

Article

An Educational Intervention Designed to Increase Women's Leadership Self-Efficacy

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Women are sparsely represented in leadership in academic science, technology, engineering, mathematics, and medicine (STEMM). Cultural stereotypes about men, women, and leaders influence the attitudes, judgments, and decisions that others make about women and the choices women make for themselves. Multilevel interventions are needed to counteract the impact of these pervasive and easily activated stereotypes, which conspire in multiple ways to constrain women's entry, persistence, and advancement in academic STEMM. We describe an individual-level educational intervention. Using the transtheoretical model of behavioral change as a framework, we assessed the success of a semester course on increasing women's leadership self-efficacy for the first three cohorts of course participants ($n = 30$). Pre/post questionnaires showed gains in leadership self-efficacy, personal mastery, and self-esteem, and decreases in perceived constraints. Qualitative text analysis of weekly journals indicated increasing leadership self-efficacy as course participants applied course information and integrated strategies to mitigate the impact of societal stereotypes into their own leadership practices. Follow-up queries of the first two cohorts supported the enduring value of course participation. We conclude that providing strategies to recognize and mitigate the impact of gender stereotypes is effective in increasing leadership self-efficacy in women at early stages of academic STEMM careers.

INTRODUCTION

Women are sparsely represented in leadership in academic science, technology, engineering, mathematics, and medicine (STEMM) (Chliwniak, 1997; Valian, 1998; National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, 2006; Hoyt, 2010; Paludi and Coates, 2011). Despite steady increases over the past 40 yr in the num-

bers of women earning doctoral degrees and initiating academic careers in STEMM (Association of American Medical Colleges [AAMC], 2010; National Research Council, 2010), women experience slower rates of career advancement, have higher rates of attrition at all career stages, and remain disproportionately underrepresented among senior ranks at academic institutions across the United States (Martinez *et al.*, 2007; AAMC, 2010; National Research Council, 2010). Compared with their male counterparts, women faculty face a number of barriers to career advancement, including fewer institutional resources (e.g., research opportunities, administrative support, and equivalent compensation). Women are also assigned more "institutional housekeeping" activities, such as committee work and service that are important but less likely to lead to career advancement (Bird and Wang, 2004; Shollen *et al.*, 2009). However, even before entering the professoriate, there is a disproportionate departure of women from STEMM careers (Martinez *et al.*, 2007).

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Rigorous experimental evidence bolstered by numerous real-world examples builds a convincing case that societal gender stereotypes conspire in multiple ways to impede the full participation and advancement of women in the STEM workforce. The pervasive and easily activated stereotypes that men are and should be agentic (e.g., logical, decisive, independent) and that women are and should be communal (e.g., emotional, supportive, dependent) reinforce assumptions that men are intrinsically more competent than women to achieve career success in STEM and especially to lead in these historically male-dominated fields (Eagly and Karau, 2002). These stereotypes affect women's own behaviors and choices, as well as the attitudes, judgments, and decisions others make about women—typically unintentionally and in spite of conscious egalitarian beliefs. Additionally, when a negative performance expectation exists, as with the implicit assumption that women do not lead as well as men, it may cause highly competent women to underperform relative to their actual abilities due to the well-described phenomenon of stereotype threat (Steele, 1997; Correll, 2004; Davies *et al.*, 2005a; Burgess *et al.*, 2012). The National Academies of Science (National Academy of Engineering Institute of Medicine, 2006), among others (Office of Research on Women's Health, 2008; Leboy, 2009), have concluded that multipronged interventions, at the individual and institutional level, are required to address these persistent root causes of gender bias in academic STEM. This paper describes the development, implementation, and evaluation of an intervention at the individual level: a course aimed at increasing leadership self-efficacy in women at the early stages of academic STEM careers.

Why Focus on Leadership?

The stages of an academic STEM career are hierarchical, and competencies in leadership and management are essential to successful career advancement (Bakken, 2002). Numerous leadership theories offer expansive explanations of how leadership affects followers' performance (Northouse, 2007), and studies suggest that leadership education is a useful career developmental tool (Barling *et al.*, 1996; Dvir *et al.*, 2002; Mullen and Kelloway, 2009). Generic leadership advice for all STEM participants ignores the considerable body of research suggesting such advice in the context of socialized gender norms may work well for men in situations in which the stereotypic male and leadership assumptions align, but may actually work against women's ability to be effective leaders (Eagly and Carli, 2007a; Eagly and Karau, 2002). Research on leadership has converged on the existence of three general styles of leaders: transformational leaders who inspire and mentor their subordinates, transactional leaders who largely reinforce the rules of the organization, and laissez-faire leaders who are essentially absent when decisions need to be made (Lowe *et al.*, 1996; Bass, 1999). Transformational leaders have been found to be the most effective across multiple fields (Lowe *et al.*, 1996).

Although gender difference was not examined in a meta-analysis of 200 experimental and quasi-experimental studies of interventions intended to improve leadership, Avolio *et al.* (2009) concluded that such leadership interventions had a positive impact across organization types, leadership levels (although a greater impact at lower levels), leadership theories, and outcomes. The endurance of two long-standing lead-

ership development programs specifically for women faculty in academic medicine and dentistry suggest that such training is effective or at least valued by women (AAMC, 2011; Drexel University College of Medicine, 2011). Our leadership development intervention differs from others by educating participants about the impact of gender and leadership stereotypes and by providing evidence-based strategies that course participants can apply in their own lives to recognize and mitigate the impact of these stereotypes. Our intervention is also unique in targeting women at early-career stages in STEM.

Using a Stages of Change Model to Evaluate Impact

We have previously used smoking cessation as a metaphor for the type of multilevel interventions that will be required to achieve institutional transformation regarding gender equity in STEM (Carnes *et al.*, 2005). Institutional transformation for smoking has inarguably occurred over the past 30 yr. This pervasive change in cultural norms required interventions at the individual level (i.e., get smokers to quit) and interventions at the institutional level (i.e., implement no smoking policies). Research on smoking cessation describes a series of five stages of change that individuals generally go through as they quit smoking (Prochaska and DiClemente, 1983). These stages are: precontemplation (unaware that a problem exists), contemplation (awareness that the current situation, including one's own behavior, needs to change), preparation (planning steps to make the behavioral change), action (engaging in the new desirable behavior), and maintenance (reinforcing the new behavior to prevent relapse). These stages have also been applied to the readiness of institutions to change practices (Prochaska *et al.*, 2001, 2006).

As originally put forth by Prochaska and DiClemente (1983), this "transtheoretical model" (TTM) of behavioral change (see Table 1) integrates tenets of many behavioral change models into four theoretical constructs: 1) the existence of the five general stages of change that individuals (or institutions) go through on their way to adopting a new habitual behavior; 2) decisional balance in which a shift in the "pros" and "cons" of action versus inaction shift in favor of engaging in the new behavior; 3) self-efficacy, which is the self-perceived ability to make and sustain change and which progressively increases as one moves toward action; and 4) processes of change, which are 10 cognitive, affective, and behavioral activities that facilitate change (Prochaska, 2008; Prochaska and DiClemente, 1983; Prochaska *et al.*, 2006).

