large body of literature on the lack of gender equality in leadership areas. Yet there is surprisingly little research into the intersection of these two areas: the subject of women's leadership in STEM fields. This paper will explore the idea that the similar nature of the barriers to women's participation in STEM, and in leadership, makes this an area that should be carefully studied, both in order to identify and understand the unique problems women in STEM leadership may face and to see how the two sets of barriers may interact to compound or reduce the problem of women's participation in STEM leadership.

Women's Participation in Science, Technology, Engineering, and Mathematics

Despite large gains made in several areas in science and technology, women still do not participate equally in all areas of STEM. According to the National Science Foundation (2011), women have achieved near-parity in several fields: mathematics, earth sciences and agricultural sciences. Women are over-represented in biology and the social/psychological sciences. Yet gaps persist in physics, engineering, and computer science (see Figure 1.)

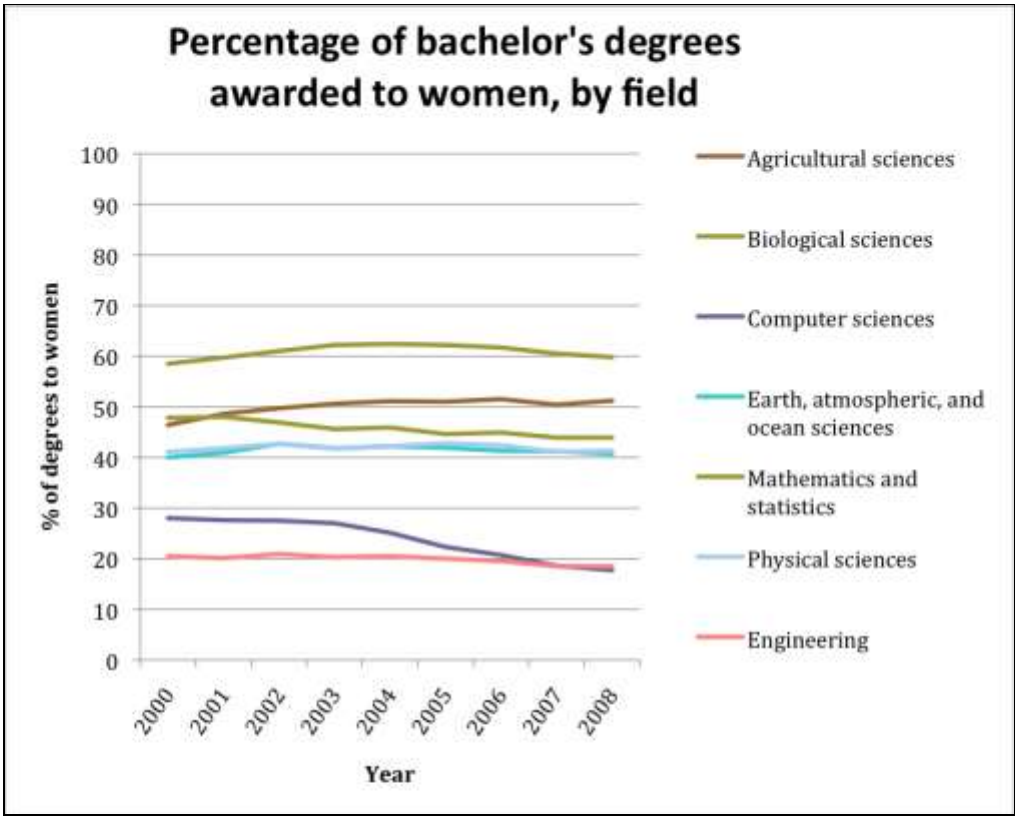

Figure 1. Percentage of U.S. bachelor's degrees earned by women, by field. Data from the National Science Foundation.

In a recently released national report, the US government notes that while women have made significant gains, the areas of science and technology remain a problem (US Department of Commerce 2011, 23): "Women earn the majority of conferred degrees overall but earn fewer degrees than men in science and technology."

Over the years a great deal of research has focused on the causes of this gender gap and possible remedies. Outright discrimination and sexual harassment were the leading problems in the lead-up to the 20th century (Gornick 1990; Rossiter 1982, 1995). As legislation and awareness helped reduce these issues, other problems arose or were drawn into visibility. Covert discrimination in the form of old boys' networks, biased hiring practices, unfair distribution of resources, and chilly climate were exposed to the light, and were found to be just as hard to combat. The latest research on gender differences in the sciences suggests that covert discrimination, implicit biases, career preferences and lifestyle choices are some of the current issues hindering women's participation in STEM.

