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AIMS AND SCOPE

Designed as a unique and much-needed resource for educators, managers, and policymakers, the *Journal of Women and Minorities in Science and Engineering* publishes original, peer-reviewed papers that report innovative ideas and programs for classroom teachers, scientific studies, and formulation of concepts related to the education, recruitment, and retention of under-represented groups in science and engineering. Discipline-specific issues related to women and minorities are consolidated to address the entire educational environment from K through post-graduate and on to continuing education. Included are explorations of feminist teaching methods, black student/white teacher interactions, cultural phenomena that affect classroom climate, and new questions to ask of science. The journal includes pertinent book reviews and "reports from the field" by women and men of color in academe, business, industry, and federal and state agencies.

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"WE'VE ALL LEARNED A LOT OF WAYS NOT TO SOLVE THE PROBLEM": PERCEPTIONS OF SCIENCE AND ENGINEERING PATHWAYS AMONG TENURED WOMEN FACULTY

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Women's career development and socialization into the sciences and engineering is generally acknowledged to be uniquely guided by factors including having role models and mentors who provide useful guidance. This study examines aspects of department culture that encourage retention of women science and engineering majors through the perspectives of ten tenured women professors in Florida public university science and engineering departments. Interviewees reflected on their personal experiences and those of their women colleagues and students to develop recommendations on social support and mentorship opportunities, improving treatment of women faculty, and developing departments that also function as a community and family. Tenured women faculty reject the pipeline approach and describe their own circuitous pathways into academia. They describe the strain of the role of "female professor" and its impact on research, teaching, and university service. These women explain how women and men together struggle to navigate divisions between departments based on research interest and with their bids for tenure and promotion to full professor. However, they explain that women emphasize community and collegiality more than men. Isolation and mistreatment of women and poor community in departments dissuade women junior faculty from continuing in the professoriate.

KEY WORDS: *faculty, women, pipeline, science and engineering, climate, gender, faculty retention, tenure and promotion, faculty recruitment*

1. INTRODUCTION

> I've been watching the problem for thirty years, and I think we've all learned a lot of ways not to solve the problem. You know, at least in terms of getting people all the way to the faculty level, we know that increasing the pipeline isn't the answer, because the pipeline's been increasing and the number of women faculty [are not]…. I think, this is going to sound terrible, but the answer is to get people who don't look like you and me convinced that this is a problem.

This candid statement from a tenured woman chemistry professor to the second author is a direct challenge to the pipeline model of the underrepresentation of women in science and engineering academic positions. The pipeline metaphor suggests two reasons for this underrepresentation: (1) the low volume of "flow" of women into enrollment as undergraduate and graduate science and engineering majors and (2) "leakage" among women who drop out of undergraduate and graduate programs or who decide not to continue into the professoriate or leave academia (Kulis et al., 2002). Despite some increase in bachelor's degree attainment among women, women make up a very small percentage of faculty in science and engineering and an even smaller percentage of tenured faculty.

The study reported here is part of a larger three-year research project designed to study engineering program culture and climate influencing persistence among undergraduate students. Interviews with women faculty reveal their own struggles to enter science and engineering faculty positions out of graduate school. Women's career development and socialization into the sciences and engineering is generally acknowledged to be uniquely guided by factors including earlier informal experiences in elementary school and availability of role models and mentors to provide useful guidance. To address this aspect of science and engineering pathways, we examine how the culture and climate of chemistry and engineering programs affect the recruitment of women to tenure-track faculty positions, their capacity to earn tenure, and ultimately their promotion to full professor. We also examine how women cope with isolation and how they work to develop friendships and social support mechanisms within their departments.

We accomplish this task using the voices of 10 tenured women faculty in Florida public university science and engineering departments. Interviewees range from newly tenured faculty to full professors and former department chairs and deans. The women agree that institutional changes must be secured to better recruit and retain women faculty and advance them through tenure into promotion to full professor. One extremely important lesson learned in this research is that departments must function as communities to fulfill women faculty's desires for open communication with colleagues and support for their personal lives. This requires cooperation between women faculty and their male colleagues and includes changes to department cultures that our interviewees believe would benefit both men and women nontenured faculty.

2. RELATED LITERATURE

The pipeline metaphor suggests that if the number of girls who engage in science, technology, engineering, and mathematics (STEM) coursework in high school increases, particularly those taking challenging courses preferably including advanced placement calculus and physics, in addition to an increase in the number of women who earn bachelor's and doctoral degrees in science and engineering, then the number of women in STEM tenured faculty positions should increase by default. The pipeline metaphor unfortunately places the onus for improving women's status in these field on girls just beginning to engage the pipeline while absolving academic departments of their responsibility in cultivating their women graduate students and sending them into the academic workforce, as well as hiring women as junior faculty at the start of their academic careers. We prefer the image of the pathway in defining career trajectories for both men and women.