As they progress through the five stages of change, individuals build self-efficacy and shift their decisional balance to perceive fewer barriers for action and a greater sense of mastery for new behaviors. Although the processes of change may apply to more than one stage, individuals do tend to rely on different processes of change as they progress toward action, and interventions are generally more effective if they are stage-matched (Prochaska, 2008). Building on the conceptual model of smoking cessation, our goal was to develop an educational intervention that would move course participants from being unaware of the impact of gender stereotypes on one's own and others' behaviors (precontemplation) toward engaging in effective, informed actions to help mitigate the negative impact of gender stereotypes on becoming an effective leader. Table 1 lists the stages of change and

Table 1. Stages and processes of change in promoting women's leadership self-efficacy in academic STEM

Stage	Process of change ^a	Conceptually defined codes
Stage 1: Precontemplation	No engagement in any change process	Lack of unawareness of gender bias in STEM; denial of one's own biases; beliefs that women do not advance in STEM careers <i>only</i> because their work or leadership abilities are not as good as men's or because they choose not to participate.
Stage 2: Contemplation	Consciousness-raising	Growing awareness of gender stereotypes and how they impact one's own and other's views of leadership from being confronted with irrefutable research evidence (e.g., from randomized controlled studies with a Goldberg paradigm); becoming "bias literate."
	Dramatic relief	Emotional responses (e.g., anger, guilt, anxiety, exhilaration) from recognizing the influence of gender on past experiences, the interaction of gender and leader role stereotypes on women's leadership success, and the acceptance of one's potential to lead and desire for leadership.
	Environmental re-evaluation	Realizing how gender implicitly influences interpretation of one's behavior and how to use knowledge of gender-based assumptions (e.g., avoid showing anger or appearing to self-promote) to effectively navigate professional situations and enhance career advancement.
Stage 3: Preparation	Self-re-evaluation	Identifying flaws in one's thinking; understanding how socialized gender roles influence one's assumptions, choices, judgments, and behaviors; committing to more effective ways of acting in various professional situations; strategically challenging stereotype-based bias in the workplace (e.g., in the wording of letters of recommendation or assignment of "institutional housekeeping" duties).
Stage 4: Action	Self-liberation	Envisioning, committing to, and ultimately making specific changes in one's behavior to effectively lead or advance toward leadership in STEM (e.g., decide to write a grant proposal or take on an administrative position) and feeling good about it; practicing strategies to avoid the negative impact of stereotype threat on one's leadership effectiveness.
	Social liberation	Identifying opportunities for leadership development for oneself and others.
	Contingency-reinforcement management	Feeling good when one leads effectively; viewing ineffective leadership experiences as learning opportunities; finding reward in helping other women; being empowered by recognizing the influence of gender stereotypes in various situations and knowing how to counteract it.
Stage 5: Maintenance	Helping relationships	Establishing and using supportive relationships among peers, advisors, mentors, and students; discussing negative or positive workplace experiences with members of this network to sustain confidence in leadership and commitment to advancing in STEM; considering the benefits of a career coach.
	Counterconditioning	Observing ineffective leadership behaviors in others; self-monitoring and self-reflection to identify effective and ineffective leadership behaviors.
	Stimulus control	Avoiding situations that allow gender stereotypes to work against one's effective leadership (e.g., making coffee) or that encourage negative evaluation in a leadership position (e.g., adopting an autocratic rather than a democratic style).

^aWavy lines between processes of change signify their importance across more than one stage.

associated processes of change with conceptual definitions that relate to increasing women's leadership self-efficacy in STEM.

Importance of Leadership Self-Efficacy

Self-efficacy derives from the work of Bandura (1977, 1991) and is a cornerstone of the TTM, increasing as one progresses through the stages of change. Leadership self-efficacy refers to an individual's belief in his or her ability to succeed in the capacity of being a leader (McCormick *et al.*, 2002). Several investigators have found that women, particularly at early academic-career stages, are more likely than men to hold low self-efficacy beliefs for leadership (Murphy, 1992; McCormick, 2001; McCormick *et al.*, 2002; Hoyt, 2005). In a study of physician-scientists, Bakken *et al.* (2003) found that self-efficacy for leadership and management skills was lower for women than men, and the difference widened after a standard lecture-format, 3-d research workshop. Self-efficacy beliefs are a useful target for intervention, because they are domain-specific and can be modified through learning experiences, and their improvement can promote career interest and persistence (Betz and Hackett, 1986; Lent *et al.*, 1996; Brown, 1999). Because low leadership self-efficacy puts women in STEM at risk of self-selecting out of career-advancing leadership opportunities (Hoyt and Chemers, 2008), we designed our course to increase women's leadership self-efficacy.

Focusing on interventions to increase leadership self-efficacy as a means to improve women's leadership engagement and effectiveness finds empirical support in the work of Hoyt and her colleagues. They found that women with higher levels of leadership self-efficacy were more likely to identify with leadership (Hoyt, 2005) and were more resilient to the negative impact of stereotype threat invoked prior to engaging in a leadership task (Hoyt, 2005; Hoyt and Blascovich, 2007). Gendered assumptions that women are less able to lead than men make women vulnerable to stereotype threat when faced with leadership tasks. Stereotype threat is a repeatedly documented phenomenon whereby individuals who are members of a group characterized by negative performance stereotypes perform below their actual abilities (Steele, 1997; Steele and Aronson, 1995). Under the threat of confirming the group stereotype, talented and competent individuals essentially become "deskilled" (Steele, 1997; Walton and Spencer, 2009). Stereotype threat can lead to stress (Croizet *et al.*, 2004), negative mood (e.g., anxiety, frustration, disappointment, and sadness; Keller and Dauenheimer, 2003; Brodish and Devine, 2009), increased self-monitoring, a reduction in mental capacity, and a decrease in motivation. The resulting impaired performance (Nguyen and Ryan, 2008; Henry *et al.*, 2009) promotes a downward cascade of self-blame, lowered self-esteem, and eventually disidentification with the domain (e.g., women do not care if they are leaders or not).

Informing potential stereotype threat victims about the phenomenon (Johns *et al.*, 2005) and providing cognitive strategies for reframing a situation and reaffirming self-efficacy (Kray *et al.*, 2001) as a means of reducing the impact of stereotype threat also find empirical support. For example, Johns *et al.* (2005) found that telling female course participants how stereotypes about gender and math ability might cause

anxiety that has nothing to do with actual ability eliminated women's underperformance compared with men. In another study, women who were told explicitly about the effect of gender stereotypes on negotiation and who were advised to work against those negative stereotypes performed as well as men and better than controls in a negotiation task (Kray *et al.*, 2001). Other interventions that provide clear external attributions for anxiety about difficult academic tasks also reduced the impact of stereotype threat on female students' math scores (Good *et al.*, 2003). Particularly relevant to reducing the impact of stereotype threat against women in a leadership context is a study by Davies *et al.* (2005b), which found that activating a female gender stereotype led female participants to choose a subordinate role over a leadership role in a group task. This effect was completely eliminated by prefacing the choice with affirmation that men and women are equivalently qualified to perform both roles. Research both underscores the benefit of educating women at early stages in academic STEM careers about stereotype threat as it relates to leadership performance, and supports promoting leadership self-efficacy as a means to combat the negative impact of stereotype threat.

COURSE DEVELOPMENT AND DESIGN

Development

With the goal of increasing women's leadership self-efficacy, we developed at the University of Wisconsin–Madison (UW–Madison) a 16-wk course titled "Women and Leadership in Medicine, Science, and Engineering." Our needs assessment included reviewing relevant research from several disciplines (e.g., social, cognitive, and organizational psychology; leadership; science education) and the existing course offerings to ensure that nothing was already available to meet our goal. We then developed the syllabus over the course of a year through iterative discussions with a group of four faculty and administrators interested in women's advancement in STEM. The group members had expertise about women in STEM, health behavior, science education, engineering administration, and leadership. The course was piloted for 1 yr, and the actionable feedback received from course participants and instructors was incorporated into the final syllabus. This syllabus was used for the 3 yr of this study. Readings were updated slightly each year or adjusted based on course participants' comments, but key papers, topics, and the class format were the same for all 3 yr. The syllabus with the most recent readings is provided in the Supplemental Material.