Discrimination and Implicit Bias

Despite overt sexism being much less common now, covert sexism and discrimination are still major factors that keep women from participating in science and technology. In a study of the factors that help and hurt women in STEM, Settles and colleagues (2006) found that discrimination and harassment were still issues. Xu (2008) noted that women were more likely to leave STEM academic environments than men because of fewer resources and lack of support. A stunning example of covert discrimination is in the report created by women faculty at MIT in 1999. Data on sex discrimination showed just how bad the problem can be: smaller research spaces, smaller start-up packages and salaries, higher teaching loads, and other burdens for women. MIT has recently issued a follow-up report showing the remarkable gains made in supporting women faculty (2011).

Lifestyle choices & family obligations

In January 2005, Harvard President Larry Summers galvanized the field of women and science by suggesting that the lack of participation of women was partly due to the fact that women just didn't want to work 80 hours weeks and spend their life in the lab. In the flurry of media attention following this statement, one oft-cited book was *Women in Science* by Xie and Shauman (2003). In this heavily researched book, the authors discuss and examine various factors that are purported to hinder women. They dismiss several (research productivity, marriage, deficient backgrounds, among others) but show that career paths are affected by choices: constrained or not. Societal constraints can and do force women to make "choices" that often lead them away from STEM.

Female scientists are more likely to be married to other scientists than male scientists are (Xie and Shauman 2003; McNeil and Sher 1997). This presents an interesting situation: who follows whom? Two scientific jobs in one geographic region can be hard to find, so usually one spouse "trails" behind the other. Often, it is the woman who ends up following behind her husband. Women with children are at a particular disadvantage, with less career mobility, less chance of promotion, and a lower likelihood of being in a STEM career (Xie and Shauman 2003).

Lack of role models and mentors

Part of the problem in encouraging women to enter technical fields is that young girls are not presented with many examples of women in the STEM areas. In a study testing how the presence or absence of female role models affects women's career preferences, Stout and colleagues (2010) showed that exposure to female STEM "experts" increased positive attitudes, self-efficacy, and connection with the discipline for female college students. Much of the literature on improving women's participation in science emphasizes the need for role models and mentors (Pritchard 2006; AWIS 1995).

Women's Participation in Leadership

When examining the literature relating to barriers to women in leadership, one sees a remarkably similar theme to what one finds with women and STEM. In *Through the Labyrinth* Eagly and Carli (2007) discuss what hinders women's leadership potential and argue that the glass ceiling is no longer a proper analogy. Women have broken through and are in positions of power; the barrier is not impenetrable. Nor is it transparent. Instead, they propose the idea of a labyrinth: there are many possible routes and many dead ends. Wrong turns and backtracking are likely and common, yet there is a successful (though not visible) path to a worthwhile goal—leadership. What are these dead ends and wrong turns?

Discrimination, Prejudice and Bias

Do women and men prejudge women's leadership abilities? Are they biased in favor of men and against women as leaders? There are two main types of research looking into the idea of discrimination and bias in this area. The first type of study is the correlational study: how do women's salaries compare to men, based on various factors? How do women's advancement rates compare to men's, taking into account performance? These sorts of studies have demonstrated that even when background factors are accounted for, women still advance slower and are paid less than men. Another type of study is the experimental case, where biases are examined in a laboratory setting, often involving college students. In these clinical studies, both men and women exhibit biases against women as leaders (Eagly and Johnson 1990). Eagly and Carli (2007) provide a thorough review of the literature, and conclude that biases do exist and are a particularly difficult obstacle.

One example of prejudice women face is in the area of negotiation. Women are not expected to be aggressive or to ask for things; this means that women often lose out in situations where men would negotiate higher salary, start-up packages, bonuses, or resources (Babcock and Laschever 2003). Virginia Valian (1999) quantifies the many small biases against women in business and other cultures, and discusses the accretion of these small biases and the long-term effects on the progress of women in leadership positions.

Family obligations

Women continue to do more of the household and child care work than men do, despite gains made in the last decades. Because women are more likely to take part-time employment, sick days, and family leave, they are slower to be promoted to positions of power. Until men participate equally in child care and household chores, women will have an additional barrier to leadership. Domestic and family responsibilities remain a major issue for female leaders (Kochanowski 2010).

Lack of role models and mentors

As in scientific and technical fields, a lack of role models and mentors provides another barrier to women aspiring to leadership positions. Eagly, Johanessen-Smith, and van Engen (2003) open their article on leadership styles by noting the severe shortage of female chief officers (1% of Fortune 500 CEOs are women). It's hard to envision yourself as a president or chief officer when you've never seen someone who looks like you in that position. A similar problem exists when women do make it into the corner office. Unless she has an advocate and role model, a female leader is likely to face a host of problems that a man would not and she will have no one to support her and back her up. One example of the importance of advocacy is the case where a woman proposes an idea in a meeting, it is ignored, and later a man proposes the same thing and it is applauded. An advocate could deflect the attention back to the woman who originally shared the idea.