2.1 Rejecting the Pipeline

Women are underrepresented among students and faculty in STEM disciplines, particularly in the physical sciences and engineering. Women make up fewer tenured faculty than expected given increases in women STEM doctoral degree recipients over the last several decades (Kulis et al., 2002). Furthermore, women earning doctoral degrees do not go on to earn tenure at the same rates as men (Hill et al., 2010).

Women make up only between 12 and 18% of associate professors and between 4 and 8% of full professors in the top 100 chemical, civil, electrical, and mechanical engineering programs. While women have caught up with men in attaining chemistry bachelor's degrees, they make up only 20% of associate chemistry professors and 10% of chemistry full professors in the top 100 programs (Nelson, 2007). Approximately a quarter of full professors in the United States are women. Only 3% of all full professors in engineering are women (Almanac of Higher Education, 2008). During the 1980s, more experienced tenured women faculty in engineering persisted into academia despite their departments discouraging them from pursuing doctoral degrees (Baum, 1989; Golladay, 1989). We submit that this is further evidence of the deficiency of the pipeline metaphor as an explanation for gender disparities among STEM faculty.

Gender disparities in the recruitment of women faculty into STEM disciplines are well noted in the literature. Trix and Psenka (2003) found that faculty use gender stereotypes in writing letters of recommendation. For example, letters of support for women applicants were shorter than letters for men and lacked relevant information more often found in letters written for men. In addition, letters for women applicants more often referred to qualities including their compassion, teaching, and effort more than achievements, research, and ability used to judge men. Hiring departments value women-typed traits less than traits attributed to men. Other research indicates that women are more likely to be hired for STEM faculty positions at major universities, even though fewer qualified women apply for these positions (National Research Council, 2009). Sadly, the women who are qualified and are hired in STEM departments within the academy as well as in other STEM occupations are more likely to leave the field than men in the field and women in other occupations (Hewlett et al., 2008; Simard et al., 2008).

2.2 Isolation and Mistreatment

Once women are hired as faculty, the struggle to gain equality with their male peers continues. Hewlett et al. (2008) describe a science, engineering, and technology workforce that women experience as a hostile macho culture, replete with isolation, mystified career paths, systems of reward emphasizing risk-taking, and extreme work pressures. Women in STEM faculty positions may be seeking refuge from the harsh realities of the private sector, yet they face unique challenges within the academic workplace, primarily dissatisfaction with departmental culture, advancement opportunities, faculty leadership, and research support (Xu, 2008), the principal topics of interest in this research study. Women in academic workplaces are more likely than men to have hostile, unfriendly encounters with their colleagues (Marschke et al., 2007).

McKendall (2000) interviewed women engineering faculty and found that most felt isolated because of their gender and tried, often unsuccessfully, to avoid drawing attention to themselves in order to cope. Women in the sciences struggle simply to be liked by their colleagues. Successful women in male-typed jobs, even women who do the "right things," are more likely to be disliked than successful men or women whose success is unclear (Heilman et al., 2004). Women also report lower satisfaction with their departments than men (Trower and Chait, 2002). Thus, once an academic position is secured, women are still frustrated in their search to secure a niche where they feel comfortable and at ease.

Women are more likely than men to report being excluded from informal and formal department events (Massachusetts Institute of Technology, 1999). Women also lack informal and formal mentorship crucial to meeting tenure and career demands (Macfarlane and Luzzadder-Beach, 1998; Rosser, 2004). Women find informal mentorship to be more important than formal mentoring because it is likely to give them entry into behind-the-scenes conversations and the hidden requirements for tenure and promotion (Trower, 2008).

2.3 Balancing Research, Service, and Family

In her study of women who are faculty members or who hold other demanding jobs in labs, Monosson (2008) defines the "elephant in the lab" as future plans or current responsibilities connected with motherhood. Family planning is a difficult area of concern for women in sciences and engineering. Huston et al. (2007) give an example of a male senior faculty member advising women junior faculty to leave academia as soon as possible if they plan to have families.

Xie and Shauman (2003) found that married women are only slightly less likely than married men to earn tenure and promotion if they have children. However, women with children are less likely than men with children to enter a tenure-track position after earning a doctorate (Goulden et al., 2009). Tenured women faculty members are less likely than tenured men faculty to have children living in the home (Mason and Goulden, 2002). Women in academia report twice as often as their male peers that they have fewer children than they had originally desired. Women who did choose to have children earlier in their careers are less likely to earn tenure than men (Mason and Goulden, 2004).

One argument is that young children impact women's research productivity because women are more likely to be the primary caregiver (Stack, 2004). Women are also more likely to have a partner with a PhD (Ledin et al., 2007) or who works full-time in another demanding career given priority in the relationship (Hewlett et al., 2008; Simard et al., 2008). Women publish less and have slower pathways to tenure and promotion to full professor because women are likely to have less time to devote to their work in addition to having more responsibilities away from work, evidence that problems exist outside academe and require cultural shifts in women's roles to see real change in women's circumstances (Ledin et al., 2007). Other research finds that women and men have similar family and household responsibilities; therefore, differences do not explain the gender differences we have noted in individual STEM faculty outcomes (Xu, 2008).