This course is listed as an Interdisciplinary Engineering course with cross listings in Medicine and Women Studies. It carries from 1 to 3 credits depending on whether course participants attend the required number of classes and complete assigned exercises (1 credit), perform an additional literature review and present it to the class (2 credits), or perform and present the results of a research project to the class (3 credits). The course meets twice weekly for 1 h and 40 min. We designed the course with the processes of intentional behavioral change in mind (Prochaska *et al.*, 2006), generally attempting to match the course material and activities with stages of change and incorporating principles of scientific teaching to promote deep and transformative

Table 2. Distribution of women students in this study

	Medicine and public health	Letters and science	Engineering	Education	Total
Graduate	6	5	1	3	15
Postdoctoral	9	0	0	0	9
Faculty	1	0	0	0	1
Other	3	1	1	0	5
Totals	19	6	2	3	30

learning (Handelsman *et al.*, 2007). The three basic elements of the course are: 1) learning about gender stereotypes and how they can influence behavior and lead to cognitive biases along with evidence-based strategies to neutralize their impact, 2) self-reflection through weekly journaling, and 3) application of course material to real-world instances through development and discussion of case studies. The course is graduate level, and most students have been graduate students, but participants have included upper level undergraduates, physicians in residency and fellowship training, postdoctoral fellows, academic staff and assistant professors (Table 2).

Design

Weeks 1–5. The format for the first 5 wk is lecture and discussion. During this segment of the course, our goal is to make the course participants “bias literate,” a term coined by the American Association for the Advancement of Science (Sevo and Chubin, 2008) to acknowledge that literacy is a necessary step toward action. Following a general overview of the course, and completion of informed consent and precourse questionnaires, course participants are asked to list off the top of their head societal stereotypes of typical men followed in sequence by stereotypes of typical women and typical leaders. As they examine the lists written on the board, each year few if any of the stereotypic words generated for women occur on the leader list while the lists for stereotypic men and leader consistently show considerable overlap. Course participants are encouraged for the next class to go online and take the Implicit Association Test (IAT), a response latency task that measures implicit attitudes reinforced by societal stereotypes (Greenwald *et al.*, 2002). We recommend that they take several of these, but especially the gender-science and gender-career IATs (Nosek *et al.*, 2011). We discuss the IAT and course participants’ reactions in the subsequent class.

Course participants are assigned three to four readings per week. A supplementary reading list is also provided. For each class, course participants select a reading from those assigned to present in detail and we provide guiding questions to answer or consider in their reading and presentation of the paper. Course participants can access all readings online through the class website. Course readings include some overviews of research, but most are reports of randomized, controlled experimental studies. Many of the studies we review have a “Goldberg paradigm” in which a male- or female-gendered name is arbitrarily assigned to a piece of work, resumé, or application with the consistent finding that both men and women rate work as being of lower quality if they think it was performed by a

woman (Goldberg, 1968; Isaac *et al.*, 2009). Other topics include: gender schemas and how unconscious assumptions about the behaviors and traits of leaders lead to accumulation of advantage for men (Bem, 1974; Holt and Ellis, 1998; Valian, 1998); evolving perspectives of leadership (Bass, 1999; Parks, 2005; Eagly and Carli, 2007a); gender differences in leadership styles (Ridgeway, 2001; Eagly *et al.*, 2003; Rosser, 2003); a review of types of power (Carli, 1999); barriers to gender equity in leadership from a social psychology perspective (Rudman, 1998; Heilman and Haynes, 2005; Heilman and Okimoto, 2007; Thomas-Hunt and Phillips, 2004; Sczesny *et al.*, 2006; Brescoll and Uhlmann, 2008); and topics on implicit stereotyping and methods of social change (Devine, 1989, 2001; Banaji *et al.*, 1993; Steele, 1997; Davies *et al.*, 2005a; Uhlmann and Cohen, 2005, 2007; Sevo and Chubin, 2008; Isaac *et al.*, 2009; Plant and Devine, 2009). We include readings on race, gender and leadership (Cheung and Halpern, 2010; Sesko and Biernat, 2010) to foster reflection of cultural differences. To highlight the complexity of these issues (Johnson *et al.*, 2011), we encourage discussion in class of how race, ethnicity, and culture may intersect with gender to affect the experiences of women in academic STEM.

Weeks 6–16. Critical reflection, application with immediate actionable feedback, and incorporating learned material into one’s lived experience are strategies to promote deep and transformative learning (Howell, 1982; Mezirow, 1990; Gestwicki, 2001; Parks, 2005; Boonyasai *et al.*, 2007; Overton *et al.*, 2009). In weeks 6–16, we invoke these strategies by having each student develop a case study and present it to the class along with questions about how to frame what is occurring and how the actors in the case could most effectively deal with one or more challenging situations. The course participants divide into discussion pairs and are encouraged to reflect on the class readings and incorporate relevant course content into case problem-solving. They reconvene for group discussion led by the author of the case. In addition, for one class session during this block we invite two or three women chairs of STEM departments to informally talk about their careers, particularly how being a woman has affected their experience or decisions. Course participants submit questions to the instructors who compile them and provide them to the chairs in advance of class.

Throughout the course, participants engage in reflective journaling about the readings and the class discussion. Journals are collected twice during the course and at the end with feedback and comments provided to the course participants after each submission.

EVALUATION

Data Collection

We used a concurrent, within-group, pre/post mixed-method design (Patton, 2002; Creswell, 2009; Hesse-Biber and Leavy, 2011) to evaluate the course. All aspects were approved by the Institutional Review Board at UW-Madison. To assess the effectiveness of the class in increasing leadership self-efficacy, we evaluated data from the first three cohorts of course participants who attended the class in 2009, 2010, and 2011. For quantitative evaluation of course participants' leadership self-efficacy and constructs relevant to the TTM, we administered precourse questionnaires to all course participants within the first 2 wk, and postcourse questionnaires after week 14. Pre/post scores for all scales were tabulated and analyzed for significant differences using repeated-measures multivariate analysis of variance (MANOVA) and univariate *F* tests. For qualitative analysis, we performed line-by-line coding (Green and Britten, 1998; Patton, 2002) of each student's journal completed over the duration of the course and email responses to follow-up queries to course participants in the first two cohorts 1–2 yr after completing the course.

Thirty women in total took the course: two African American, two Asian, two Asian American, one American Indian, and one Hispanic, in addition to 22 non-Hispanic, white women. Data from the one male graduate student who took the course were not included. Course participants were recruited through a chain sampling method (Patton, 2002) with flyers, emails to graduate program coordinators, and personal contacts. Table 2 shows the distribution of course participants by discipline and career level.

Measures

Leadership Self-Efficacy. Participants were asked to rate their pre/post efficacy beliefs for leadership using Murphy's (1992) Self-Efficacy for Leadership metric (Murphy, 1992). This general measure of leadership efficacy contains eight statements to which participants respond by indicating their level of agreement on 7-point Likert scales ranging from 1 (strongly agree) to 7 (strongly disagree). Example items include, "I feel that I know a lot more than most leaders about what it takes to be a good leader" and "Overall, I believe I can lead a work group successfully" (Murphy, 1992). Cronbach's alpha indicated high internal reliability for the leadership self-efficacy scale both pre (0.90) and post (0.91).

