Gendering Engineering Leadership: Aspirations vs. Shoulder Tapping

Dr. Cindy Rottmann, University of Toronto, ILead

Cindy Rottmann is a Research Associate at the Institute for Leadership Education in Engineering (ILead) at the University of Toronto. Her research interests include engineering leadership, engineering ethics education, critical theory, teacher leadership and social justice teacher unionism.

Dr. Robin Sacks, University of Toronto

Dr. Sacks is an Assistant Professor in the Faculty of Applied Science and Engineering at the University of Toronto teaching leadership and positive psychology at both the graduate and undergraduate levels. Robin also serves as the Director of Research for the Engineering Leadership Project at the Institute for Leadership Education in Engineering which aims to identify how engineers lead in the workplace.

Ms. Annie Elisabeth Simpson, Institute for Leadership Education in Engineering

Annie is the Assistant Director of the Institute for Leadership Education in Engineering at the University of Toronto. Her doctoral work focusses on young women and leadership development. She has her Masters degree in Adult Education and Counselling Psychology. Annie teaches courses, designs experiential curriculum, and contributes to the strategic direction of ILead.

Dr. Doug Reeve P.Eng., University of Toronto

Professor Reeve is the founding Director of the Institute for Leadership Education in Engineering (ILead) at the University of Toronto. Providing opportunities for leadership learning has been central to his work with engineering students for over twenty-five years. Dr. Reeve is a professor in the Department of Chemical Engineering and Applied Chemistry and served as Chair from 2001-2011.

Gendering Engineering Leadership: Aspirations vs. Shoulder tapping

Introduction

Despite some progress, women and other minoritized groups continue to be under-represented in faculties of engineering and engineering workplaces [1-4], a disparity that intensifies at each stage of an engineers' career [5, 6]. Our primary objective in this paper is to examine an unexpected finding emerging from our study of engineering leadership—the significant over-representation of men in engineers' identification of exemplary leaders. We explore two possible explanations for this finding—individual women's disinterest in leadership and structural constraints limiting their rise. We use a post-hoc statistical analysis to examine the former and a focused literature review to generate hypotheses about the latter.

Methodology

Data for this paper was drawn from larger study on engineering leadership driven by three research questions: 1) What is engineering leadership? 2) What are the skills and traits of successful engineering leaders? and 3) How can engineering educators better prepare engineers for leadership? Phase one of the study responded to the first question. It involved a grounded theoretical [7, 8] analysis of transcripts from focus groups with 45 engineers employed by four engineering-intensive organizations. This qualitative phase led us to construct three professionally relevant leadership orientations for engineers—*technical mastery* (the "go to" engineer for technical questions), *collaborative optimization* (engineers who build high performing teams), and *organizational innovation* (engineers whose creative ideas drive the company) [9, 10]. Our second phase involved a survey to test our grounded theory of engineering leadership with a larger sample of engineers. This survey helped us respond to our second research question [11].

This paper presents our post-hoc examination of an unintended finding from phase two of our project—our survey of engineers working for two international organizations with head offices in Canada. We sent the survey link to key leadership personnel at our two partner organizations and invited them to distribute it to their engineers. Our contact at the smaller organization distributed the survey to all engineers working across provincial locations, while our contact at the larger organization distributed it to a sample of (primarily junior) engineers working at the central office. According to our records, 288 employees opened the survey and 175 completed it. Please see table one for a summary of our sample characteristics.

Our sample is younger and less experienced than engineers in the country with a slight over-representation of chemical and mechanical engineers. The gender split (74% men, 26% women) reflects that of Canadian engineering graduates over the past two decades. We used Cronbach's alpha to test the reliability of survey scales using the full complement of data collected (n=75, 31 survey items, 3 scales) and found that all three scales met the social science reliability threshold of 0.7 [12]. After analyzing data related to the three engineering leadership orientations and answering our initial set of research questions, we decided to examine defining characteristics of individuals identified by our participants as exemplary engineering leaders. It was at this point that we noticed a significant over-representation of men in the pool of highly esteemed leaders.

In this paper, we use a factor analysis and Chi-Square Goodness of Fit test to examine one possible reason for this disparity—a gender difference in engineers' leadership aspirations. We then use a focused literature review to hypothesize two alternative explanations for our finding.

