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Engineers' Perceptions of Diversity and the Learning Environment at Work: A Mixed Methods Study

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Abstract: Women and people of color are particularly underrepresented in the science, technology, engineering, and mathematic (STEM) disciplines. This mixed methods study surveyed 527 engineers and interviewed eight female engineers to examine the current culture climate for diversity in engineering worksites, and how gender, race, and age intersect and affect engineers' perceptions of organizational inclusiveness and the learning environment surrounding diversity.

Attention to diversity issues is not new to American business, nor to the field of adult education. The 1987 publication of *Workforce 2000: Work and Workers for the Twenty-First Century* (Johnston & Packer, 1987) predicted that the majority of new workers would be women and traditionally underrepresented groups. While this has been a concern in all disciplines and professions, women and people of color are particularly underrepresented in the science, technology, engineering (Gibbons, 2007), and mathematics (STEM) disciplines. A National Academies report encourages STEM disciplines to examine exclusive practices that currently limit the participation of underrepresented groups (National Academy of Sciences, 2007). However, beyond research that focuses on a lack of women and the obstacles they face, particularly in academia little is known about diversity initiatives in STEM workforces.

While there is a wide body of adult education research and theory that deals with structural inequities based on gender, race, culture, and class in the process of educating adults in classrooms and learning in the workplace (Barrett, Cervero & Johnson-Bailey, 2003; Bierema, 2008; Brooks & Clunis, 2007; Johnson-Bailey & Cervero, 2008), with limited exception, such as Delores Rice's (2011) presentation at last year's AERC on Black women engineers' career experiences, there is a lack of critical research focused on diversity and learning in engineering worksites. A review of the research and literature on race and ethnicity in workplace learning from 1980-2005 (Brooks & Clunis, 2007) concluded that most research does not address the complexity of the dynamics related to race and ethnicity in the workplace around structural inequalities and that studies of workplace learning and issues related to diversity in engineering is lacking. Given this lack, the *purpose of this mixed method study was to investigate engineers' perceptions of diversity and the workplace learning environment surrounding diversity education efforts in engineering occupations. The specific questions that guided this study are: (a) To what extent do engineers perceive that engineering worksites foster learning about diversity issues related to gender, race/ethnicity and culture? (b) What are engineers' perceptions of diversity in engineering workplace culture? and (c) Do interactions between gender, race and age influence engineers' perceptions of diversity in engineering organizational culture?*

Theoretical Framework

The theoretical framework that guides this study combines critical and feminist adult education perspectives, informed by poststructural feminist theory, with Rasmussen's (2007) diversity mosaic perspective in organizations. Because the diversity mosaic model combines theoretical concepts with practice oriented tools, it is well suited for application in engineering and other workplaces where rational, objective approaches are familiar and the dominant group is motivated more by sustainable business models than theoretical concepts of social justice. Furthermore, the model is helpful for organizations and their employees to become aware of unconscious acceptance of dominant culture and power relations. The critical feminist adult education perspective enhances this awareness by placing importance on the positionality of people and allows for an examination of how individual difference in areas such as gender, culture, race, age and socioeconomics, intersects with social structures and personal perceptions. This is accomplished through discourse deconstruction to examine the role of language in the reinforcement of truth assumptions that maintain dominant ideology and hegemony (St. Pierre, 2000) and examining the interrelationships between politics, power relations, social structures, actions, discourse, and individual's perceptions. Through these mechanisms, answers to questions such as who is in control of the learning, how and what is being taught, and who benefits can serve to make visible inequalities, and prompt a change in values and beliefs that maintain social injustice and promote democratic work environments (Hatcher & Bowles, 2006).

Research Design

The design was a mixed methods research methodology (commonly called mixed methods) that contains both quantitative and qualitative techniques. By using mixed methods this study takes advantage of the benefits of having a wide data base of engineers' perceptions obtained through a quantitative survey combined with in-depth, qualitative interviews that added richness and included the voices of underrepresented populations (O'Cathain, Murphy & Nicholl, 2007). The survey was sequenced before the interviews and the quantitative findings informed the qualitative portion.

Participant Selection

The population for this study is engineers who are deemed qualified to practice as professional engineers (PEs) by Pennsylvania and the National Council of Examiners for Engineering and Surveyors. Unfortunately, the list contained no demographic information. Recognizing that women are likely to be underrepresented in this population, a stratified sampling technique was employed. This resulted in a randomly selected sample of 644 for the female list and 762 from the male list for a total of 1,406 mailed surveys (Dillman, 2007). With 527 completed surveys returned (45% female and 55% male), the overall response rate was 37.5 percent. Although predictable, but disappointing nonetheless, the returned survey sample was 94% White and 6% persons of color. However, with the exception of the youngest category (30 and under) an acceptable distribution of age groups was obtained.