Decisional Balance. To estimate decisional balance, we utilized the Sense of Control metric operationalized by Lachman and Weaver, which contains two dimensions: personal mastery and perceived constraints (Lachman and Weaver, 1998). Participants were asked to answer both the personal mastery and perceived constraints questionnaires in the context of being a leader. Within a leadership context, we defined personal mastery as an individuals' belief in his or her ability to achieve goals relevant to leadership, and perceived constraints as an individuals' belief that factors beyond his or her control will impede achievement of leadership goals (Lachman and Weaver, 1998). These two constructs were likened to the "pros" (feelings of mastery) and "cons" (perceived constraints) that shift for individuals as they progress through the stages of change and build self-efficacy for en-

acting a new behavior (Prochaska *et al.*, 2006). This Sense of Control measure has been predominantly used in studies on health and well-being, including in the longitudinal study of Midlife in the United States (MIDUS II), and to our knowledge (Lachman and Weaver, 1998; Inter-University Consortium for Political and Social Research [IUCPSR], 2006), we are the first to use it as an indicator of decisional balance for leadership.

For this research, Lachman and Weaver's four statements about personal mastery and eight statements about perceived constraints were used pre- and postintervention to assess decisional balance. Course participants were asked to rate their level of agreement with each statement on 7-point Likert scales ranging from 1 (strongly agree) to 7 (strongly disagree) (Lachman and Weaver, 1998). Example statements about personal mastery include, "When I really want to do something, I usually find a way to succeed at it," and "Whether or not I am able to get what I want is in my own hands" (Lachman and Weaver, 1998; IUCPSR, 2006). Examples of statements about perceived constraints are: "There is little I can do to change the important things in my life," and "I sometimes feel I am being pushed around in my life" (Lachman and Weaver, 1998; IUCPSR, 2006). Cronbach's alpha values for the personal mastery scale were 0.82 (pre) and 0.77 (post); alpha values for the perceived constraints scale were 0.85 (pre) and 0.75 (post).

Self-Esteem. Participants rated their self-esteem in a leadership context on the MIDUS II Self-Esteem metric (IUCPSR, 2006). Items on this measure were adapted from the Rosenberg Self-Esteem Scale (Rosenberg, 1965) and assess individuals' general sense of confidence and personal value (Rosenberg, 1965; IUCPSR, 2006). This measure was included because high self-esteem is linked to willingness to pursue leadership opportunities (Linimon *et al.*, 1984), making a change in participants' self-esteem relevant. The MIDUS II survey contains seven items ranging from, "I am no better and no worse than others," to "I certainly feel useless at times" (IUCPSR, 2006). Participants rated their level of agreement with each of the seven items using 7-point Likert scales ranging from 1 (strongly agree) to 7 (strongly disagree). Cronbach's alphas for pre/post measures were 0.16 and 0.34, respectively, putting the usefulness of this scale for our purposes in doubt.

Qualitative Analysis

To perform line-by-line coding and narrative analysis, we imported all course participants' journals into NVivo (QSR International, Burlington, MA), a textual analysis software program that facilitated coding and analysis (Richards, 2006). Using the stages and processes of change as a framework, we performed deductive thematic analysis (Boyatzis, 1998) on the journals to identify participant learners' perceptions and insights derived from their course-related experiences (Brookfield, 1990; Mezirow, 1990; Branch, 2005; Hesse-Biber and Leavy, 2011). Discussion and interpretation of deductive codes occurred until achieving consensus (C.I., M.C., and A.K.). Coding was done predominantly by the first author (C.I.). Two authors (A.K. and C.I.) independently coded two journals with 89% interrater agreement. We analyzed text from two sources: written journals kept during the class for all three cohorts and email responses to follow-up queries

Table 3. Pre/post questionnaire results

Scale	Means and SDs for measures		<i>p</i> Value
	Beginning of course	End of course	
Self-Efficacy for Leadership	Mean = 5.23; SD = 0.86	Mean = 5.85; SD = 0.77	< 0.001
Self-Esteem	Mean = 4.56; SD = 0.64	Mean = 4.79; SD = 0.62	< 0.001
Personal Mastery	Mean = 6.09; SD = 0.91	Mean = 6.25; SD = 0.63	< 0.001
Perceived Constraints	Mean = 2.12; SD = 0.90	Mean = 1.8; SD = 0.71	< 0.001

with course participants in the first two cohorts 1–2 yr after completing the course. For the latter, the 18 course participants in the first two cohorts were contacted by email and asked to reflect on the class and any aspects of the course that had been useful in their subsequent academic lives. Eight responded. Confidentiality was protected in all text analysis by assigning pseudonyms and removing any personal identifiers from the text.

RESULTS

Pre/Post Questionnaire Responses

Questionnaire data were partially incomplete for three of the 30 course participants, resulting in 28 to 30 participants for individual analyses. Statistical analysis used SPSS version 19 software (IBM, 2011). Scores on related items were combined to create measures for leadership self-efficacy (eight items), self-esteem (seven items), personal mastery (four items), and perceived constraints (eight items). The data were assessed for normal multivariate distribution (Zimmerman, 1994; Behrens, 1997; De Carlo, 1997) and were analyzed with repeated-measures MANCOVA and univariate *F* tests (Coley and Lohnes, 1971; Duntzman, 1984; Glass and Hopkins, 1996; Tabachnick and Fidell, 1996). Class year was added as a covariate to the final model to remove variance attributable to year-to-year differences among classes (Glass and Hopkins, 1996; Tabachnick and Fidell, 1996).

The final MANCOVA model indicated a main effect for pre/post scales (Wilks' lambda $p < 0.001$). Univariate *F* tests for each scale found significance differences in all four scales (Table 3) with no interaction between classes. Results indicated significant increases in course participants pre/post scores for leadership self-efficacy ($F = 30.74, p < 0.001$), self-esteem ($F = 35.07, p < 0.001$), and sense of personal mastery for leadership ($F = 8.56, p < 0.001$), and a significant decrease in perceived constraints to leadership ($F = 18.74, p < 0.001$). All of these changes were in the desired direction. Differences within the individual class years were not as important as participation in the course.

As a group and for the majority of individual class participants, the questionnaires suggested a significant positive effect of the course in the desired direction. However, there were individual differences. The patterns of individual change for personal mastery were influenced to some degree by ceiling effects. All but three of the 28 participants who had complete data were in the top third of the range, and four were at the top score of 7 at both pre- and posttest points. Scores on the post measure went down slightly (0.25 to 0.50) for eight course participants. Scores stayed the same for eight and went up for 12 (0.25 to 2.5). Self-esteem scores were all

in the midranges: individual scores went down slightly (0.14 to 1.29) for nine, stayed the same for three, and went up (0.14 to 1.86) for 15. For personal constraints, three scores stayed the same, seven went up (–0.13 to –0.38), and 18 went down (0.25 to 1.63). Self-efficacy scores went up (0.13 to 3.38) for 19 participants, stayed the same for one, and went down (0.13 to 1.25) for eight. Twenty-three of the 28 participants had a net positive change for the four indicators combined (0.29 to 4.67). Five had net negative changes (–0.09, –0.14, –0.92, –1.18, –2.57).

Mapping Qualitative Data to Stages of Change

All 30 course participants contributed journal entries for weeks 1–5. One student missed journal entries for weeks 6–10 and seven course participants missed journal entries for weeks 11–15, so we compared journals from weeks 1–5 with their combined journals from weeks 6–15. The journal text was deductively coded into the five stages of change with the 10 related processes of change (Prochaska *et al.*, 2006). The processes of change were conceptually defined for our purposes as indicated in Table 1. Figure 1 illustrates the number of course participants with coded text in each stage of change and shows the increasing number of individuals with coded text in stages 3–4 in the second set of journaling consistent with increasing self-efficacy. Only two had text coded as being in stage 5, the maintenance stage.