Women faculty members are less likely than their male colleagues to believe their universities support raising a child while pursuing tenure. STEM fields are particularly challenging because the nature of lab research does not sustain stopping the tenure clock. Parents in faculty positions also struggle to find convenient childcare on campus (Trower, 2008). Trower (2008) suggests that universities that develop policies which allow faculty to better balance work and family are at an advantage in recruiting and retaining women faculty. We agree with this assessment. Unless universities move toward policies allowing women to have equity with respect to men, it is unlikely that we can expect women to advance in their respect fields, particularly in the sciences where research productivity is especially valued.

2.4 Contributions to the Literature

Women are not inherently unsatisfied with their jobs, just less likely to tolerate negative department climate and low job satisfaction (Callister, 2006). In this respect, gender differences in job satisfaction and intent to leave are mediated by department culture. This study examines the experiences of successful women faculty to make two sets of contributions to the current literature on women in sciences and engineering. Through these contributions, we develop recommendations for ways to improve department climate and job satisfaction.

First, this study approaches pathways from the perspectives of women who have "made it" and rejects the "pipeline" narrative as too narrow in its interpretation of how women forge their careers in engineering and the sciences. Analyses integrate women's retrospective examinations of their own experiences as well as their interpretations of colleagues' experience to construct *women's* pathways instead of assuming women and men have the same pathways. This approach is particularly useful for studying women who began their undergraduate pathways as early as the 1950s and as recently as the 1990s.

Second, this study focuses on the culture and climates of engineering programs instead of the specific behaviors of the women themselves. Studies that focus on women's experiences either purposefully or unintentionally place the onus on the women themselves as being fully responsible for their own fate. Revealing the espoused values of tenured women faculty reveals their contributions to the culture of departments as well what they need from the culture of their departments. Focusing on institutional issues as voiced by those who have successfully navigated through those issues allows us to make recommendations about how universities and departments can retain tenure-track women in engineering. Analyses and intervention at the department level have the most promise to address gender segregation within fields.

3. METHODOLOGY

This study is embedded in a three-year National Science Foundation sponsored research study investigating program culture and organizational conditions that promote successful completion of undergraduate chemistry and engineering degrees among women and minority students. Our research team visited four engineering programs and five chemistry programs at five large public universities in the Florida State University System. The University of Florida (UF) in Gainesville is the flagship university and has the largest engineering program in the system. Florida State University (FSU) and Florida Agricultural and Mechanical University (FAMU) in Tallahassee share the FAMU/FSU College of Engineering. FAMU is the only historically black college or university (HBCU) in the state system. Along with UF and FSU, the University of South Florida (USF), with its main campus located in Tampa, is the state's third Research I Carnegie classification university. Florida International University (FIU) in Miami is unique among American universities because it boasts a majority-minority student population, including 63.8% undergraduate Hispanic students in 2007.

We made three site visits to each campus and conducted interviews during each visit. The interviewers, lead by the second author, conducted 80 interviews across sites with men and women faculty and administrators of all ranks, including non-tenure-track faculty and staff. We recruited all faculty and administrators willing to speak with us. We particularly sought to interview women and minority faculty, both of whom were underrepresented in engineering departments across all institutions.

Given the overall project focus on undergraduates, the guiding question for all interviews was "What contextual (e.g., cultural/climate) factors in chemistry and engineering programs affect students' motivation and ability to successfully complete college degrees in these areas?" Our primary project goal for faculty interviews was to understand their perceptions of department climate and culture for student learning. We also asked interviewees to assess how department climate and culture impact their careers. These responses are the focus of this study.

Women faculty experiences underscore the stress and strain of the department and help us better understand challenges faced by women at all levels of sciences and engineering. Interviews lasted approximately 45–60 minutes and followed a semistructured interview guide. Interviewers encouraged faculty to be free and open about their experiences by using open-ended questions with targeted probes. The semistructured interview protocol addressed the following broad themes:

- Background and early experience in the field
- Strengths, weaknesses , and core values of the department
- Formal and informal rapport with undergraduates
- Obstacles faced by students
- Recruitment and retention of women and minority students and faculty

Interviews varied in the extent to which the interviewees discussed their career and past and present experiences with department culture. Women interviewees were more forthcoming than men about department efforts to recruit and retain women faculty. After interviews were completed and transcribed, members of the research team reviewed transcripts and coded them using a qualitative analysis software. These codes were derived from the literature developed for the larger study. All transcripts were coded at an inter-rater reliability of at least 80%, within the acceptable range. The following codes within these three themes make up the focus of this study:

1. Background – background, position, choosing university, academic preparation
2. Strengths, weakness, and core values of the department – department climate, department culture, department characteristics, department recruitment
3. Recruitment and retention of women faculty – women and minorities, satisfaction, job duties

This study draws from interviews with ten tenured women faculty in chemistry and engineering interviewed across five universities (Table 1). Given the low number of tenured women faculty in university chemistry and engineering departments at the five institutions, any participant could be easily identified with a small amount of information. For this reason, we are careful to keep interviewees as anonymous as possible. We assigned a fictitious name to each interviewee. The only personal identifiers used are field and rank or length of tenure shown in Table 1. Marital status is mentioned in the text where relevant. We do not mention faculty's race, ethnicity, nationality, age, current university, or past affiliations. This study does not mention any names or relationships with other faculty members.