The qualitative sample was selected from the survey respondents according to the following non-exclusive criteria: (a) indicate a willingness to participate in the interview, (b) self-identification as a female, (c) self-identification as a woman of color, (d) those who are age 40 and under, and (e) those whose survey results generally indicate engineering workplace culture does not foster a climate for diversity and/or do not like their job. Eight female engineers, including two women of color were interviewed.

Data Collection and Analysis

The quantitative data collection instrument was a workplace diversity climate survey that through a series of questions scored on a four point Likert scale, quantified theoretical dimensions that have been found to be pertinent in culture climate assessments; (a) recruitment, (b) retention, (c) communication, (d) leadership, and (e) interpersonal climate (Ioannou, 2008; Murphy, 2005; Rasmussen, 2007). Two other factors, learning environment and employee engagement (job satisfaction) were added to investigate the learning environment and to explore connections between workplace climate factors and employee engagement. The data analyses included scale reliability and descriptive tendencies for engineers' overall perceptions. After creating indices for the theoretical dimensions, analysis of variance (ANOVA) to ascertain differences in the mean index responses of male and female engineers and engineers in different age groups and multiple regression analysis to determine the presence of predictor relationships between; (a) gender and age and the seven culture climate indices, and (b) the seven culture climate indices plus gender and age and employee engagement was conducted.

The qualitative data were collected via interviews using a semi-structured format where questions were pre-prepared, but also allowed for extemporaneous clarifying questions that explored themes in greater depth. For example, although an interview guide ensured the same questions were being asked of each person, participants frequently expanded on topics or steered the conversation to areas that were personally important. The data gathered from the interviews were transcribed and analyzed by constant comparison, a method of organizing data that begins with identifying commonalities, organizing categories and finally coding for themes and patterns (Patton, 2002).

Findings and Discussion

Since this study used a mixed methods methodology where the quantitative data were analyzed first and informed the qualitative portion, it is fitting to discuss the quantitative findings and then segue into the qualitative findings providing an integration of the findings when informative.

Quantitative Findings

As mentioned previously, only 6% of the quantitative sample represented people of color and therefore the survey findings must be interpreted as primarily White perspectives; the sample size for persons of color was insufficient to do any statistical analysis based on race or ethnicity. For each of the seven dimensions the scale reliability, a measure of internal question consistency, indicated that all the scales were reliable at a Chronbach's alpha of 0.7 or better. The survey findings suggest that the overall engineers' perceptions of the engineering workplace culture are positive and that over 90% agreed or strongly agreed that they "like their job" and "their company inspires them to do their best in the way of job performance." To test for differences in perceptions between men and women and by age brackets, a one-way analysis of variance (ANOVA) test was run at 95% confidence level and was considered significant at a 0.05 or less p value. Those results show that while still favorable, women's perceptions for all of the indices are less favorable than their male counterparts. Differences in perceptions between the age groups proved statistically significant for three of the indices, retention, communication, and employee engagement. The fact that age was implicated in diverging perceptions and was significant as a predictor for employee engagement (discussed below) supports the consideration of age and how it intersects with other positionalities in research. The findings from the multiple

regression analysis confirmed that gender had a predictor relationship with all the culture climate indices while age was not a predictor. Finally, of the five independent variables (age, recruitment, retention, leadership, and interpersonal climate) that were significant in predicting employee engagement, interpersonal climate was the strongest predictor. Interestingly there was a negative relationship between the index of recruitment and employee engagement which suggests that in general, White engineers do not seem to agree with recruitment efforts that are specifically designed to target underrepresented populations. These results support some survey respondents' negative comments that criticized the need to investigate issues of diversity in engineering and suggested that engineering, which is of course populated by engineers, is not subject to racial or gender prejudice. Frequently, these comments indicated an approach that was critical of affirmative action philosophy, and so this was further explored during the interviews with the eight female engineers in the qualitative portion of the study.