Stage 1: Precontemplation

Few course participants entered the class with precontemplation statements. This is likely because course participants taking this course have self-selected interest in the topic of women and leadership in STEM. One non-U.S. student indicated that she took the class "because she needed a graduate class in leadership." She was the only student whose journaling text was almost entirely in the precontemplation stage. She often stated and reported in her journal that she had "no problems with bias." One journal entry, in particular, illustrates her response to a class discussion:

I heard a lot of angry voices from our classmates lately, mostly about how many times they have been ignored or treated unfairly because they are women. Did each one of the cases truly reflect the bias against women? Are there any situations where our male colleagues did outperform us? We need to be able to tell the differences and then make the good decisions.—Wan

Although these points were worthy of consideration, her arguments did not lead her to question her own bias. She never went beyond contemplation and had only three coded references within the process of change labeled "consciousness-raising." Three other course

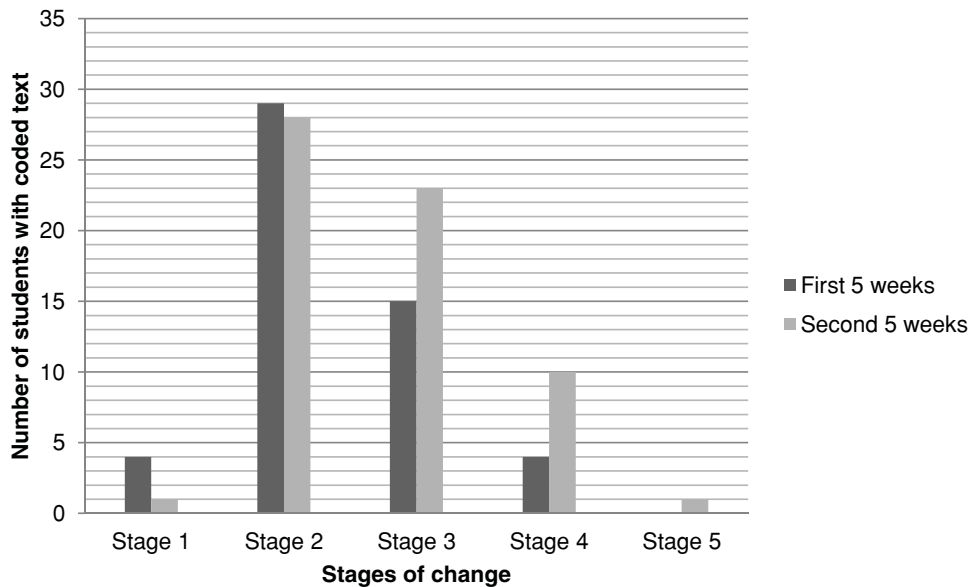


Figure 1. Number of students with coded text at different stages of change in first 5 wk vs. second 5 wk.

participants that had coded precontemplation text moved quickly into contemplation as they were confronted with research evidence of implicit gender bias. One such statement coded as consciousness-raising was,

When I started the class, my thoughts were along the lines of, “I don’t experience gender bias in my work situation, but I’m sure it’s going on in the abstract. It will be interesting to learn about it and see how I can become a better leader.” . . . Of course, one of my ideas coming into this class was that I hadn’t been affected by gender bias in academia. But then we got to the Eagly and Carli article on the labyrinth and again my comfortable preconceptions were shattered.—Mandy

This student moved into the contemplation stage because she found the evidence “indisputable.”

Stage 2: Contemplation

All 30 course participants had text in the contemplation stage; this accounted for 90% of the journal text. This is likely again a reflection that most of these women took the class because they were already interested in the topic. The contemplation stage had coded processes of change including consciousness raising, dramatic relief, and environmental re-evaluation (Prochaska and DiClemente, 1983; Table 1).

Consciousness-Raising. Journal descriptions of course participants’ responses to taking the IAT indicated how the experience provoked them to examine their own bias; such text was coded as “consciousness-raising”:

I took the black/white racism IAT and the gender career/family IAT. [The IAT] gives me hope that I can work on my biases—particularly about gender and career. Turns out, horrifyingly, that I have a moderate bias against women and careers. WHAT!!! After everything I’ve done to establish my own successful career path, how can this be? I guess I’m in the right class. . .—Polly

The second week of class one student reported consciousness-raising, “As the class progresses and we en-

ter week two, I’m nursing a virulent case of discouragement.” This occurred as course participants read excerpts from Valian’s *Why So Slow?* and Eagly and Carli’s *Women and the Labyrinth of Leadership* (Valian, 1998; Eagly and Carli, 2007b). Valian reported that as a woman rises into leadership, the mere fact that she is successful leads people to see her as succeeding against expectations, attributing her success to luck, the task being easy, or hard work rather than competence (Valian, 1998). Course readings illustrate how experiments document that women who display highly agentic traits (associated with male stereotypes) and are clearly competent in male sex-typed positions will be deemed as competent as men, but are viewed as less likable and more hostile than equally successful men (Eagly and Karau, 2002). As highly agentic women assert authority outside of traditionally female sex-typed jobs, they are likely to encounter reactive opposition to their authority (Ridgeway, 2001); women appear to be able to reduce this opposition by “softening” assertive, competent behaviors to increase their influence (Carli, 1999). One student reflected on

The slow, insidious lessons that we must be feminine but not too feminine (we wouldn’t be able to take care of ourselves); smart but not too smart (the boys won’t like us); nice but not too nice (then we’d be easy).—Polly

Course participants during the semester started identifying stereotypes in their surroundings:

[A senior woman during a grant review] commented that a study had proposed a sample including an adequate representation of women. Then she proceeded to make a joke about how they didn’t need to enroll women because “women can’t be trusted anyhow.” In that moment, she undermined the validity of data from female research participants. . . I can’t remember a time that I’ve felt so outraged! I cannot even begin to speculate what motivated that comment. She is a woman scientist—how can she say such a thing? What was a very important professional experience for me also illuminated stereotypes against women. It is disappointing that it exists at all.—Jane

Course participants reviewed a meta-analysis in which Eagly *et al.* (2003) found very little difference in the effectiveness of male and female leaders but noted that when a difference was found, women leaders were more likely to use a "transformational" style, which is considered the most effective leadership style across multiple work environments (Lowe *et al.*, 1996; Bass, 1999). Course participants' own self-conceptions about leadership were altered:

I see all too much laissez-faire leadership around me. . .and the destruction in its wake. . . True to this article, I've gotten mentoring and role modeling from the many remarkable women with whom I work, but little guidance at all from the handful of men with whom I interact regularly. . . What so impressed me with Eagly's paper was just how well the findings correlate with my experiences this year in that the two people I know who use transactional and laissez-faire styles are both men. The women I know in leadership all generally utilize [transformational] styles.—Polly

Other students started identifying their own leadership styles:

I work hard to generate enthusiasm from everyone for differences of opinion and I consciously work to get quieter team members to give input. I actually thought for a long time that this maybe meant that I was not a "real" leader. It is from these readings and this class that I've recognized that this may in fact be a strength.—Madeline

It seems to me that we do not think of ourselves as leaders (which was very true in my case). If we expect for others to see us as a leader, it must first start with self.—Rosalind

Dramatic Relief. The research evidence presented in the studies reviewed in class illustrated constructs that these women had experienced but could not previously identify. The findings often triggered an emotional response coded as "dramatic relief":

