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ADDRESSING GENDER EQUITY IN THE PHYSICAL SCIENCES: REPLICATIONS OF A WORKSHOP DESIGNED TO CHANGE THE VIEWS OF DEPARTMENT CHAIRS

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This research note presents data on the replication of a carefully planned intervention to increase the commitment of department chairs in the physical sciences to the hiring and career advancement of women. Three separate workshops for department leaders in chemistry, physics, and material science were held. Participants' views regarding factors that affect attracting women candidates, the hiring of women faculty, and barriers to women's career progress changed significantly from before attending the workshop to after attending. When differences occurred between the disciplines, changes were most apparent for chemistry department chairs. Reasons presented for these differences included variations in the representation of women in the field and elements included in the chemistry workshop that involved greater public acknowledgment of needs for change.

KEY WORDS: *gender equity workshops, higher education faculty, STEM department heads*

1. INTRODUCTION

The scientific and engineering challenges facing the world are becoming increasingly complex and global, with issues ranging from energy and environmental sustainability to assuring safe and available foodstuffs for current and future generations. Policy reviews have highlighted the need for a strong science, technology, engineering, and mathematics (STEM) workforce to meet these challenges, calling for prolonged efforts to recruit and retain the best and brightest students, scientists, and engineers who represent all sectors of society (e.g., National Academy of Sciences, 2005).

Data indicate that the failure to tap the potential pool of STEM talent may be especially acute within academia. Even though women are earning an increasing proportion of ad-

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vanced STEM degrees, their representation on university faculties has not shown a similar rise. For example, while women currently earn 30% of the PhD degrees in chemistry, only 15% of the chemistry faculty at the top fifty most research active universities are women (Nelson, 2007; Raber, 2007). In materials science and engineering (MSE), 13% of the university faculty are women, while 26% of the PhD and 28% of the BS degrees are granted to women (Nelson, 2007). In physics, women occupy only 9.5% of the faculty positions across all ranks at the major research universities (American Institute of Physics, Academic Workforce Survey, 2006).

There are many factors believed to play a role in these disproportionate patterns of representation (Stockard *et al*., 2008; Goldin and Rouse, 2000; Hall, 2008; Handelsman *et al*., 2005; Kulis and Sicotte, 2002; Lawler, 1999; National Academy of Sciences, 2007 ; Rossiter, 2000; National Academy of Sciences, 2006 ; Sonnert and Holton, 1995; Trix and Psenka, 2003; Valian, 1998). A central theme, however, has been recognition of the role of departmental leaders in promoting (or forestalling) change.

Based on this research, several federal agencies supported a workshop for department heads in academic chemistry departments in January 2006 to address the under-representation of women. The workshop was designed (1) to make department leaders aware of the low representation of women in their respective fields and of research regarding why this occurs, (2) to motivate department leaders to work for change in their units, (3) to develop a series of strategies and goals to increase the recruitment and retention of women faculty in their departments and institutions, and (4) to obtain a commitment from departmental leaders that they would work to implement these goals and strategies. Our evaluation of this workshop, previously published in *JWMSE* (Stockard *et al*., 2008), found that the experience increased the awareness of the chairs to the barriers that women chemists face in academia and the chairs' commitment to facilitating change.

Based in part on this success, the federal agencies sponsored replications of the workshop for chairs of academic departments in two other STEM areas: physics, in 2007, and materials science and engineering (MSE), in 2008. This research note examines these replications, focusing on changes in attitudes and views from before attending to after attending the workshop and comparing the results to those obtained with chemistry heads. We examine whether there were changes in the chairs' attitudes toward the challenges that women scientists face and whether the workshop was equally effective for each group. Because the content of the workshop was similar for each group, it could be expected that similar changes would be found for participants at all three events. However, as explained more fully below, there were slight differences between the workshops involving the extent to which participants publicly acknowledged issues regarding gender inequities, ranging from simply noting the findings presented in the sessions (MSE workshop), to developing recommendations based on the session content (physics and chemistry workshops) and adopting goals for the coming years (chemistry). Building on the general tenets of cognitive dissonance theory, which suggests that people will alter their beliefs and attitudes to reduce "dissonance" or inconsistencies (Fetsinger, 1957) and the notion that attitude change follows behaviors (such as the public stating of goals), it could be predicted that there would be greater changes for the chemistry chairs, who had the most overt and public behaviors acknowledging the need for change.