We acknowledge that the need for anonymity is a limitation of this study. We cannot effectively gauge how race, age, university, past affiliations, or other experiences impact interviewees' perceptions of faculty life and recruitment and retention of women faculty in their departments. We also cannot make specific conclusions about the climate and culture of each department. Due to the primary focus on undergraduate

TABLE 1: List of interviewees

Name	Field	Rank	Years of tenure
Jane	Chemistry	Associate	<5
Trudy	Chemistry	Asociate	<5
Anne	Chemistry	Associate	<5
Joan	Chemistry	Full	>10
Rachel	Chemistry	Full	>10
Sally	Engineering	Associate	<5
Lois	Engineering	Associate	5-10
Peggy	Engineering	Associate	<5
Betty	Engineering	Associate	>10
Bobbie	Physics	Full	5-10

experiences and recruitment and retention of women and minority students, some interviewees spent more time than others taking about background, strengths/weaknesses of their department, and retention/recruitment of women faculty. Interviewers were careful not to make assumptions about women's experiences based on the literature or any preconceived notions of women in science and engineering or the departments. These unique narratives allow this study to reveal general aspects of organizational culture that impact recruitment, retention, tenure, and promotion of women science and engineering faculty.

4. RESULTS

Several interviewees point out that although half the chemistry majors in their departments and across the country are women, improving pathways to undergraduate chemistry degree attainment does not lead to a later increase in chemistry doctorate degree recipients or women faculty. The pathway to the professorate is a long and arduous one comprised of several steps. Women in science and engineering do not necessarily consider moving from undergraduate into graduate school and then decide to be a professor at the same rate as men. Despite a growing pipeline of women going into STEM fields in college and even into graduate school, the culture and climate of science and engineering departments does not adequately support women.

4.1 Rejection of the Pipeline

Lois is a long-tenured faculty member who entered the sciences at a time when there were low expectations for women's mathematics and science achievement. She did not mean to become an engineer. Lois had to wind her way through several different academic and career pathways before meeting individual mentors who directed her into engineering, mostly because her high school counselor did not lead her toward engineering:

> My high school guidance counselor called me in and sort of chastised me, because I had gotten like an 800 on my math SAT. He said, "Girls don't usually get that kind of score." And I said, "I'm sorry. I didn't mean to. I took the test and that's what I got." So when I went to college, I didn't really have…good guidance so I ended up studying biology. (Lois)

Lois went on to work in medicine, environmental studies, and public health before learning about engineering from colleagues at a consulting firm. These colleagues encouraged her to enroll in an engineering program and earn her PhD.

Sally recently earned tenure in engineering. In high school, Sally was strong in mathematics and science, but did not know how to continue her interests in math and science without becoming a mathematician or scientist, saying she did not want to "do math problems all day long" or do "a chemist set" or "dissect some animals." According to Sally, many in our society believe math and science are "very scary and frightening or something you're afraid of or it's totally nerdy and you don't want to be associated with it."

Sally learned about engineering from a workshop run by The Society of Women Engineers (SWE) at a local university. The appeal of engineering as a practical, problem-solving field with application to the real world had enormous appeal: “You actually get to work on things that are relevant to the world, and so I guess overall, I wanted to be an engineer, I just didn’t know it. I just didn’t know it was an actual field, and that’s what got me started” (Sally).

4.2 Recruiting Women Faculty

Even after getting started in engineering, Sally did not see a career in academia as her final goal. “Well, actually when I was an undergraduate, I wasn’t really thinking that far yet, but I wanted to do some graduate work and I started my masters, and then I was thinking, ‘Well, should I go into PhD as well?’ and then decided, ‘Well, what would I do with a PhD?’, and I’ve always enjoyed teaching...” Sally’s gradual progression into academia is familiar to more experienced faculty.