TABLE 1: SAMPLE CHARACTERISTICS

Category	Sub-Categories	% of Sample
Sex	Male	74
	Female	26
Age	20-29	43
	30-39	33
	40-49	10
	50-59	10
	60+	4
Engineering Experience (years)	0-2	22
	3-5	24
	6-10	25
	11-20	11
	21-30	10
	31-44	8
Leadership Roles	Engineer in Training	21
	Engineer, not management	31
	Middle management	35
	CEOs/Directors/Executives	13
Discipline	Chemical	30
	Mechanical	28
	Electrical	10
	Materials	7
	Other Engineers	12

Methodological limitations

Our first methodological limitation emerged from our decision to use a convenience sample [13]. While this sampling strategy allowed us to pilot the survey in an efficient manner with supportive industry partners, it prevents us from generalizing our findings to the full population of North American engineers. Our second methodological limitation was a consequence of our small sample size. We had initially planned to use inferential statistics to analyze our data, but the data points feeding into our scales failed to meet the assumptions of normality and heterogeneity of variance underlying these tests. Thus we could not legitimately conduct parametric tests such as t-tests or analyses of variance. We were, however, able to use descriptive statistics and non-parametric tests to analyze our data. Our final methodological limitation relates to the post hoc nature of our analysis. The gendered nature of leadership was not an explicit focus of our study. It was our early parsing of data that led us to isolate participant sex as an interesting variable for study. Please read our findings with these limitations in mind.

Findings

Our interest in explaining a demographic trend in participants' exemplary leadership identification led us to ask the following two research questions:

1) How do engineers' peer-identified leadership exemplars break down by sex?
2) Can the significant over-representation of men in participants' identification of ideal leaders be attributed to differing leadership aspirations between men and women?

These questions structure our findings.

1) How do engineers' peer-identified leadership exemplars break down by sex?

The 175 engineers who completed our survey were asked, among other things, to identify three ideal engineering leaders in relation to the three leadership orientations that emerged from phase one of our study—technical mastery; collaborative optimization; and organizational innovation [9, 10]. The prompts for these orientations were as follows: "Imagine the person you go to most often with your technical questions (Technical Mastery)," "Imagine the person who builds high performing teams by bringing out the best in everyone (Collaborative Optimization)," and "Imagine the person whose creative ideas drive the company (Organizational Innovation)." They were asked to indicate the sex and organizational role of each individual and evaluate the CEAB-based skills (Canadian version of ABET) and traits of these individuals. We will be presenting our analysis of the leadership orientations, skills and traits elsewhere [11], but for this analysis, we examine how our participants' 443 ideal leaders broke down by sex. Please see figure 1 below for an illustration of our findings.

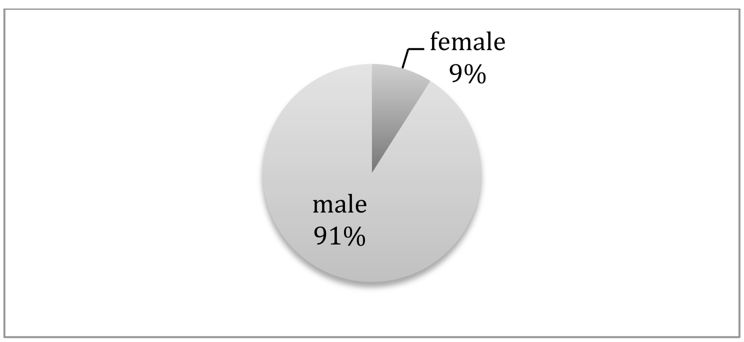
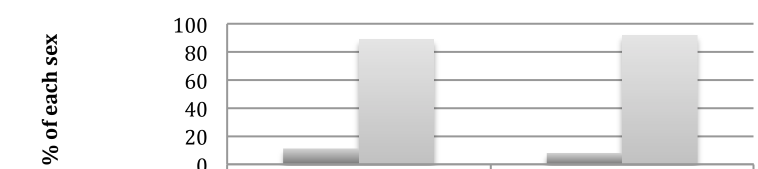


FIGURE 1: SEX OF ENGINEERS IDENTIFIED AS EXEMPLARY LEADERS BY ENGINEERING COLLEAGUES

We conducted a Chi-square goodness of fit test (non-parametric equivalent of a one sample t-test) and found a significant difference between engineers' selection of exemplary leaders by sex X^2 (1, N=148)= 99.78, p<.001, very large effect size (Cramer's V=0.67). Given the considerably greater proportion of male over female engineers from whom to choose; however, we decided to re-run the tests to match the sex ratio of men to women in our sample. Even with this adjustment, participants significantly favoured male leaders in numbers greater than would be expected by chance given their workplace distributions X^2 (1, N=148)=25.04, p<.001, small effect size (Cramer's V= 0.17).