I found myself sitting in the first class of this course and listening to the review [the instructor] gave of the topics to be covered in the course and the statistics surrounding unconscious gender bias in the field that I plan to go into. I got choked up.—Chelsea

As course participants progressed through the course, they started identifying and describing their own reactions to implicit bias. Being heard was an important part of dramatic relief:

I think that it is true (and likely, mainly due to socialization into our culture) that many women are soft-spoken and don't speak forcefully during meetings. I have noticed this in myself, but interestingly enough, before this class I always blamed myself. I sometimes feel that if I don't speak assertively or forcefully, it is because I lack self-confidence. While that may still be the case, . . . just because I have been taught, or acculturated to be a certain way, does not mean that I can't still be successful, or be heard in a group.—Tiera

This statement illustrates important reflections relevant to increasing leadership self-efficacy. The ability to attribute her feelings to an external cause is an important neutralizer of stereotype threat (Johns *et al.*, 2005). Lack of confidence and

"not being heard" were important subthemes in the contemplation stage. Several discussed being ignored in a group. Another student talks about being heard:

After reading the papers, I learned that most people believe that men are more scientifically gifted than women, that masculine and leadership traits are intertwined in most people's minds, and that having one's ideas ignored in a group leads to a greater decrease in self-confidence for women than for men. Knowing the first two things helps me to understand why people are more likely to listen to a man and knowing the last helps me to realize why I feel less confident in my own abilities after 7 years of being ignored. Just because someone isn't listening doesn't mean that I don't have a thought worth listening to.—Dahlia

Lack of confidence was a frequent concern for women in this class. Reflection through class discussion and journaling highlighted incongruities:

I wasn't pretty or soft-spoken or quiet and I didn't sit quietly. . . It was a wonderful experience to have [another student] tell me on the first day of class that I didn't need to apologize for being me and being outspoken. It was enormously liberating and the only time in my life I've ever had such an experience. For that alone, I will always be grateful for this class. . . I think I can learn to love myself the way I am. At least that's what I'm working on.—Mandy

Environmental Re-evaluation. Environmental re-evaluation is a process that combines affective and cognitive assessments of the impact of one's behavior on other people. After being exposed to research on stereotype threat, course participants perceived how stereotype threat had undermined their performance and could impact their professional aspirations (Steele, 1997; Davies *et al.*, 2002, 2005b). One required reading illustrated how women participating in a study were exposed to gender-stereotypic television commercials, and subsequently became vulnerable to stereotypic threat, which led them to avoid leadership roles in favor of supportive roles (Davies *et al.*, 2005b). Margaret, an older student, reframed past negative experiences:

It's interesting how long it has taken me to reflect on my life experiences and see them as though I am an observer, not a participant in my life. . . I had no conscious thought that any negative experiences I had during those times might not have been my fault and were artifacts of my gender. Rather, I attributed it to my failure to perform adequately. I do remember thinking I needed to be the best, that I always needed to get one of the highest grades in my classes, and although I am a fairly competitive person and that's probably a lot of it, I was conscious that my path through engineering school would be much easier if I had high grades to prove I was capable of being there.—Margaret

A doctoral student described her initial experience entering graduate school:

The other thing that struck me was [how] pessimistic the women were towards themselves. Unfortunately, I encountered that type of feeling quite a lot my first semester of graduate school. . . In one of my classes I was much more prepared than most of the class, and therefore did better on the homework and tests. The second class I felt much less prepared than the rest of my class. And for some reason I let this second class

define my self-image that first semester... While I continued to remind myself of this, I let it call into question even my being admitted into [a science] graduate program. Unfortunately, it was depressingly easy to consider the male to female ratio in the class, and to see myself as being admitted mostly based on my gender. Luckily I had support from classmates, and my second semester went much more smoothly... While now I see how incorrect those thoughts were, I find it sad that it even came to mind, and that it was a thought none of my male classmates (so the majority of my classmates) would even have to consider.—Mattie

Certainly the “threat was in the air” (Steele, 1997), but also a growing realization of course participants’ habitual responses to their social environment and to how being a woman does not make one immune from colluding in the propagation of gender bias. The statement by this student underscores the importance of informing women about the very real impact of gender stereotypes on evaluation of women’s performance in typically male domains, and the importance of recognizing and self-regulating one’s own gendered assumptions. Environmental re-evaluation can be seen in the following student’s text:

One of the ideas I’m struggling with is the idea that women tend to punish other women for being successful because of the perceived lack of communality... I can definitely think of successful women whom I dislike because I do think they are very selfish or I know for a fact that they are willing to bend the rules or even cheat to succeed. I also know that the idea of disliking women for simply being successful is so upsetting that I immediately discount that I could do that... I’ll have to pay closer attention to how I react to others and why (bottom line of this course).—Dahlia

This student was reflecting on one of the most intriguing concepts presented in the class, that men and women have the same biases toward women (Valian, 1998; Isaac *et al.*, 2009). Knowledge that all of us are part of a culture that perpetuates bias appeared to mitigate anger expressed by some course participants. In the contemplation stage, course participants expressed raised awareness of the bias around them, often verbalizing emotional reactions (dramatic relief) when confronted by the evidence. As the course participants reflected on their own experiences with stereotype-based bias, particularly in STEMM, they engaged in environmental re-evaluation. Through this process of change, course participants increasingly understood how their behavior could reinforce or reduce activation of gender stereotypes and how to use this knowledge to effectively navigate professional situations and enhance career advancement.

Stage 3: Preparation

Self-Re-evaluation. The preparation stage reflects a commitment to imminent action. The process of change typical of this stage is self-re-evaluation of one’s previous attitudes and beliefs in light of new knowledge. Course participants sometimes clearly identified various types of “tool-kits” taken from research reviewed in class. The text below illustrates this student’s interpretation of effective leadership-promoting strategies and included specific citations from class readings:

Don’t get angry when situations arise. The less emotional you are, the better. There is a delicate way to

self-promote and still be likable (Brescoll *et al.*; Rudman).

Make sure your task is clearly stated. If teamwork is necessary, LEAD the group, or take on a specific role with specific actions (Heilman and Haynes).

If you are putting forward evaluations, make sure there is an individualistic evaluation with specific criteria for rating performance. Where there is ambiguity in task or role, there is the tendency to lean on stereotypes of any kind (Heilman and Haynes).

Women need to see other successful women with both agentic and communal qualities (Bem, Carli *et al.*, and Ridgeway) in order to perpetuate a women in leadership paradigm and to eliminate the perception that women leaders are somehow unlikable, hostile, and abnormal in some way—appearance, personality, or otherwise. Support and encourage each other to aspire to greatness in their field even though we have never seen a woman do it (or very few women).—Find a female mentor and be a mentor (Parks-Stamm *et al.*; Heilman and Okimoto).

Avoid being too communal as you aspire to leadership. Delegate the tasks, lead committees—buy, but don’t bring the food! (Heilman and Okimoto; Rudman).