Different Leadership Styles and Expectations of Leaders

There is a great deal of research on leadership styles. The most commonly referenced are the three proposed by James MacGregor Burns (1978): transactional leaders, transformational leaders, and laissez-faire leaders. While historically male leaders have evinced transactional styles of leadership (keeping people in line, giving direction, praising and punishing), a new style of leadership has emerged that focuses on inspiring workers, promoting innovation, serving as a role model, and building community. This style, termed transformational leadership, has been shown to be a more effective method of leading people (Eagly et al. 2003). This is true in academic environments as well (Isaac et al. 2010; Brown and Moshavi 2002). Women are more likely to exhibit transformational leadership styles (Eagly et al. 2003; Guadagno and Cialdini 2007). In a study of female university presidents, Madsen (2008) noted that these successful women often had an androgynous leadership style, with both instrumental and expressive qualities. Expectations of leadership style from someone of a particular gender can be problematic when a leader does not follow gender norms.

The Double Bind

One of the issues that women face involves several of the previous barriers. Women are expected to be nurturing and communal, yet leaders are supposed to be forthright and agentic. When a woman acts agentically, she is often viewed negatively or with hostility since she is acting outside of her gender norms. This is just one of several “double binds” that women face. Kathleen Hall Jamieson (1995) proposes five double standards that hinder women’s participation in leadership. The first is the Womb/Brain: women have to choose between being a mother or being a leader. Women who rise in leadership ranks often have no children or delay having children. Conversely, women who choose to stay home to raise children have little or no access to leadership opportunities. This begets a false assumption that a woman must choose between the two. The second double bind is Silence/Shame: “women are condemned for something they are forbidden to do” (ibid 17). Women were not allowed to speak for themselves or others, and then were derided for never standing up and speaking out. The third double bind is Sameness/Difference: when compared against a male norm, women lose whether they claim to be the same as men (and therefore unfeminine) or different from men (and therefore lesser). The fourth double bind is Femininity/Competence: a woman can be viewed as feminine or she can be viewed as competent but not both. The last double bind is Aging/Invisibility: as a woman ages, she become a wrinkled crone but as a man ages he becomes a wise sage. These double binds are just another example of how our society hinders women’s paths to leadership.

Women and Leadership in STEM

What do these barriers mean for those women in science and technical areas who aspire to leadership positions? They certainly face two sets of challenges, in different arenas. Two possibilities present themselves: (1) Women wishing to lead in STEM fields are faced with a double challenge, having to leap hurdles presented both from their chosen content area and their desired position; or (2) women who successfully navigate the barriers in their content area are better positioned to successfully navigate the barriers on the path to leadership.

The lack of available literature on women's leadership in STEM implies that this question is not only unanswered, but relatively unexplored. What little research is available focuses mostly on descriptions of the problem, rather than underlying reasons. Niemeier and Gonzales (2004) report on the numbers of women in STEM leadership positions in the academy. Using data from the Association of American Universities, they write that 90% of engineering departments in the sample had male department chairs and just 2.5% had female chairs (the remaining being of unreported gender). Physical and mathematical sciences were little better, with 88% male and 5.5% female department chairs.

The lack of women in physics leadership positions was a topic of discussion at a IUPAP International Conference on Women in Physics (Gebbie et al. 2002) and a paper was developed with reasons and ways to advance women's leadership in physics. Preparing women for leadership, equitable selection processes, industry and academic responsibilities were just some of the items listed. This was followed up in 2005 with another paper (Williams et al. 2005) making new arguments for the importance of getting women into physics leadership. Yet again, there is little discussion of the underlying reasons for the lack of women in these positions. Solutions to the under-representation are presented with no research exploring the reasons for the problem.

A few researchers have focused on characteristics of successful female STEM chairs: Isaac, Griffin, and Carnes (2010) interviewed medical school departments with female chairs to discover what behaviors and personalities have the most impact on a woman's perceived leadership performance. They report that the most successful women include both stereotypical male and female behaviors: agentic actions as well as communal actions, along with a transformational leadership style. Dominici and colleagues (2009) interviewed female faculty at Johns Hopkins University (including women from medicine, science, and engineering) and found that leadership style, family obligations, and biases including lack of recognition were key factors women proposed for the underrepresentation of women in leadership. Conrad et al. (2010) found that the hierarchical nature of medical school academic departments can hinder women's advancement.