Women in our sample were slightly, but not significantly, less likely than men and older engineers to do this. Please see figures 2 and 3 below for these findings.



	F participant	M participant
Chose F Leader	11	8
Chose M leader	89	92

FIGURE 2: SEX OF IDEAL LEADER BROKEN DOWN BY SEX OF PARTICIPANTS

Figures two and three suggest that the background characteristics of engineers are unlikely to mediate their over-identification of male colleagues as ideal leaders.

	20-29	30-39	40-49	50-59	60+
Chose F leader	10	10	7	7	0
Chose M leader	90	90	93	93	100

FIGURE 3: SEX OF IDEAL LEADER BROKEN DOWN BY AGE OF PARTICIPANTS

Leaving background demographics of evaluators aside, there are several possible explanations for our findings. The first one is easy to test. If we assume that engineers mostly select ideal leaders from among the pool of colleagues who occupy formal leadership roles, it is possible that our 91% selection of male leaders is a reflection of the available pool of candidates. Our data suggests that this may be part of the story, since the percentage of men in formal leadership roles (80%) is greater than the percentage of men in the sample as a whole (74%). However, given that this percentage is not sufficiently high to explain the over-representation of men among engineers identified by participants as exemplary leaders (91%), there must be another set of contributing factors. It is possible, for example, that male engineers make better leaders than female engineers, that engineers have been socialized to think of men as better leaders than women, and/or that male engineers are more attracted to the idea of leadership than are female engineers. We lack the data to test the first two hypotheses, but our response to the next research question sheds some light on the third.

2) Can the significant over-representation of men in participants' identification of ideal leaders be attributed to differing leadership aspirations between men and women?

We measured the leadership aspirations of men and women by comparing the percentage of men and women who prioritized the "organizational/group influence" scale emerging from our factor analysis of survey data. Factor analysis is a data reduction strategy used by social scientists to reveal latent constructs underlying self-report survey items. It is based on an adjusted correlation matrix and tells us how much of the variance in participants' responses can be explained by underlying variables. In total, we found that 63% of participants' item response variance was explained by the four factors below:

- F1: Technical Skills & Innovation (explained 26% of the variance)
- F2: Collaboration & Social Networking (explained an additional 18% of the variance)
- F3: Organizational Planning & Influence (explained an additional 10% of the variance)
- F4: Entrepreneurial Aspirations (explained an additional 9% of the variance)

Please see table 2 for our factor analysis pattern matrix with ten sample items. Factor loadings with an absolute value above 0.4 are highlighted as they indicate "high" loadings [14]. If two items are highlighted with the same shade, it means individuals either tended to agree or disagree with both. If two items are highlighted with different shades, it means there was either no relationship between participants' responses to the items or individuals who agreed with one item, tended to disagree with the other.

TABLE 2: PATTERN MATRIX[a] FOR FACTOR ANALYSIS (N=175)

	Factor			
Sample Items	1	2	3	4
As a junior engineer when dreaming about my future I imagined... | Doing technically complex work	.868	.048	-.030	.007
When beginning a new project I focus on... | Technical complexities and tasks	.644	-.011	.037	-.001
I derive satisfaction from... | Seeing my innovative engineering ideas put into practice	.618	-.136	.230	.116
During my years as an engineering student I spent my time... | Building social networks	-.147	.791	.022	.009
As a junior engineer when dreaming about my future I imagined... | Being part of great engineering teams	.250	.679	.096	-.050
When beginning to work with a new team I... | Inspire my team with \"the bigger picture\" of the project	.137	-.044	.788	-.040
I derive satisfaction from... | Thinking strategically about organizational growth	.006	-.132	.695	.074
When beginning a new project I focus on... | Team dynamics	-.115	.159	.492	.030
As a student, when dreaming about my future I imagined... | Launching a start-up driven by my innovative ideas	-.014	.023	-.011	.938
As a junior engineer when dreaming about my future I imagined... | Launching a start-up driven by my innovative ideas	.038	.091	.036	.776

a. Rotation converged in 6 iterations.