—Lena

Course participants learned that when gender stereotypes are activated, raters are less likely to attribute a woman’s success to ability than a man’s success, a construct called attributional rationalization, which results from the assumption that men are more competent than women (Swim and Sanna, 1996; Heilman and Haynes, 2005). This student made a commitment to correct others:

They somehow think that it is easier to publish as a [field], and that my many publications do not represent the same amount of effort as their fewer articles. Until this article, I never questioned this. But, the next time someone suggests that there is a lower bar for my field, as was imposed on other women (oh, it’s easy to publish there) and discussed in Valian, I plan on correcting them...—Sophia

Toward the end of the course, one student expressed self-re-evaluation and preparation to act in new ways. Her statement reflects increasing professional self-efficacy as a woman in science:

One of my goals in taking this course was to read more of the scholarly literature and be able to speak knowledgeably about studies and theories that match the “feelings” and notions I have perceived for a long time regarding biases, especially against women in science. I feel that I have achieved that and I feel empowered by having that knowledge in my pocket to support the instincts I have about the issues. I hope that after this course ends I will be able to use this information to improve my interactions with the world and others’ as well.—Chelsea

Stage 4: Action

Self-Liberation. Self-re-evaluation can progress to self-liberation as one envisions, commits to, and ultimately changes one’s leadership behavior. The action stage included statements about actions taken. Expressions of the underlying processes of change (Table 1) that stimulate and reinforce action are evident in a number of course participants’

statements. Growing self-efficacy is evident in the content and tone of course participants' statements. This self-efficacy extends to resilience to resistance encountered in response to new actions. One student wrote,

I told my boyfriend's uncle at his family's Easter celebration today that I was thinking about reapplying to medical school. He looked at me and said, "What was it you wanted to be again, a pediatrician? At least you'll be prepared for staying home with the kids." Then he laughed. Ugh. (And no, I don't want to be a pediatrician. I'm interested in oncology.)—Lelen

Another student in the action stage wrote:

I have begun to "Grow into my own," and have made strides in asserting myself. Most recently, I asserted myself by calmly and politely telling a man to stop waving his pointer finger in my face as he was yelling at me! I politely reminded him that I was the trained expert, as the scientific advisor on his committee, and used an empathetic approach by rephrasing what he was telling me with, "I hear what you are saying. . . . This approach helped to diffuse [*sic*] the situation and garnered greater respect for me and my role. Subsequent interaction has been very positive!—Stephanie

A physician-resident reported:

I took [the instructor's] advice and started to introduce myself as Dr. [XX], rather than [Valerie] to patients and families. I think [she] is right. The title Dr. does help to establish the expectation of, and the groundwork for, leadership, especially, when I walk into a patient's room with a nurse and a medical student, who both look older than I, and one of whom happens to be male. I think this is a great example of how membership to a certain class can help identify a woman as a leader. It's like wearing a bigger nametag that says "Hey, pay attention to me. I'm a small, young, woman."—Valerie

Social Liberation. Social liberation in our context is conceptualized as identifying leadership opportunities. One course participant indicated social liberation by deciding to switch from a non-tenure to a tenure track during the course and beginning the administrative process to make this happen. She wrote:

I didn't have a very accurate schema about what it takes to be a strong leader. In all honesty, my schema was likely biased towards more masculine characteristics. My more agentic leadership schema has been replaced by a schema based on transformational and communal characteristics—all characteristics that I personally value.—Jane

A new assistant professor developed a new grant proposal:

I think I have further demonstrated sound leadership in developing the idea, getting it vetted, and "delivering the goods" (defined as the grant proposal—which will be done by Friday). That said, I know there is no guarantee that this will be funded (given the expected volume of proposals, I am not holding my breath—blue isn't my color), but you can't win if you don't play.—Pamela

Contingency-Reinforcement Management. This process of change in our context includes recognizing the influence of gender stereotypes on one's own and other's leadership and knowing how to counteract them. The impact of women's expression of anger in a professional setting appeared in

several course participants' journals after reading Brescoll and Uhlmann's paper, which found that both male and female evaluators conferred lower status on angry female professionals than on angry male professionals (Brescoll and Uhlmann, 2008). One student who habitually responded with anger at work illustrated the process of contingency-reinforcement management in changing her behavior:

I saw a good friend of mine let her emotions get the better of her at work today. . . I've seen her do this before. In the past, I had identified with her indignation and anger, and would have probably done the same thing (react angrily in public at work) to vent my frustrations, but not now. Now, any time I see anyone do this, or catch myself doing it, all I can think of is how damaging of a career move it is to display your anger in the work place. I have made a conscious effort not to do so in the past two months.—Valerie

Tina was able to identify ineffective leadership and then tell her friend how to counteract gender stereotypes.

Stage 5: Maintenance

The maintenance stage has continuing behaviors from the action stage and includes the processes of helping relationships, counterconditioning and stimulus control. In the last two stages, these processes often overlap.

Helping Relationships. Helping relationships, another process of change typical of both action and maintenance stages, involve gaining and giving support for new behaviors. Course participants described examples of this during the last weeks of journaling. Margaret coordinates student programs. She wrote:

What's been really interesting is interacting with some of the female grad students in my programs. They are so relieved when someone else (me) calls out a gender issue during a conversation—they want to talk about it but never in a million years will they bring it up because nobody wants to be seen as that woman who complains.—Margaret

Part of helping relationships is seen in how course participants learned how to communicate principles from the course as illustrated in this student's experience:

I also had an awesome moment when I was discussing this class with other [science] graduate students. One of my friends mentioned how he didn't think he treated his female students any differently than his male students. I told him it was possible, but so often reactions are subconscious. I then went into some examples, such as secretarial work and talking over another person, mentioning that the way to change the behavior is to first recognize when it happens. I then started to tell him of an incident a couple hours earlier when I was recalling a conversation I had, but [had] another student butt in to tell the "same" story. In the midst of my telling that story, another guy did exactly that: he started to talk over me, but then he caught himself, realizing what he was doing. It was funny that it was happening as I was telling of another instance, but also awesome that he was able to catch himself. Really, I think it's great that [my male friends] listen and actually digest what I say about this class.—Mattie

Counterconditioning. Counterconditioning involves self-monitoring and self-reflection in the realm of leadership and

is seen in this early-career physician's description of how she now does "chit-chat":

Part of this negativity has been realizing how much energy I have drained from dealing with the political nature of getting my research career launched in this next phase. . . . The mailbox chit chat is also critical albeit time consuming. It's the only way I've been able to get things to move in the system rather than stuck on someone's table for a week or two.—Nadia

Statements that reflected processes of helping relationships and counterconditioning in order to sustain action were evident for course participants:

Each day I have to work to distance myself from self-doubt. . . . and to see myself as what I really am (if that is possible). This positive "self-talk" is reinforced by the care and support of my mentors and coworkers. I have also been able to see myself as a mentor by working with students.—Annette

Another wrote:

I have had such a good experience working at [XX]. Being in a warm, non-threatening environment has really begun to help me get my confidence back and to realize that academia is really not a terrible place after all. This class was wonderful because it opened me up to a whole group of (mostly) women who have all had similar struggles. It is so powerful to realize that you are not alone and you are not crazy.—Tiera

Stimulus Control. Stimulus control involves avoiding situations that allow gender stereotypes to work against one's goals. During the course, one student made an appointment with her mentor to discuss her mentor's experiences as a graduate student and postdoc. Her mentor warned her about women postdocs being saddled with running conferences. In this case, a helping relationship provided support for exercising stimulus control:

According to her, the position is described as one that will "increase your visibility" and get you contacts with big names in your field. In reality, it just reinforces to all the important people in your field that you're a secretary. . . . However, she stressed the importance of limiting your input. At some point, you have to say, this is in fact the secretaries' job, and have them do the truly organizational aspects: arranging transportation, reservations, etc. So in retrospect, I'm extremely glad to have spoken with her, because these are things no one tells you about.—Mattie