Another paper that discusses women's leadership in STEM is from Page, Bailey and Van Delinder (2009). This more philosophical article proposes that the masculine hegemony in STEM areas is a hidden barrier to women's participation, and some of the proposed solutions such as mentoring are not addressing the culture which is itself a hindrance.

An interesting study from a different perspective is Hopewell and colleagues' 2009 paper in which the researchers examined language in university leaders' speeches for connections between gender and STEM. They found few connections, and usually only when talking about broader diversity issues. If leaders in academe rarely talk about women and STEM, then how much harder is it for a woman in STEM to become a leader?

Eagly and Carli mention briefly that the biases appear to be worse for those women in male-dominated areas: "Resistance to women's leadership is strongest in highly masculine domains…" (2007, 167). They mention that women in these areas may need to behave differently as leaders than women in other areas: "Breakthrough women…would rarely win approval for using a new and different leadership style." (ibid, 167). One other note speaking directly to women and leadership and STEM comes from Madsen (2008, 94): "All of these presidents either majored or stated that they would have majored…in math or science."

Some literature shows obvious connections between the two areas being discussed; mentoring is often cited as a huge aid to supporting women in both science and in leadership. Susan T. Gorman and colleagues (2010) report on how a "mentoring web" at Stevenson University has promoted growth in their School of the Sciences. Brown University's ADVANCE program has included peer-mentoring groups to support women in STEM (no author 2010).

Other research also suggests an analogue between the two areas under consideration. Women pioneers in leadership positions were often advised to "act like a man": the power-dressing suits, never showing emotion, playing hardball (Grogan & Shakeshaft 2011). Similarly, early women pioneers in science often were described as *one of the boys*. They dressed in pants, never wore makeup, were as focused on their science as any of their male compatriots, to the detriment of any family or social obligations (Gornick 1990).

Another similarity exists in a more philosophical realm. One can buy books, read articles, attend workshops on "women's leadership", yet one does not see products espousing "men's leadership". The word "leadership" has historically meant men's leadership. The prefix was unnecessary because leaders were men. Once again this sets up a dynamic where men are the norm and women are different (Grogan & Shakeshaft 2011). The same is true in the nature of science. Many people have studied the nature and philosophy of science and recommended a "feminist science" (e.g. Keller 1985; Schiebinger 1999) Yet no one mentioned "masculinist science"; it was simply "science". Again, the way men did science was the norm; to do things in a more feminine or feminist way was the outlier. Today, things are shifting to a more neutral tone in both areas. Women's leadership has become transformational leadership, relational leadership, collaborative leadership (Grogan & Shakeshaft 2011). Feminist science has become collaborative science, group science. The idea of the lone (white male) researcher making scientific advances is now accepted as ludicrous. Science is interdisciplinary and dependent upon people working together. Science can happen outside of traditional labs (Eisenhart and Finkel 1998). Women need to see this; society needs to promote this more realistic view of science. Patricia Lowrie (2008) even argues for inclusive leadership in STEM as a way to promote women's participation in STEM fields.

Despite the small bits and pieces presented in this paper, there is an obvious lack of comprehensive research devoted to the theme of women and leadership in STEM fields. In academic circles, department chairs are an ephemeral group to study: many chairs serve 6 years and step down. This may be one reason for the lack of research. The more likely explanation is that there are simply so few women to study because of the severe under-representation of women in these areas that it is difficult to get an accurate picture.

Conclusions

Given the lack of research, it is difficult to say for certain whether women in STEM fields on a leadership path have an easier time or a harder time. Yet the data that is available suggest that there are even more hurdles for female leaders in STEM areas than in other fields; they must overcome barriers both in their content area and in leadership areas.

The issues that hinder women's participation in STEM areas have a large overlap with the issues hindering women's participation in leadership. Implicit biases and discrimination, family obligations, and the lack of role models and mentors are just a few of the problems facing society and the women trying to succeed in their chosen area.

Given the importance of science and technology to national economies and success (e.g. *Rising Above the Gathering Storm*, National Academy of Sciences, 2007 and *Rising Above the Gathering Storm Revisited*, National Academy of Sciences, 2010), the US needs to be promoting STEM and STEM education to everyone. It cannot afford to turn away talented and interested individuals. Not only are women needed in these fields, women are needed to be leaders in these areas both for their own sakes and to serve as role models for the next generation of women in STEM. The lack of research on women's leadership in STEM is itself one more barrier to overcome in pursuit of the critically important goal of truly equitable participation in science, technology, engineering, and mathematics.

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