In addition, there are differences between the three disciplines in culture, history, and the representation of women. Chemistry and physics are well-established disciplines in the sciences that have had a long history of low female representation. However, physics has historically had fewer women than chemistry at the undergraduate, graduate, and faculty levels,

and this could impact the results, perhaps leading to less awareness of gender issues, at least initially. Observations and anecdotal evidence indicate that the chemistry community has recently been very active in promoting gender issues, with more visibility given to the topic than in other physical science disciplines, which may also impact our findings. In contrast to physics and chemistry, materials science is a relative newcomer to the academic world. It was initially populated largely by engineers but in recent years, has also attracted chemists and physicists interested in "molecular architecture." Given its relatively recent emergence in academe as well as its more interdisciplinary population of scholars, participants might be more receptive than those in other areas to the possibility of change. On the other hand, in trying to establish recognition and acceptance as a discipline, they could be less receptive to change and appearing to "rock the boat."

Clearly, given the paucity of research in this area, our analyses were, by necessity, exploratory in nature. Even so, we believe that this research is important. As explained more fully in our previous article (Stockard *et al*., 2008), interventions that produce significant changes in views regarding diversity and discrimination are relatively rare. In addition, replications are a central element of attempts to establish causality (Shadish *et al*., 2002). The work that we report here is the only study of which we are aware that examines attempts to influence the views of leaders in academic STEM departments across three different settings.

2. METHODOLOGY

2.1 Procedures and Sample

All workshops were held in the Washington, DC, area and were funded by the federal funding agencies (National Science Foundation, National Institutes of Health, and the Department of Energy and Basic Energy Sciences) that are the primary source of funding for research in the three areas. Each workshop began with an evening opening gathering, followed by sessions over the next day and a half. A steering committee for each of the workshops was involved in the planning and implementation of the workshop program. These steering committees consisted of representatives from the respective fields who also attended the workshop for their field. Representatives of the sponsoring federal agencies were also in attendance.

Details about the workshops, including the full agendas, final report, and speakers, can be found on their respective websites. Many of the topics covered at the three workshops were similar, following the model that was originally developed for the first workshop held for chemistry chairs and described more fully in our earlier article (Stockard *et al*., 2008). All workshops consisted of six sessions with similar or related content. Each session consisted of a mix of invited speakers, panel discussions, and breakout sessions.

The participants in this study were the science and engineering departmental leaders who were invited to attend the three workshops. The departments and labs ranked most highly in research funding were targeted for invitations for participation. This decision was prompted by the funding agencies, who wanted to target efforts on schools that produced the largest number of graduate students in the fields. Organizers reported that from about two-thirds (material sciences) to over 90% (chemistry) of those who were invited actually attended and that they could discern no pattern of differences between those who attended and those who did not attend the workshop. All participants' travel and lodging expenses were covered by the federal agencies. Data were available from thirty-six participants in the chemistry workshop, thirty-three participants in the physics workshop, and twenty-eight in the MSE workshop.

The common themes discussed in each session of the workshops included the current gender demographics in each field, the presence and impact of gender bias in the workplace and review process, work–life balance issues, the impact of childbearing on career advancement, and challenges and opportunities for departments and institutions in their quest to achieve gender equity. The chemistry and physics workshops had a session on challenges and opportunities for funding agencies in promoting gender equity. For the MSE workshop, this session was replaced with a discussion of current best practices in industry, national laboratories, and universities. The physics workshop had a session on training the next generation of physicists.

All workshops had a theatre group provide an interactive sketch that exemplified the problems that women face in their education and career advancement in science and engineering fields. In the physics and chemistry workshops, participants in the breakout sessions were given the task of developing recommendations for policies that could be adopted by institutions to achieve the workshop goals. For the MSE workshop, breakout session participants developed a series of findings related to the topic of the session. All breakout sessions were followed by participants reporting the recommendations and findings to the full meeting, including a final summary at the conclusion of the meeting. For the chemistry workshop, chairs adopted a series of goals for department chairs and institutions to try to reach in the coming years. Chairs were asked to choose two specific goals that they would commit to on the workshop website and to report progress on these goals over the course of the following year. Reports summarizing the workshops and the recommendations generated were completed for all three meetings and are posted on the respective websites.