Joan is a long-tenured faculty member and former administrator. She believes that young scholars do not consider the long-term sacrifices made by women in the sciences:

> I think when you’re 18 or 19, you are not looking at people wondering whether or not they have lives and kids along with their careers. I think it’s not on the event horizon. They are going to start seeing it when they are in graduate school and they are looking for the next step: “Do I want a post-doc? Do I want to be a faculty member? Do I want an industrial job?” I think it kicks them like that. (Joan)

Joan suggests that as women actually look ahead to their careers, they realize that meeting social, personal, and career goals may be difficult. Joan and other interviewees are clear that much of the problem is that women faculty recruitment and retention is considered a “female issue” in departments dominated by men. Joan recalls a workshop on hiring minority faculty funded by major federal funding agencies that was attended primarily by women and minorities. Her department chair asked her to go and she believed the conference “ghettoized the women.” She believes such conferences are not the answer: “This is going to sound terrible, but the answer is to get people who don’t look like you and me convinced that this is a problem” (Joan). Several women complain that recruiting women is not an actual priority for their departments. “There is some verbiage in place somewhere in our department literature that…gives some lip service to diversity, but as far as implementation or really cognizance like that, it’s not there” (Lois). Joan and other interviewees believe they must convince male faculty and administrators that the lack of women faculty is a problem.

4.3 Isolation and Mistreatment by Male Colleagues

Lois realized the full extent of the underrepresentation of women in engineering while she was in graduate school. “[T]his ‘women in engineering’ thing was funny, because there wasn't a ladies room… It was quite an eye-opener to go there…[Y]ou just develop your way of kind of not letting things get in your way" (Lois). Jane was the only woman in her department for seven years before two more women were hired. When asked if being the only woman impacted anything in her career, she responded, "No, I don't think it did. No, nothing. I just work." Interviewees expressed their dismay at the lack of women in their departments. Most interviewees developed coping strategies similar to those employed by Lois and Jane that allowed them to focus on their career goals instead of succumbing to loneliness.

Several faculty report a "chilly" climate for women who are poorly treated by male faculty. Betty reports that her engineering department does not reach out to women and minorities. She describes the general impact of a faculty member who "treats the women really bad" and the damage he causes to the reputation of the program.

> And I've seen [women] students crying and being insulted. I mean, those things of course hurt the program…. It doesn't end here. They talk. They go out and then they say, "Oh such-and-such treated me like this. Stay away, don't go to [my university]." So it is very difficult when you have that type of reputation and here I am like, "There's me. I'm here if you have any problems, come and see me," but by the time I see them it's too late. We don't have faculty reaching out or trained to work with women and minorities… We have one female. She has been treated so bad she doesn't want to do anything. Why should she? (Betty)

Betty presented a common frustration faced by tenured women faculty, many of whom feel that they are fighting a losing battle. Despite their efforts to encourage women students, male colleagues undermine those efforts by treating students poorly. Women junior faculty face mistreatment from their male colleagues as well. Betty recalled a tense situation in which a female colleague was given "disrespectful" and "humiliating" tasks in the lab by a male colleague. Lois mentioned a former colleague who left after a year, presumably because of how she was treated by a male faculty member:

> He put a lot of pressure on his new faculty to write proposals and do this and do that and "jump when I say jump"…. One of my students said that they had seen her come out of his office in tears. You just don't treat people like that, you know, and so she got another job…. She had just finished her PhD and you get to develop her. (Lois)

Interviewees attribute this behavior to the interpersonal style of some male colleagues. Lois reflected on her time at a previous university, which led her to develop a cultural explanation that many men in engineering are from cultural backgrounds that do not respect women, and these men transmit these beliefs in ways they may not even realize.

4.4 Friendship, Social Support, and Community

Out of this loneliness and isolation springs the need for friendship and social support among colleagues. All women interviewed express great relief and pride when talking about new women hired in their departments or about joining departments with other women. Bobbie explained that leaks in the pipeline to STEM undergraduate and graduate studies create small cohorts of women who persist, and it is important for them to "have friends who do something like what they do, both for now and ten years from now." Lois copes with a difficult department atmosphere by doing collaborative work with colleagues outside the university, because "at the end of the day you want to feel like you did something." She develops a sense of accomplishment by attending conferences and engaging women colleagues outside the university.

Department communication and collegiality is particularly important for women faculty. Joan noticed among her students that women tend to cluster more than men, particular if they perceive the work to be hard. According to Joan, women students and faculty seek each other out for social support. Peggy believes women benefit "through communication and sharing of ideas and being/feeling that you are a part of the greater picture." Interviewees mention how they feel excluded from some department activities because they are women or because of their research interests. Several women point out that a strong department is one in which faculty work together, and a weak department is one that lacks community:

> There is, in my feeling, no sense of community or value of community in the department. A prime example is that I could sit in my office and not talk to my colleagues on either side for a month, literally. I mean, you may say hello in the hallway, but there is no social interaction that occurs, it's just not valued, and. . . so I think that that is the greatest weakness. (Peggy)

Some women emphasize that having a good casual relationship with colleagues, including the freedom to discuss nonacademic affairs, improves their perception of department community. Often department members have longstanding rituals that exclude newer members of the department:

> There are small groups that have camaraderie. And I also joke with some of the faculty, because my first year there was a core group of faculty who were doing lunch together. I didn't think…there was absolutely no bad intention…but they didn't even think to invite me to go to lunch. I remember one day when I just got so tired of it, they were on the elevator going down and the doors were even closing, I just looked in and said, "Well I didn't want to go with you anyway." And they just looked at me like, "What are you talking about?" (Peggy)

Peggy does not indicate that she was not invited because she is a woman, but the overall sense of community in her department is so poor that her colleagues did not even consider making her part of their lunch group. "We don't talk to each other enough, we don't know each other." Peggy recalled facing a major family crisis with little support or even acknowledgement from her colleagues, reporting that only two faculty colleagues acknowledged her tragedies over a difficult three-year period. In this respect, Peggy felt isolated not only by the underrepresentation of women in her department but also by the lack of social support and friendship from her colleagues. Peggy's solution lies in the department chair's power to promote department community.

4.5 Balancing Research, Service, and Family Responsibilities

Integrating personal and family lives into the department is an important aspect of community for interviewees. After being a graduate student, postdoctorate, and junior faculty member at elite institutions outside of Florida, Joan finds the family atmosphere in her department "refreshingly different." The prestige and benefits of her former university were not sufficient to fit the expected workload.

> [I]t was expected basically that you would work 80 hours a week. Many of my colleagues were on their second or third wife. One of my colleagues whom I dearly love referred to his children as no. 1 through no. 4, and I was convinced he couldn't remember what their names were…. And so in the end that drove me crazy, because I love science, but I'm not "monofocused" like that.

Joan describes her current department as "very collegial," mentioning collaborative work between faculty members and that her colleagues "have lives." "There is this freedom to have a life, and everybody understands that if you are a single mother with two kids, you do have to go home at 5:00. No one is all over your back for not being here until midnight." Joan is pleased with the family atmosphere in her department and the freedom to have a life compared to her previous institution.

Jane believes her research group is a kind of family because they see each other often and have a good relationship: "You see me all the time and nights and on weekends…. Even the undergraduates that I advised, they still are calling me their mentor." Joan recalls that one of her fondest faculty memories was a department function in which the children of faculty and graduate students were included in a group dinner.

Department community and collegiality rewards women faculty for managing the strain between research, service, and family in their own lives. Joan appreciates the atmosphere of her current department largely because of the upheaval she's faced in her research. Joan also had to rebuild her research group after having children. She notes that men build their careers during their mid- to late 30s "when women's biological clocks are ticking out." These biological differences cause setbacks in meeting research goals: "I have rebuilt my research group multiple times. I had to do a rebuild when I moved, I had to do a rebuild after each child because no one will join your group when you are pregnant or nursing an infant…" (Joan). When asked by the interviewer why colleagues would not join her research group when she was pregnant, Joan replied, "I do not know. But I discovered with both children that I had a two-year gap in graduate students." This included both men and women. She questioned herself, asking, "Do the hormones scare them?" Joan also had to rebuild after taking a university administrative position and now refuses to take other leadership positions, saying, "I have spent a lot of time and effort being the first woman this, that, and the other, and you know what? It ain't my turn this time… I've battered down enough doors already…" She continues to regret the strain that university service put on her ability to build her research group. She held administration positions in the past and still receives offers to apply for dean positions at other institutions. Joan believes it is time for the next generation of women to come along and face these challenges.

4.6 Tenure and Promotion

Rachel recalls that the conditions for women at her university were grim in her early years in the 1970s and 80s. "There weren't many women in the whole college, even when I went up for full professor." She was lonely as a woman and as a scholar doing research in an area different than her male colleagues. Despite her initial loneliness, Rachel felt that her department allowed her to grow: "You weren't just pigeon-holed, and I have grown." Much of her growth came from a difficult battle for tenure and promotion.

Rachel relied on mentorship from a retired woman full professor from her department and support from women in other departments in her fight for tenure. Her department did not support her when she went up for tenure. She challenged them head on with support from other women, who spread the word around the university about her plight. She had support from her department and faced resistance from the college in her bid for promotion to full professor. Rachel eventually opened pathways and gained support from administrators who did not support her in the past. She describes the support she received when she went up for full professor:

> The dean did support me then, even though he was the same dean that voted against me when I first went up for tenure. You end up convincing these people in the long run. If you're persistent and you don't give up, you hold your ground and you push forward.

Rachel's growth allows her to mentor women junior colleagues and advocate to the department on their behalf. Rachel takes pride that now her department is well-respected nationally in terms of hiring women faculty. As the first woman in her department, Rachel actively works to recruit more women and continues help them gain promotion into tenure-track positions despite opposition.

