A Classroom Intervention to Reduce the Gender Achievement Gap in College Science  
Final Report  
September, 2012

The goals of the proposed work were to (1) better understand the mechanisms through which women’s STEM performance can be improved, focusing specifically on the psychological changes that are produced by a self-affirmation we have shown to increase the performance of women in college physics, (2) test the effectiveness of our intervention in other contexts (e.g., courses with different content, professors with different teaching styles, students of various demographics), (3) provide necessary data for a larger grant focusing on dissemination of the intervention, and (4) bring psychological perspectives more explicitly into CU’s work on STEM education.

A number of activities were undertaken with an interdisciplinary team consisting of myself, a post-doc in the psychology department who was partially funded with this award (Jane Stout), and two collaborators in physics (Noah Finkelstein, Steve Pollock).

1. **Data Collection**: Our prior research showed that a brief writing intervention improved the course performance of women in an introductory calculus-based physics course at CU. Additional data were collected in Fall 2011 further exploring the mechanisms through which the writing intervention operates. We specifically compared our standard affirmation, which asks participants to affirm values that are important to them, with a modified intervention that asks them to consider attributes on which they excel. Both exercises act to affirm an aspect of the self, but values affirmation is more focused on reinforcing what one’s values, whereas the attributes affirmation focuses on dimensions along which one excels. One can thus be seen as focusing more on self-definition whereas the other focuses more on self-elevation. We found that both were effective in improving the performance of women, with no clear benefit of one version over the other at the end of the semester. This information is relevant to building a fuller understanding of whether only very specific types of self-affirmations are beneficial, or whether a broader class of self-focused activities can be beneficial. We are also still following these students in subsequent semesters to see if the benefits are equally long-lasting.

2. **Analysis of Existing Data**: A second and major activity of the award was to further analyze data we have been collecting since Spring 2010 for evidence of the mechanisms through which the affirmations work. To do so, we focused on the content of what students write in response to our prompts. With past research as a guide, we developed a detailed coding scheme and trained a number of undergraduates who then read through the several thousand written answers we have obtained over the course of our research. Past research has suggested that increasing one’s sense of connection and belonging may be particularly beneficial in buffering women in science from the negative consequences of their numerical minority status. Other research indicates that achievement and individuality is viewed as more congruent with pursuing STEM careers compared to a focus on serving and connecting with others. Our coding scheme was thus designed to identify a number of themes related to belonging, agency (e.g., achievement, individuality, power status), and communality (e.g., helping others, connecting with others). Our coders were able to identify these themes in participants’ written responses with a high degree of agreement. We are still in the process of these analyses, but initial results indicate that valuing agency does not underlie the effectiveness of the intervention. That is, affirming agentic themes (e.g., discussing the personal importance of achievement and power) does not mediate the benefits of the affirmation. We also found no evidence that valuing communality diminished
the benefit of the affirmation. By contrast, we found some evidence that endorsing and discussing issues of belonging is beneficial. We found that a very high proportion of women in our affirmation conditions (>90%) spontaneously discuss issues of belonging. The writing exercise thus might benefit women because it reminds them of general feelings of social connectedness.

Another major set of analyses focused on exploring relations among a wide range of self-report measures that we have collected during all our intervention studies. Particularly interesting results were obtained with our belonging measures. We found that for both men and women, feeling a higher sense of connection and acceptance within physics was associated with beneficial educational outcomes (e.g. higher course grades, greater intentions to take additional physics classes). However, for women, issues of gender stereotypes affected belonging. Specifically, women who more strongly endorse the cultural stereotype that men are better at science felt a lower sense of belonging in physics. Not such relation between stereotype endorsement and belonging was found for men.

3. **Dissemination of Intervention:** I corresponded with 8 separate researchers or instructors outside of CU about our intervention. I talked in detail with two groups of researchers about the analysis and interpretation of their results. We continued to refine a set of materials and procedural descriptions to guide others in the administration and analysis of our intervention. Interest in the intervention remains high and we are continuing to develop the best ways to share it and advise others in its administration, including consideration of a web portal.

These activities have advanced our understanding of the processes that affect gender representation in STEM. More notably, they have lead us to focus in detail on the critical role being played by the subjective feeling of fitting in, being personally accepted, respected, and included as a member in an academic discipline. Our coding of what students write about during the affirmation intervention and our analyses of self-reported belonging among students in physics both highlighted the importance of belonging.

These results lead us to develop what we hope will be an even more potent version of our intervention. Although most women in the affirmation conditions of our prior research spontaneously wrote about belonging-related issues, we nevertheless thought it might increase the potency of our intervention to explicitly focus students on belonging. We thus redesigned our intervention to ask students to consider how various values help them feel closer and more connected with people. We have administered this modified version in classes this semester and will evaluate its effects on course performance at the end of the semester.
We also developed a new theoretical model of how belonging within STEM facilitates academic outcomes, and what factors might affect belonging (see Figure 1). We have initially focused on four important antecedents of belonging based on extant research. While some of these should affect belonging among both men and women (instructor and social support), they may nevertheless contribute to gender differences in STEM belonging for two reasons. First, women in STEM may experience them to a lesser degree than men (e.g., less support from teachers), thwarting their ability to experience a secure sense of belonging. Second, women in STEM are more likely than men to experience belonging uncertainty, a greater sensitivity to belonging-related cues in the social environment among members of stigmatized and/or underrepresented groups. When presented with the same situation, belonging uncertainty can cause women to suffer greater reductions in belonging than men. Finally, women may be subject to additional socio-cultural factors such as negative cultural stereotypes about their math and science ability and stronger interest in communal goals that affect their belonging more so than that of men. As can be seen in our model, belonging is a critical nexus through which such variables influence STEM representation and achievement, which we operationalize in several ways (e.g., actual class performance, continued pursuit of a STEM major).

The model we developed formed the basis for a grant submitted in July, 2012 to NSF, “Broadening Women’s Participation in STEM: The Critical Role of Belonging.” The project is designed to pinpoint theoretically-derived factors that explain how women experience a lower sense of belonging in STEM than men and understand why a thwarted sense of belonging in STEM affects both achievement (e.g., grades) and representation in STEM (e.g., retention). The proposed research combines both large scale field research with smaller experimental lab studies to optimally test all aspects of the model. The investigative team is multi-disciplinary, consisting of psychologists and physicists. We choose to focus on this grant rather than a grant focused on dissemination of the intervention, as initially proposed, for several reasons. First, the former is designed to understand at a broad level the mechanisms that affect retention and achievement within STEM. Second, such a theoretically focused project was directly responsive to the particular funding call, whereas a grant focused on dissemination of the intervention would not have been.

We disseminated our work in several ways. Posters were presented at the 2012 Physics Education Research Conference, the annual meeting of the Society for Personality and Social Psychology, and the CU Science Education Initiative and Integrating STEM Education conference. A peer-reviewed conference preceding report is in press and we plan to write up our analyses of the belonging data for publication.