2.2 Measures

Attendees were required to complete a questionnaire that examined their attitudes and perceptions regarding women's representation in their respective fields before attending the workshop and were also asked to complete a questionnaire on the same topics after the conference was over and they had returned to their home institutions. The questions involved their views about women's representation in academic departments and addressed issues covered in the workshop sessions. One set of questions asked about issues regarding attracting women job applicants, another asked about hiring women into their departments, and the third involved factors that affect women's careers. The questions were reviewed by an expert panel composed of steering committee members for the chemistry workshop. All of the panel members had extensive experience and knowledge of issues regarding gender equity in the sciences.

The questions about issues that affected their department's ability to attract, or recruit, women applicants asked attendees to use a four-point scale, ranging from "not difficult" to "major difficulty," to indicate the difficulty of each of the follow factors: (1) lack of mentoring of potential women faculty or scientists, (2) uncertainty about employment for spouse/partner, (3) unwelcoming department/lab environment, (4) concerns of candidate for having both family and successful career, and (5) few successful women in the unit.

The question regarding hiring was phrased: "To what degree have the following factors limited your ability to hire women in your department in the last five years?" The issues included both those that could be seen as out of the control of a department or institution ("Too few female applicants for advertised faculty positions" and "Female candidates are in such high demand, we have lost them to other institutions"), those that were within their control or purview ("Not enough financial support from the higher levels of administration for making a

competitive offer to the women candidates" and "Inability to provide employment for spouse/partner"), and those that directly involved issues of departmental climate and discrimination ("Lack of commitment of department faculty members to increase the number of women faculty" and "Some current faculty members are opposed to hiring women faculty"). Responses were given on a four-point scale ranging from "not a limitation" (1) to "serious limitation" (4).

Finally, the questions regarding effects on women's careers asked about eleven factors that could affect women's career progress and were related to the issues of bias and prejudice discussed in the workshop. These questions were phrased: "In your view, how important are the following issues in slowing the career progress of women chemistry faculty at research universities relative to their male peers?" The issues included in the list ranged from those that could be seen as related to women's own behaviors and career approaches ("women do less self-promoting and marketing of themselves than men," "balancing professional and family obligations,") to those that could reflect either their own actions or discrimination by their departments and the profession ("lack of success in obtaining funding," "inability to compete for graduate students"), to those that more clearly reflect discrimination and prejudice by departments ("few female colleagues," "women getting heavier teaching and/or service responsibilities," "unwelcoming departmental climate," and "women being excluded from important departmental and institutional decisions") or by the profession as a whole ("women having less opportunities to be mentored by top chemists," "gender discrimination in the peer review process of papers and grants," and "subtle biases against women that accumulate over the years"). Responses were given on a five-point scale ranging from "not an issue" (1) to "very important" (5).

2.3 Analysis

Two-way repeated measures analyses of variance were used to analyze the data. This procedure is superior to a series of paired t-tests because it allows us to use one statistical procedure, rather than three, to examine changes in views over time in the three fields. Responses given before and after the workshop were treated as a repeated measure, and the field of science (chemistry, physics, and material science) was treated as a factor. This allowed us to examine the extent to which responses varied from before to after the workshop (the repeated measure), between department chairs from the three disciplines (effect of field), and also if the difference across time varied across the three disciplines (an interaction effect). Following conventions in the social sciences, a conservative probability level of 0.10 was used to flag interaction effects as significant, while the 0.05 level was used for main effects.

As noted above, we expected that all participants would be more aware of gender biases after attending the workshop. Given differences in the workshop proceedings as well as differences between the three fields in the representation of women and disciplinary culture, we also expected that there might be differences in the level of awareness between the three fields and differences in the amount of change from pre- to postworkshop. Again, however, it should be emphasized that our analyses were exploratory in nature.

3. RESULTS

There were significant differences between the fields in their reports of the percentage of their faculty that were women. All of the department leaders reported that women were most often

found in non-tenure-track positions, followed by the rank of assistant professor. In all areas the fewest women were at the rank of full. However, women were significantly more likely to be in the MSE departments (reporting an average of 31.9% of their faculty/staffs, including non-tenure track, being women) than in chemistry departments (reporting an average representation of 18.0% women) or physics departments (with 11.6% women). Analysis of variance indicated that these differences were statistically significant ($F = 29.l4$, $p < 0.001$), and post-hoc tests confirmed that each pair of comparisons was also significantly different.