The reduction of 31 survey items into four scales provided us with some useful feedback about our survey at the same time as it allowed us to isolate a "leadership" factor independent of gendered notions of technical and collaborative orientations. After isolating survey items contributing to each of the four underlying factors and providing each participant with a mean score for each factor, we graphed the percentage of people whose highest mean score corresponded with each factor. Please see figure 4 for the distribution of priority factors across our 175-person sample.

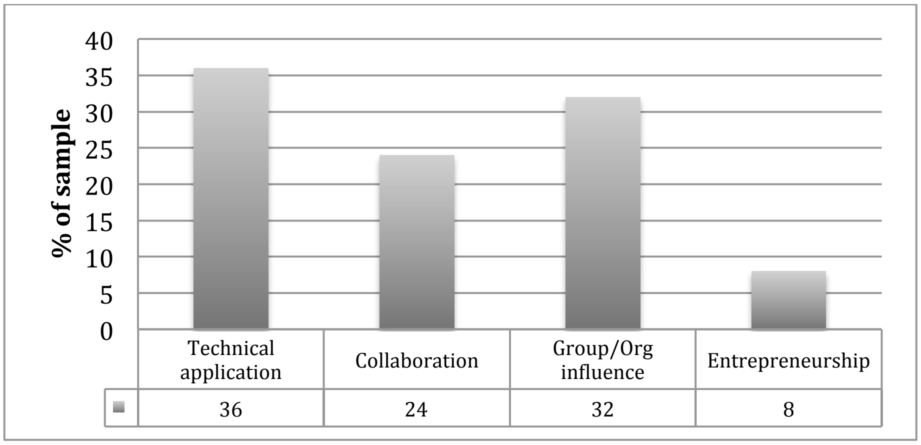


FIGURE 4: SAMPLE DISTRIBUTION OF PRIORITY FACTORS

Given our interest in examining the leadership aspirations of male and female engineers, we broke the "Organizational/Group Influence" bar down by sex. Please see figure 5 for our findings.

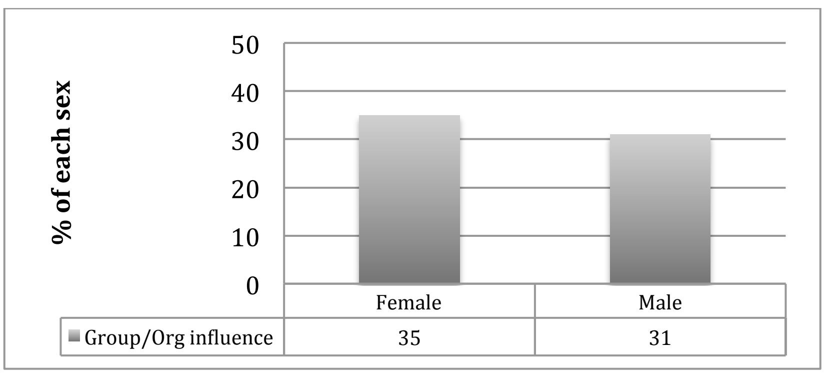


FIGURE 5: LEADERSHIP ASPIRATIONS BROKEN DOWN BY PARTICIPANT SEX

As figure 5 illustrates, men and women tended to prioritize leadership over the other three factors at about the same rate. If anything, women were slightly more rather than less likely to prioritize leadership. This finding challenges the hypothesis that men are more likely to be identified as ideal leaders because they are more likely to aspire to leadership roles that involve group or organizational influence.

Discussion: Examining the literature on women in leadership for alternative explanations

It may seem unorthodox to conclude a conference paper with a literature review, but given the secondary nature of our analysis, our limited data collection on gender at the organizational or societal level, and the increasingly implicit nature of gender-based discrimination, we decided to extend our work by reviewing the literature on factors constraining women's rise to leadership.

Wellington, Brumit and Gerkovich examined barriers constraining women's rise to leadership by surveying 825 executives of Fortune 1000 companies. In order of importance, the executives believed the following factors were holding women back: limited line experience, limited access to informal networks, stereotypes about women's abilities, failure of top leaders to assume accountability for women's advancement, lack of role models, commitment to personal or family responsibilities, lack of mentoring, lack of awareness of organizational politics, different behavioural style from the organizational norm, lack of opportunities for visibility and inhospitable corporate cultures [15]. Their survey results suggest that organizational constraints and gender role stereotypes, rather than limited leadership aspirations or limited skill sets among women are to blame for the lack of gender parity in senior leadership positions. We examine these two factors in greater depth below.