The department chair has a large influence on faculty recruitment and faculty development. Lois complains that her department recruits "pedigrees" instead of creating a "signature program" with unique specialties that could define it, and she believes that recruiting faculty is more difficult without a specific product to sell. She describes a department leader as a "dictator" and "somewhat of a tyrant," saying, "We just had a dictatorship, and so whatever the dictator wanted, he did." Lois complains that her department leader uses teaching load as a punishment for not allowing the department to "buy out" her teaching load with funds from her three projects. Lois perceives this as a major lack of respect for her work and the prestige it brought to the department. She recalls a discussion with her department chair:

> I mean, I've been here eight years. I work hard. I've written all these papers. I get no support in teaching, and I looked at him and said, "Have you ever taught three courses at the same time, run three research projects, and managed eight students?" And he looks at me and says, "Maybe you should take a sabbatical." And I said, "I'm not here to talk about a sabbatical. I'm here because you know I think I deserve to be a full professor. My credentials are at least as good and better than many of the people who are full professors in the department."

Lois did not claim that she has not been promoted to full professor because she is a woman. She also gave the example of a man who faces similar problems, because it is possible that some women in the sciences and engineering perceive these slights as sexism. Interviewees distinguished between gender issues and general poor community or poor treatment of faculty.

5. DISCUSSION

Increases in women's enrollment in chemistry and engineering have led to minimal increases in women faculty in chemistry and engineering. Talented women in the sciences and engineering are not generally encouraged to pursue academic careers in these fields (Almanac, 2008; Hill et al., 2010; Kulis et al., 2002; National Research Council, 2009; Nelson, 2007). More women need to become familiar with engineering in order to recruit and retain additional women in the field and to academia specifically. Tenured women faculty describe the circuitous routes they took to get to the professoriate. These women were talented high school students and report participating in informal science-related activities sponsored by organizations such as SWE. Despite the interest and talent, these women relied on others to help guide them into male-typed careers, including the sciences and engineering.

Through the backgrounds of these women, we've learned that the pipeline metaphor is ineffective for understanding how women enter academia, earn tenure, and are promoted to full professor. Few women apply for STEM faculty positions, even though some research finds that they are more likely to be hired than men (National Research Council, 2009). Departments consider recruiting women faculty to be a "female issue." Men who dominate science and engineering departments expect women to deal with these issues. Recruitment of women will remain a problem as long as men are not convinced it is a problem. The women who are hired may be more likely to leave the field because so few women apply and are recruited into STEM (Hewlett et al., 2008; Simard et al., 2008).

Interviewees report frustration with the isolation of being the only or one of few women in their departments, and they immerse themselves in their work and career goals. They also collaborate with women in STEM outside of their university for support and build alliances with women in other departments at their university. Women may focus their attention outside their department in order to avoid drawing attention to themselves, as reported by McKendall (2000).

Despite their lack of "fit" in STEM departments (Trower, 2008), interviewees still seek out community in their departments. It is important to note that interviewees do not necessarily believe they are excluded by department colleagues because they are women. They acknowledge that the longstanding cliques and traditions in their departments isolate men as well, particularly junior faculty. They also stress that community and collegiality are more important to women than men. For this reason, poor community in STEM departments may dissuade more women than men from seeking tenure and promotion.

6. RECOMMENDATIONS AND CONCLUSIONS

Interviews with women with tenure revealed that although these women are highly successful in their respective fields, they continue to struggle with gender-related pressures, including university service deemed by their peers to be particularly related to their roles as women professors. These professors show concern for the future of women in their disciplines, but they do not believe that increasing the number of women undergraduate majors will automatically lead to an increase in the number of women in the professoriate, particularly at the associate and full professor levels. Interviews reveal the need for a welcoming department culture and good social fit throughout the tenure and promotion process. The women we interviewed provided examples of department experiences in undergraduate and graduate school and as junior faculty that influenced their orientations toward their disciplines.

Based on the literature and the experiences of women in our study, we make three recommendations to improve the culture and climate of science and engineering departments, with the hope that these efforts would improve recruitment and retention for women faculty.

- First, create social support and mentorship opportunities for undergraduate women through organizations such as SWE that directly connect women pursuing science and engineering degrees with peers and women faculty mentors. Even though the pipeline metaphor does not accurately describe the movement of women from undergraduate science and engineering into the professoriate, women who do make it into academia rely heavily on colleagues outside their departments, who they often met through these organizations early in their career.
- Second, improve the treatment of all junior faculty to maximize the likelihood that men and women will remain to apply for tenure and then for promotion to full professor. Women in this study were clear to point out that retention is not only a "female issue." Male junior faculty are often also isolated in their departments and struggle with department in-fighting and cliques and pressures that discourage junior faculty throughout academia. Mistreatment of women students and junior faculty by senior male faculty also discourages women from continuing in their departments and perhaps also in their field.

- Third, develop departments that function both as communities and as families to fulfill women's needs for open communication with colleagues and support for their personal lives. Each solution depends heavily on cooperation between women faculty and their male colleagues and includes changes to department cultures that women interviewed believe would benefit both men and women nontenured faculty and women students.