3.1 Attracting Women Candidates for Faculty Positions

Table 1 reports results regarding perceptions of the chairs on five issues that are commonly noted for difficulty in attracting women as candidates for faculty positions. The mean values for the preworkshop survey (pretest) are given in the left-hand columns of the table, and the mean values for the postworkshop survey (post-test) are in the middle columns. The probability values derived from the analyses of variance are given in the last set of columns. The probability values associated with "change" examine the hypothesis that responses differed from pretest to post-test (equivalent to results from a paired t-test), those associated with "field" examine the hypothesis that responses differed between the three fields (as in a factor analysis), and those associated with "interaction" examine the hypothesis that pre-post differences vary from one field to another or, alternatively, that field differences varied from pretest to post-test. In all cases, the null hypothesis was that there was no difference. Significant differences, that is, results that would lead us to reject these null hypotheses, are in boldface.

For two items there were significant differences in the preworkshop and postworkshop responses that were similar across the three fields: (1) lack of mentoring of potential women faculty and (2) uncertainty about employment for spouse or partner. In both cases, the chairs in all three areas viewed the issues as more difficult after the workshop than they did before the workshop. One item (no. 3 regarding an unwelcoming environment) had a significant interaction, indicating different changes across the fields. Department chairs in chemistry and MSE viewed unwelcoming department and lab environments as a greater challenge for attracting women candidates after the workshop than before the workshop. In contrast, the workshop experience led physics chairs to view this as less of an obstacle. For one item there was a significant difference between disciplines, but no pretest–post-test difference. This was item no. 4 regarding the candidate's concerns for having both a family and a successful career. In this case, the chemistry chairs viewed this issue as more of contributing factor to the difficulty in attracting women candidates than the physics chairs. There were no significant differences across disciplines or over time for the fifth item regarding few successful women in the unit contributing to the difficulty in attracting women candidates.

3.2 Hiring Women Faculty

Table 2 gives the responses to the question regarding factors that have limited their departments' ability to hire women in the last five years. For five of the six items department chairs viewed the issue as a significantly greater limitation after the workshop than before the workshop. For four items the change in perceptions occurred in a similar manner across all three disciplines, with respondents seeing the issues as a more serious limitation at post-test: (2) women are in such demand they are lost to other institutions; (3) there is a lack of commitment of faculty to hiring women, (4) some faculty are opposed to hiring women, and item

TABLE 1: Perception of potential factors that make recruiting women faculty candidates difficult, by field at pretest and post-test

	Pretest descriptives Mean scores			**Post-test descriptives Mean scores**			**Analysis of variance *p*-values**		
	Chemistry (*n*=36)	MSE (*n*=28)	Physics (*n*=33)	Chemistry (*n*=36)	MSE (*n*=28)	Physics (*n*=33)	Change Pre to post	Field	Interaction
1. Lack of mentoring of potential women faculty/ scientists	2.26	2.25	2.06	2.63	2.57	2.21	**0.004**	0.10	0.60
2. Uncertainty about employment for spouse/ partner	3.06	2.79	2.97	3.22	3.00	3.09	**0.05**	0.23	0.91
3. Unwelcoming department/lab environment	2.03	1.96	2.13	2.37	2.11	1.91	0.35	0.56	**0.05**
4. Concerns of candidate for having both family and successful career	3.25	2.79	2.58	3.28	3.00	2.71	0.20	**0.01**	0.73
5. Few successful women in the unit	2.71	2.36	2.69	2.97	2.54	2.53	0.36	0.13	0.20

Notes: The scale ranged from 1 = not difficult to 4 = major difficulty.

All significant differences are bolded. The *p*-values for the "change" column indicate whether or not there was significant change from pretest to post-test. The "field" column indicates significant differences across the discipline (chemistry, material sciences, or physics). The "interaction" column indicates if there was a significant difference in the change from pre- to post-test across the discipline.

(6) an inability to find spousal employment. There was a significant interaction for one item, (5) not having enough financial support from the higher administration for a competitive offer. The chemistry chairs saw the issue as more serious after the workshop, while the MSE chairs saw it as less important and there was little change for the physics chairs. Finally,

there was one item where there were significant differences by discipline but no significant differences from pretest to post-test: (1) too few applicants for the position. This was viewed as a greater limit by both the chemistry and physics chairs than by the material sciences chairs, a perception that matches the different representation of women in their departments as reported above.