Eagly and Karau attribute the underrepresentation of women in leadership to the incongruity of socially sanctioned gender roles and leadership roles [16]. Their theory suggests that gender role stereotypes of men as agentic (decisive, focused on action, operating independently) and women as communal (concern for the welfare of others, collaborative, operating interdependently), combined with the organizational role stereotype of leaders as agentic cause many individuals to perceive men as natural leaders and women as natural caretakers. When women act in ways that are consistent with the gender role stereotype—communally—they are viewed as non-leaders, and when they act in ways that are consistent with the leader role stereotype—agentic—they are viewed as inappropriately masculine. Thus, regardless of a particular leader's behaviour, women are more likely to be judged critically than are their male counterparts. Faulkner makes a similar argument in her ethnographic study of engineers employed by an engineering and architectural firm in the UK [17]. In particular, she found that participants' stories about "real" engineering separated the technical and social domains, elevating the former over the latter. This dominant narrative about engineers' true professional identities (technical problem solvers), when combined with socially constructed stereotypes of men as technical experts and women as social experts, led to professional tensions and a narrowing of organizational scope. Joshi conducted an quasi-experimental study with research lab teams in science and engineering and found that both men and women tended to rate men's expertise more highly than women's, and that male evaluators tended to rate their female peers less favourably when those peers were highly educated [18]. Finally, Tonso has written a number of persuasive articles highlighting the implicit infusion of masculine tropes in engineering education and engineering identity construction [19-22]. Together, these articles suggest that gender role stereotypes combine with dominant discourses about leadership and professional identity to shape our evaluation of an individual's competence. Relating these concepts back to our survey findings, it is possible that the engineers in our sample evaluated women more harshly than men because of a perceived incongruity between gender roles, leadership roles and engineering identity.

Ragins and Sundstrom focus less on social stereotypes and more on the sex-differentiated access to material resources and organizational power experienced by aspiring leaders [23]. Compared to men, these researchers found that women's access to jobs, resources, social networks, promotion and power resembled an obstacle course. The divergent career paths experienced by men and women allow men to rise faster and farther than their equally competent female counterparts. The limited visibility of these divergent paths allows organizations to maintain gender inequity in senior leadership roles without breaking human rights law. Bobbitt-Zeher examined human rights cases of sex discrimination in a mid-western state over a 15 year period and found that discretionary policy—rather than sexual harassment or other forms of overt prejudice—was a major mechanism for retaining organization-wide sex discrimination [24]. This was particularly pronounced in male dominated workplaces. Finally, Simpson examined how gender imbalance at different levels of an organization affect female managers and found that gender parity, particularly at the senior management levels creates a culture that is more conducive to the rise and well-being of aspiring female leaders.[25]. Together, these three articles highlight the importance of equitable access to organizational resources for men and women aspiring to leadership. In relation to our finding that men were over-represented in survey participants' identification of ideal engineering leaders, it is possible that organizational streams, tracks, norms, policy decisions, gender parity at senior leadership levels, networks and other structural resources implicitly privileged the rise of male engineers over their female colleagues. The resulting over-representation of men at the top of the organizational hierarchy, along with their increased access to resources and power might then increase the likelihood that men will be identified as ideal leaders over equally competent women.

These two variables—1) gender-role stereotypes about leadership and engineering identity [16-18] and 2) sex-differentiated access to social and organizational resources [23-25]—cannot reveal the true story behind our numbers, but they do allow us to frame our post-hoc analysis by adding a level of explanatory grist to an unintended finding in our engineering leadership survey.

Conclusions & Implications for Engineering Education

Our findings suggest that while male and female engineers are attracted to leadership at a similar rate, men are considerably more likely than their female counterparts to be identified or "shoulder-tapped" by both male and female colleagues as exemplary leaders. One implication of this finding for improved gender equity in engineering leadership is that promotion on the basis of "shoulder tapping" or "fit" is more likely to privilege men than is promotion on the basis of individuals' aspirations or working preferences. Allowing male and female engineers to self-identify for leadership opportunities is one of many human resources strategies to reduce demographic disparities in the engineering profession. A related implication for engineering education is to help engineers unpack their assumptions about leadership, engineering identity and socially sanctioned gender roles. Exposing students to Eagly and Karau's role incongruity theory of prejudice toward female leaders [16], Faulkner's institutional ethnography of an engineering and architectural firm [17], Simpson's analysis of gender imbalance and organizational fit [25], and Joshi's [18] and Tonso's [20, 21] gendered analyses of engineering teams might help them engage in this process. Finally, engineering leadership researchers interested in replicating or explaining our findings would be well advised to design a study examining gender role stereotypes of evaluators and gender-divergent career paths in engineer-intensive organizations.