Qualitative Findings

The major qualitative findings are organized in light of four areas (a) engineering as not beyond racial or gender prejudice; (b) effects of organizational context: size and scope; (c) the flexibility in family friendly companies; and (d) workplace learning is primarily on the job. As discussed below, for the women interviewed, interactions between age and race did seem to be a source of diverging experiences and perceptions

Engineering as not beyond racial or gender prejudice. When investigating the phenomena of engineering as a profession that is immune to racial and gender prejudice, the interviewees' perceptions were clearly divided along generational lines with the younger women (31-40) expressing some support that engineers are more concerned with an engineer's ability than their race or gender. Perhaps because their experiences relate an intersection with multiple sources of discrimination, the two women of color focused on the lack of awareness within the engineering community of existing racial/cultural and gender bias, while the white women spoke more frequently of gender bias. For example one woman of color said:

There's no evidence that that is true...it's very easy to say that [hiring and promotional decisions are not made on the basis of gender or race] while your office remains all White and male. If all of this were true, you would have substantially more people of color and women in your company and you would have made an effort to make sure that that happened.

A White female engineer in the 51-60 age bracket commented specifically about the gender prejudice she experienced in her career when she said:

I believe there are others who are prejudice. I've been told I don't want a damn female working for me - straight out. That was the response that I got when I was searching for a job and I wasn't hired.

In contrast, the four White female engineers in the 31 to 40 age group generally indicated that they have not personally experienced gender discrimination. For example, two of them addressed the issue directly saying, "But I never felt...any issues about me being a female. I mean no discrimination or not being wanted in the workforce" and "Anytime that I felt like someone was not respecting me, I saw them not respecting people pretty much across the board. It wasn't because I was a girl...I didn't have any experiences like that." However, one woman qualified her remarks indicating that when you wanted to move up the ranks, the assumption that everyone had a fair chance was not reflective of reality and she noted:

I've seen that when you want to be an engineering manager, director, or supervisor, that totally comes off. That is one of the reasons why I left my old company. Ten manager spots opened up last year and I interviewed for at least a couple of them. Some of them were not even posted, they didn't even interview; they just appointed people. But all ten spots went to ten white males.

These women engineers' workplace experiences with bias, particularly when examined through multiple lenses of oppression serve as a basis to question the hegemonic truth claiming that engineering is a prejudice free zone.

Effects of organizational context: size and scope. The findings indicate that larger organizations that are U.S. or internationally based with a global scope are more supportive of diversity. This support is demonstrated by the presence of a diverse workforce (women and people of color in the ranks and management), a visible diversity policy and diversity training programs. The women who worked in small, family or privately owned companies indicated that there was a lack of written policy and that, as one woman said, "It [diversity] doesn't even come on their radar screen."

The flexibility in family friendly companies. The mixed methods findings bring into question a common engineering rhetoric that engineering worksites are not welcoming and do not support family obligations. The women who were interviewed indicated that the organizations in which they are currently working are quite family-friendly, and allow for some work flexibility. However, in many cases they chose to work in these flexible organizations and contrasted their current work climate with previous employment that was not sensitive to their personal needs. Furthermore, approximately 70% of the survey respondents agreed or strongly agreed that their company provides job flexibility in the form of working at home and compensatory time. Additionally, 80% responded favorably that they are satisfied with the balance between their work and personal responsibilities and 85% indicated they feel comfortable taking time off to deal with a family or personal issue.

Workplace learning is primarily on the job. Eighty one percent of the survey respondents indicated that most of their learning is done on the job and slightly less, 72% said their company encourages learning through mentoring relationships. Although all of the women who were interviewed agreed that on the job learning and mentoring experiences are a big part of their development as engineers, they did not expand on how those experiences are structured in terms of availability and value. One woman did refer to an underlying issue with on the job learning and mentoring in terms of career progress when she said, "it doesn't really matter whether you have aspirations in any other particular direction; if you are not seen as someone they want to develop they want you in a spot where you are predictable."

Implications for Adult Education

By paying particular attention to race, age and gender when examining engineers' perspectives of diversity and learning in the workplace, this mixed methods study contributes to the body of knowledge about adult learning, cross discipline research, plural methodology, and workplace inequality. There is a distinct lack of literature with critical perspectives that include interactions of race, gender, and age about workplace learning and diversity related to STEM environments (Brooks & Clunis, 2007). While there are critical perspectives in adult learning theory that focus on power and privilege, most in engineering are unaware of such theories allowing hegemonic ideals, structures, and practices that maintain inequality to persist

unchallenged. Additionally, because adult learning in engineering appears to be primarily unstructured and not evaluated, issues of power and privilege remain hidden (Barrett, et al., 2003; Johnson-Bailey & Cervero, 2004; Johnson-Bailey & Cervero, 2008). By valuing and paying attention to on the job learning and mentored learning experiences, engineering organizations could have a more diverse, developed, capable and engaged workforce. Thus an understanding of the political aspect of workplace learning and a perspective of knowledge as plural and subjective may serve to assist engineering organizations in critically examining traditional culture and create more inclusive organizations for all engineers.

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