TABLE 2: Perceived limitations to ability to hire women scientists, by field at pretest and post-test

	Pretest descriptives Mean scores			**Post-test descriptives Mean scores**			**Analysis of variance *p*-values**		
	Chemistry (*n*=36)	MSE (*n*=27)	Physics (*n*=34)	Chemistry (*n*=36)	MSE (*n*=27)	Physics (*n*=34)	Change Pre to post	Field	Interaction
1. Too few applicants for positions	3.31	2.52	3.32	3.11	2.67	3.32	0.84	**.001**	0.21
2. In such demand women are lost to other institutions	2.89	2.41	2.73	3.08	2.78	2.79	**0.01**	0.30	0.31
3. Lack of commitment of faculty to hiring women	1.56	1.30	1.53	1.94	1.41	1.82	**0.001**	0.078	0.34
4. Some are opposed to hiring women	1.14	1.07	1.06	1.33	1.30	1.18	**<0.001**	0.58	0.67
5. Not enough financial support for competitive offer	1.39	1.81	1.47	1.83	1.67	1.44	0.33	0.36	**0.02**
6. Inability to find spousal employment	2.69	2.26	2.29	3.08	2.44	2.53	**0.01**	**0.02**	0.69

Notes: The scale ranged from 1 = not a serious limitation, to 4 = serious limitation.

3.3 Barriers to Women's Career Progress

Table 3 reports the chairs' views of barriers that slow the progress of women's careers. Of the eleven items, there were significant changes from before the workshop to after the workshop in nine items, and in all cases the chairs saw the nine issues as more important barriers after the workshop experience. The only items for which there was no change in their views from before to after the workshop were the ones that they also recorded as being the biggest limitation on women's career progress: (1) having few female colleagues and (2) balancing professional and family obligations. For four items the pattern of change was similar across the three disciplines: (6) women do less self-promoting than men, (9) women's inability to compete for the best graduate students, (10) women being excluded from decisions, and (11) gender discrimination in the peer review process. Interaction effects appeared with five of the items (using the conservative level of 0.10 as indicating significance): (3) women having heavier teaching and/or service responsibilities, (4) an unwelcoming departmental climate, (5) fewer mentoring opportunities, (7) subtle biases that accumulate over the years, and (8) lack of success in getting funding. In all cases the change over time was greater for the chemistry chairs than for the chairs in other departments. In most cases the other chairs also saw the issues as more problematic at post-test, but the change was not as great.

4. SUMMARY AND DISCUSSION

The findings discussed above indicate significant changes in attitudes regarding factors that affect recruitment, hiring, and the career progress of women for participants from all three fields after attending the workshop, although patterns differed somewhat from one discipline to another. With respect to recruitment of, or attracting, women candidates, after attending the workshop the chairs in all three areas were significantly more likely to see lack of mentoring and issues with spousal employment as factors that make attracting candidates more difficult. Chemistry and MSE chairs also saw an unwelcoming environment as more of a challenge after the workshop. With respect to hiring, compared to their preworkshop responses, the chairs in all three disciplines were significantly more likely to cite the demand for women at other institutions, a lack of commitment and opposition of their faculty to hiring women, and an inability to find spousal employment as factors that limited their ability to hire women. In addition, the chemistry chairs, but not those in other disciplines, saw lack of financial support from higher administration for a competitive offer as more of an issue in affecting hiring. When asked about barriers to women's careers, the chairs were significantly more likely to see most of the issues listed as a more serious limitation at post-test but, again, when differences between the fields appeared, changes from preworkshop to postworkshop were strongest for the chemistry chairs.

The social science literature routinely notes that replications of studies are extremely important in advancing our cumulative knowledge base, but are, unfortunately, relatively rare (Lindsay and Ehrenberg, 1993). In addition, as we noted previously (Stockard *et al*., 2008), examples of interventions that significantly alter attitudes toward issues regarding diversity and inequality are uncommon. Our results, which largely replicate the findings reported in our original analysis of one workshop, thus provide important additional evidence regarding the potential utility and strength of this intervention.

Of the twenty-two comparisons that were described above, seventeen (three quarters of the total) involved statistically significant changes from preworkshop to postworkshop,

TABLE 3: Importance of potential factors for slowing the progress of women academic scientists, by field at pretest and post-test.