References

1. ASCE, *Land of plenty: Diversity as America's competitive edge in science, engineering, and technology.* Leadership and Management in Engineering, 2001. **1**(4): p. 27-30.
2. Holmes, M., *Understanding our history: From "Betty, girl engineer" to dean of engineering.* SWE Magazine, 2013. **59**(2): p. 28-33.
3. Layne, P., *In their own words: African-American women scientists tell their stories* SWE Magazine, 2007. **53**(2): p. 22-28.

4. NSERC, *Women in Science and Engineering in Canada*, 2010, Corporate Planning and Policy Directorate, NSERC: Ottawa. p. 82.
5. Bhatia, S. and J.P. Amati, *"If these women can do it, I can do it, too": Building women engineering leaders through graduate peer mentoring.* Leadership and Management in Engineering, 2010. **10**(4): p. 174-184.
6. Fouad, N., *Leaning in, but getting pushed back (and out)*, in *American Psychological Association Annual convention*2014: Washington, DC.
7. Glaser, B., *The constant comparative method of qualitative analysis.* Social Problems, 1965. **12**(4): p. 436-445.
8. Glaser, B. and A. Strauss, *The Discovery of Grounded Theory*. 1967, Chicago: Aldine. 271.
9. Reeve, D.W., et al. *Engineer leadership in organizations and the implications for curriculum development*. in *Canadian Engineering Education Association Conference*. 2013. Montreal, QC.
10. Rottmann, C., R. Sacks, and D.W. Reeve, *Engineering leadership: Grounding leadership theory in engineers' professional identities.* Leadership, 2014: p. 23.
11. Reeve, D., C. Rottmann, and R. Sacks. *The ebb and flow of engineering leadership oprientations*. in *American Society of Engineering Education Annual Conference and Exposition*. 2015. Seattle, WA.
12. Kline, P., *Handbook of Psychological Testing*. 2nd ed. 1999, London: Routledge. 752.
13. Miles, M.B. and A.M. Huberman, *Qualitative data analysis: An expanded sourcebook*. 2nd ed. 1994, Thousand Oaks: Sage.
14. Field, A., *Discovering Statistics: IBM SPSS Statistics*. 4th ed. 2013, London: Sage. 916.
15. Wellington, S., M. Brumit Kropf, and P.R. Gerkovich, *What's holding women back?* Harvard Business Review, 2003. **81**(6): p. 18-19.
16. Eagly, A.H. and S.J. Karau, *Role congruity theory of prejudice toward female leaders.* Psychological Review, 2002. **109**(3): p. 573-598.
17. Faulkner, W., *"Nuts and bolts and people": Gender-troubled engineering identities.* Social Studies of Science, 2007. **37**(3): p. 331-356.
18. Joshi, A., *By whom and when is women's expertise recognized? The interactive effects of gender and education in science and engineering teams.* Administrative Science Quarterly, 2014. **59**(2): p. 202-239.
19. Tonso, K.L., *Advancing women in leadership: Violence(s) and silence(s) in engineering classrooms.* Advancing Women, 1997. **1**(1): p. 1-16.
20. Tonso, K.L., *Student engineers and engineer identity: Campus engineer identities as figured world.* Cultural Studies of Science Education, 2006. **1**(2): p. 273-307.
21. Tonso, K.L., *Teams that work: Campus culture, engineer identity, and social interactions.* Journal of Engineering Education, 2006. **95**(1): p. 25-37.
22. Tonso, K.L., *Violent masculinities as tropes for school shooters: The Montreal Massacre, the Columbine Attack, and Rethinking Schools.* American Behavioral Scientist, 2009. **52**(9): p. 1266-1285.
23. Ragins, B.R. and E. Sundstrom, *Gender and power in organizations: A longitudinal perspective.* Psychological Bulletin, 1989. **105**(1): p. 51-88.
24. Bobbitt-Zeher, D., *Gender discrimination at work: Connecting gender stereotypes, institutional policies and gender composition of the workplace.* Gender & Society, 2011. **25**(6): p. 764-786.
25. Simpson, R., *Gender mix and organizational fit: How gender imbalance at different levels of the organization impacts on women managers.* Women in Management Reveiw, 2000. **15**(1): p. 5-18.