Longer-Term Impact

Out of 18 course participants in the first two cohorts, eight responded to our email query about whether and how the course affected their subsequent professional lives. Their responses support an enduring impact of participation in this course. Some describe actions in the realm of academic STEM leadership. Elements of several processes of change (e.g., counterconditioning, self-liberation, helping relationships, and stimulus control) were found. One course participant reported that the class taught her to create a "critical mass" for meetings she organizes to avoid tokenism for underrepresented groups. She also uses the course content to help other women strategize when negotiating salaries and obtaining letters of recommendation. One physician in a new

leadership position uses strategies to teach residents how to interact with staff, and also how to express disagreement. Another early-career scholar negotiated and obtained a new start-up package that she attributed to information gained from the course. She also learned that she does not have to say why she is not available for meetings, especially when it involves her family. Another course participant continues to examine her motives, noting that "the real challenge is to correct the implicit negative associations residing within our views. . . . to replace the biases that we have individually internalized." A former graduate student who now has a postdoctoral position at a prestigious university stated, "I'm not exaggerating when I state that I think about lessons and readings from your course almost every day. . . . I am constantly pulling ideas from the 'toolbox' that I made." A course participant who was a new assistant professor made a commitment during the class to write a large National Institutes of Health (NIH) grant—and got it. She wrote:

I feel like this class impacted the way I think and view power and leadership positions within academic medicine. I feel like I put on a pair of glasses that lets me see the world a little differently, and I have not taken them off since. I don't see the world as an inherently better or worse place (so the glasses are not rose-colored). But I feel that I can see patterns beneath behaviors that were previously not viewable by me.—Madeline

DISCUSSION

We identified leadership self-efficacy as an empirically supported target for an intervention to increase women's participation and advancement in academic STEM. To this end, we developed an educational intervention in the form of a semester course for women early in academic STEM careers. We used the transtheoretical model (TTM) to evaluate the course's impact on participants' beliefs about their own leadership abilities and the translation of those evolving beliefs into action. TTM proved to be a useful framework for our evaluation due to the centrality of self-efficacy in the model. Although this "stages of change" model was initially applied to individual smokers as they progressed to becoming non-smokers, Prochaska found it useful in conceptualizing and promoting institutional change (Prochaska *et al.*, 2001) and subsequently used TTM to assess institutional readiness to advance women scientists (Prochaska *et al.*, 2006). Our work finds that this model also provides a useful framework for assessing leadership self-efficacy in individual women in STEM. In addition to self-efficacy, the five stages of change and the accompanying 10 processes of change provided a rich context for examining the impact of the course.

Quantitative analyses of differences between pre/post survey scores for all measures were significant. The significant increase in scores for leadership self-efficacy, in particular, provides direct support for the course's positive impact on course participants' confidence and competence for leadership (McCormick *et al.*, 2002). Because high domain-specific self-efficacy beliefs predict career interest and help to bolster career persistence (Hackett and Betz, 1981; Betz and Hackett, 1986; Betz and Voyten, 1997; Brown and Brooks, 1996; Lent *et al.*, 1996; Bandura *et al.*, 2001), this intervention's apparent success in improving women's leadership self-efficacy

may increase the likelihood that participants will pursue leadership opportunities and work harder to achieve their leadership goals. In addition to increased leadership self-efficacy, the increase in participants' self-esteem scores is relevant in that individuals with high self-esteem may be more likely to pursue leadership roles (Linimon *et al.*, 1984). The significant pre/post increase in personal mastery and decrease in perceived constraints for course participants supports movement of course participants toward engaging confidently in new leadership behaviors. Interpreted within the TTM's framework, results from all quantitative measures provide evidence that the course helped facilitate course participants' preparation to engage in leadership behavior by building their self-efficacy beliefs for leadership, increasing their sense of personal value, decreasing their perceptions of barriers to leadership, and increasing their feelings of personal mastery for effective leadership.

Although not all class participants showed posttest scores in the desired direction, we have no compelling evidence that the class caused harm. As we continue to gather data from subsequent classes, we may be able to determine if there are any predictors of who will benefit most from the course.

Results from the qualitative analysis of course participants' journals provided a window into the content of their thought processes as they progressed through the course, and also helped to identify which course activities were most influential in modifying their beliefs about their abilities for leadership. We were gratified to find that course participants often specifically cited the research discussed in class in their reflections. This suggests that our attempts to make the course participants "bias literate" were successful and supports the premise that literacy is a prerequisite to action in addressing the impact of stereotypes (Sevo and Chubin, 2008). The course participants' statements repeatedly illustrated how their newfound literacy enabled them to recognize implicit gender bias, including their own. As one student noted: "once you see it, you can never go back." The course participants' narratives also reflected a reconceptualization of leadership, as many learned to recognize the incongruence between implicit assumptions about leaders and actual effective leadership. This realization frequently permitted the course participants to see themselves as leaders.

Stereotypic threat is a construct with which the course participants clearly identified. Of the multiple bias constructs named throughout the readings and class discussions, stereotype threat was mentioned by name most often in the journal text. Course participants could describe specific instances in which they had experienced it and how it felt. They seemed relieved to have a term to name what they had experienced and a scientifically validated external causal attribution for their discomfort or poor performance. Women in STEM are bombarded daily by situational cues that subtly reinforce that leaders are men and women are subordinates (Burgess *et al.*, 2012). This course presented evidence for the root causes of these inaccurate, but powerful, messages and provided participants with tools to deconstruct them. This course also provided an "identity-safe" environment in which course participants could speak up, propose new behaviors, and obtain immediate feedback. The course exposed participants to successful women STEM faculty on a personal level. Journals frequently included statements about how meaningful it was to hear the stories of the women chairs as well as the real-

world practical suggestions and examples provided by the class instructors. In addition to the women chairs serving as positive role models for the course participants, interaction with such accomplished women may inoculate participants to the negative effects of gender stereotypes. For example, Stout *et al.* found that female students' self-concept benefited from contact with female experts and led to enhanced self-efficacy, domain identification, and commitment to career persistence (Stout *et al.*, 2011).

Course participants' journals provided evidence that their self-efficacy beliefs for leadership were positively impacted by applying course information to their own life experiences. Specifically, journals documented course participants' integration of evidence-based techniques to mitigate the impact of societal stereotypes into their own leadership practices. This technique subsequently seemed to positively influence course participants' leadership self-efficacy beliefs and increase their engagement in leadership behavior. The follow-up statements more than a year after class suggest that at least some course participants are continuing to intentionally engage in leadership in different ways than they had before the course.

Overall quantitative and qualitative results supported the effectiveness of the course in improving women's leadership self-efficacy through bias literacy, invoking efficacy-building experiences (e.g., presentations and discussions, meeting role models; Brown, 1999), and incorporating opportunities for deep and transformative learning (e.g., journaling, case studies). The limitations of our study include its location at a single institution and self-selection of course participants. Taken together, however, our data suggest that for the majority of early STEM career women who take our course, the impact is positive and sustained. The impact has the potential to have a more pervasive impact as these women and subsequent cohorts take on leadership roles, help other women strategize about career negotiations, and disseminate what they have learned to male and female colleagues. As evidence of the potential for a broader impact, the course participant who indicated that she wrote for an NIH R01 grant because of her experience in the course informed us in follow-up that her proposal was funded. This success marks the launch of a future influential, bias-literate, woman leader in academic STEM.

CONCLUSION

This mixed-methods evaluation of three cohorts of course participants with follow-up at 1–2 yr provides strong evidence that the approach taken by this course does increase leadership self-efficacy among women early in academic STEM careers. Our results also suggest that course participation empowers these women toward evidence-based actions to identify and reduce the influence of gender bias in their professional lives. This type of educational intervention is missing in the traditional STEM curriculum. However, the results of our work suggest that replicating and disseminating a course like ours to all women who are future or early-career STEM faculty may be an effective addition to strategies to promote the persistence of women in academic STEM and their participation in leadership.

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