	Pretest descriptives Mean scores			**Post-test descriptives Mean scores**			**Analysis of variance *p*-values**		
	Chemistry (*n*=36)	MSE (*n*=28)	Physics (*n*=33)	Chemistry (*n*=36)	MSE (*n*=28)	Physics (*n*=33)	Change Pre- to post-	Field	Interaction
1. Few female colleagues	3.83	3.64	3.47	3.91	3.75	3.53	0.34	0.14	0.98
2. Balancing professional and family obligations	4.50	4.22	4.22	4.42	4.30	4.28	0.80	0.35	0.56
3. Women getting heavier teaching and/or service responsibilities relative to their male colleagues	2.17	2.78	1.70	2.86	2.74	2.03	**0.006**	**0.002**	**0.05**
4. Unwelcoming departmental climate for women	2.63	2.86	2.58	3.11	2.71	2.76	0.09	0.73	**0.05**
5. Women having less opportunities to be mentored by top chemists	2.50	2.57	2.53	3.28	3.07	2.66	**<0.001**	0.47	**0.08**
6. Women do less self-promoting and marketing of themselves than men	2.91	3.07	3.13	3.29	3.43	3.16	**0.04**	0.83	0.43
7. Subtle biases against women faculty that accumulate over the years	3.23	3.46	3.34	3.89	3.57	3.47	**0.01**	0.82	**0.07**
8. W omen's lack of success in obtaining funding	1.97	2.29	2.00	2.60	2.32	2.28	**0.01**	0.75	**0.08**
9. Women's inability to compete for the best graduate students	1.91	1.89	1.82	2.60	2.25	2.09	**<0.001**	0.36	0.24
10. Women being excluded from important departmental and institutional decisions	1.85	2.21	1.88	2.65	2.61	2.16	**<0.001**	0.33	0.28
11. Gender discrimination in the peer review process of their papers and grants	2.26	2.46	1.97	2.85	2.68	2.13	**0.01**	**0.05**	0.29

Notes: The scale ranged from 1 = not a serious limitation, to 4 = serious limitation.

markedly greater than the number of significant changes that would be expected by chance. In ten of these comparisons, similar changes occurred from pretest to post-test for attendees in each of the three fields, while in seven comparisons the nature of changes varied somewhat from one field to another. In almost all cases, however, the chairs reported being more aware of limitations and barriers to hiring and women's career progress after the workshops, including areas such as a lack of commitment on the part of other faculty to hiring women and inequities in involvement in decision making, assignments of students, availability of mentors, and the peer review process.

Changes were slightly more likely to occur with attitudes regarding limitations to hiring (five out of six results significant) and barriers to women's career progress (nine out of eleven significant) than with the questions regarding difficulties in recruiting or attracting candidates (three out of five significant). In other words, the workshop did not seem to change the chairs' views regarding how difficult it was to get women to apply for positions as much as it changed their views regarding factors related to hiring and women's career progress. We suspect that there may be somewhat less research available about factors that contribute to making recruiting of women faculty difficult. In reviewing the content of the workshops, this topic was addressed less than the others, yet observers suggest that the number of women applicants in these fields is often quite low.

There were some cases (seven out of twenty-two) where the pattern of changes varied from one field to another. In all of these cases the changes were stronger for the participants in the chemistry workshop than those at the other workshops. We are unsure why these differences appeared but offer two speculations that could be examined in further research. It is possible that the participants in the chemistry workshop might have been primed for participation and change by other events happening in their discipline, such as the demographics of their undergraduate and graduate student populations. Currently the participating chemistry departments have achieved gender parity at the BS level, and nearly 30% of the PhD students are female. In contrast, for MSE and physics the numbers are far below parity at the BS level (28% and 20%, respectively) and even lower for the PhD level (26% and 10%, respectively). Hence there has been considerable dialogue in recent years in chemistry about what factors contribute to such a "leaky pipeline" for women chemistry from gender parity at the BS level to 15% at the faculty level at the top fifty research universities (Raber, 2007; Nelson, 2007).

A second possible explanation, anticipated above, may involve the content of the workshops. As described above, the activities at the end of their workshop varied slightly, from simply summarizing the workshop content (MSE chairs), to making recommendations based on the content (chemistry and physics chairs), to developing a series of goals for the coming years (chemistry chairs). As expected, based on the tenets of cognitive dissonance theory, the greatest changes over time occurred for the chemistry chairs, and it is possible that that this public commitment could have fostered attitude change. Notably, there was no discernable pattern of differences between the MSE and physics chairs, suggesting that it was the stating of goals and not just the development of recommendations that might have been most important.

There were only five items for which there were no significant differences from preworkshop to postworkshop: concerns about combining family and career as a barrier to attracting women candidates and as a barrier to women's career progress, having few women in the unit as a barrier to attracting candidates and women's career progress, and too few applicants as a barrier to hiring. It could be argued that these items reflect areas where one would expect less change. Average responses to all of these items were consistently high.

Hence the presentations may have been reinforcing opinions, and there was less room for change over time. Second, the workshop was oriented toward helping decision makers see ways in which departmental and university practices could be altered to increase women's representation, and they did not focus as much on issues regarding broader societal issues that affect the current representation—or lack thereof—of women in the departments, and these broader issues are, arguably, related to areas covered in these items.

To summarize, the results of this research replicated our previous conclusions (Stockard *et al*., 2008) regarding the extent to which a workshop held over a few days could result in changing views regarding gender equity. Such replication is noteworthy, both because of the rarity of replications in the field in general as well as the rarity of interventions regarding diversity and discrimination that have been shown to be successful. The fact that these significant changes occurred in three different settings with representatives of three different, although related, disciplines lends further credence to the results.

Further research should, of course, examine the extent to which these differences persist over a longer period of time as well as the extent to which they are related to changes in practice within the respective fields. Additional research should examine the efficacy of these workshops in other settings and with other fields, as well as the extent to which the format might be used with other issues. Finally the impact of varying workshop content and, especially, the extent to which the development of goals and stated commitment to these goals can influence attitude change would be important to study.

REFERENCES

American Institute of Physics, *Academic Workforce Survey*, College Park, MD: American Institute of Physics, 2006.

Festinger, L., *A Theory of Cognitive Dissonance,* Stanford University Press: Stanford, CA, 1957.

Goldin, C. and Rouse, C., Orchestrating impartiality: The impact of "blind" auditions on female musicians, *Am. Econ. Rev.*, vol. **90**, no. 4, pp. 715–741, 2000.

Hall, L.E., *Who's Afraid of Marie Curie? The Challenges Facing Women in Science and Technology*, Berkeley, CA: Seal Press, 2008.

Handelsman, J., Cantor, N., Carnes, M., Denton, D., Fine, E., Grosz, B., *et al*., More women in science, *Science*, vol. **309**, no 5738, pp. 1190–1191, 2005.

Kulis, S. and Sicotte, D., Women scientists in academia: Geographically constrained to big cities, college clusters, or the coasts?, *Res. Higher Educ.*, vol. **43,** no. 1, pp. 1–30, 2002.

Lawler, A., Tenured women battle to make it less lonely at the top, *Science*, vol. **286**, no. 5443, pp. 1272–1278, 1999.

Lindsay, R.M. and Ehrenberg, A.S.C., The design of replicated studies, *Am. Stat.*, vol. **47**, no. 3, pp. 217–228, 1993.

National Academy of Sciences, *Beyond Bias and Barriers: Fulfilling the Potential of Women in Academic Science and Engineering*, Washington, DC: The National Academies Press, 2007 .

National Academy of Sciences, *To Recruit and Advance Women Students and Faculty in U.S. Science and Engineering*, Washington, DC: The National Academies Press, 2006.

Nelson, D., *A National Analysis of Minorities in Science and Engineering Faculties at Research Universities*, Norman, OK: University of Oklahoma, 2007.

Raber, L.A., Small increase in women faculty, *Chem. Eng. News*, vol. **85**, no. 52, pp. 44–46, 2007.

Rossiter, M.W., A less than golden age for women in chemistry, 1970–2000?, Washington, DC: Workshop Report on Women in the Chemical Workforce, 2000.

Shadish, W.R., Cook, T.D., and Campbell, D.T., *Experimental and Quasi-Experimental Designs for Generalized Causal Inference*, Boston, MA: Houghton-Mifflin, 2002.

Sonnert, G. and Holton, G., *Who Succeeds in Science? The Gender Dimension*, Piscataway, NJ: Rutgers University Press, 1995.

Stockard, J., Greene, J., Lewis, P, and Richmond, G., Promoting gender equity in academic departments: A study of department heads in top-ranked chemistry departments, *J. Women Minorities Sci. Eng.*, vol. **14**, no. 1, pp. 1–27, 2008.

Trix, F. and Psenka, C., Exploring the color of glass: Letters of recommendation for female and male medical faculty, *Discourse Society*, vol. **14**, no. 2, pp. 191–220, 2003.

Valian, V., *Why So Slow? The Advancement of Women*, Cambridge, MA: MIT Press, 1998.