This study is limited somewhat by the sampling strategy employed in the larger study. Faculty were not recruited to participate based on tenure and status, even though all women were specifically asked to participate in this study. The women interviewed for this study do represent the small number of tenured women among science and engineering faculty in Florida universities.

Research should continue to examine successful programs in science and engineering departments across the country and attempt to adapt those strategies at more institutions. Successful programs that focus on recruiting, mentoring, and retaining women in tenure-track and tenured positions, as well as promoting the assumption of leadership responsibilities among women, can serve as models for other programs that seek to better integrate women and address the challenges described above.

Additional research should examine how the next generation of women in science and engineering academia deal with similar issues and whether they hold a more optimistic view of pathways from undergraduate degrees into academia. Research must also address faculty turnover by utilizing university and state university system-wide data on faculty retention and promotion by sex and race. Collection of such data will allow more quantitative and mixed-methods research on challenges faced by junior faculty, particularly women. Such data will also allow quantitative comparisons of experiences of all faculty to help identify the role of gender in determining fit within a department culture.

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CLIMATE FOR RETENTION TO GRADUATION: A MIXED METHODS INVESTIGATION OF STUDENT PERCEPTIONS OF ENGINEERING DEPARTMENTS AND PROGRAMS

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This mixed methods investigation, part of a larger study examining student participation in science, technology, engineering, and mathematics (STEM) programs, reports findings on departmental climates that enhance retention to completion of engineering degrees for women and underrepresented minorities. Quantitative analysis of student surveys conducted in the fall of 2007 at four selected Florida engineering programs revealed that faculty support, personal agency and peer support, and perception of social and academic fit were associated with student retention to completion; however, no statistically significant gender or racial differences were found. The r_{wg} statistic, which captures agreement among students within departments and programs, indicated that sufficient homogeneity existed that justified aggregation of data. Analyses of interviews and focus groups data showed that women and underrepresented minorities were not treated differently, nonetheless they experienced department climate differently from their majority peers. Our findings suggest that sexism and racism are subtle and students experiencing them are often unable to articulate it. This study illustrates the use of a mixed methods approach in examining the complex issue of gender and race in the context of climate for retention to graduation in engineering.

KEY WORDS*: education outcomes, engineering programs, mixed methods, organizational climate, STEM, persistence*

1. INTRODUCTION

The relatively few number of women and underrepresented minority (i.e., African Americans, Hispanics, and Native Americans) students enrolled and/or graduating with science, technology, engineering, and mathematics (STEM) degrees is troubling. Although women comprised 57% of the approximately 15.8 million undergraduate students enrolled at all institutions in the United States in 2007, only 50.2% of science and engineering (S&E) degree recipients were women (National Science Foundation [NSF], 2010a–2010c). In 2007, the percentage of African Americans and Hispanics enrolled at all US institutions were 12.3% and12.4%, respectively, whereas only 8.3% and 7.9% of these respective racial/ethnic groups graduated with S&E degrees (NSF, 2010a–1010c). During their freshman year in 2007, approximately equal proportions of African Americans (32.7%) and Hispanics (38.0%) compared to Whites (32.9%) expressed the intention to major in S&E fields, whereas African Americans and Hispanics comprised only 16.2% of S&E bachelor's degree recipients in 2007 (NSF, 2010a, 2010d). In 2007, only 26.1% of about 5.024 million employed scientists and engineers with bachelor's degrees were women, and in terms of race/ethnicity, the proportion of employed scientists and engineers who were African American, Hispanic, and Native American were 3.9%, 4.6%, and 0.4%, respectively(NSF, 2010e).

Despite the large body of research examining the participation of women and students of color in STEM fields (Clewell and Campbell, 2002; Hubbard and Stage, 2009; Wyer, 2003), NSF statistics show that women and minorities continue to be underrepresented in STEM fields in terms of enrollment, graduation, and employment. The National Science Board (2002) projects that employment in STEM fields during the current decade will increase three times faster than employment in all other occupations. Added to the projected 25% of the number of scientists and engineers reaching retirement age by 2010 (Building Engineering Science Talent Report, 2004), the United States faces a shortage of scientists and engineers. The low number of students graduating with engineering degrees and the continuing increase in the number of jobs requiring S&E training presents an enormous challenge to educators, researchers, and policymakers to search for a clearer understanding of what factors contribute to the underrepresentation of women and minorities in S&E fields.

To produce sufficient numbers of scientists and engineers and remain competitive in the global economy, US colleges of engineering need to find ways to encourage women and minorities to enter S&E more generally (Committee on Equal Opportunities in Science and Engineering Report [CEOSE], 2000) and retain these underrepresented groups of students to graduation. According to Goodman (2002), women do not drop out of engineering due to academic difficulty as much as they are compelled to do so by discouraging academic climates. Studies show that departmental culture influences program retention (Berger, 2002; Braxton and McClendon, 2002; Noel et al., 1985; Pascarella and Terrenzini, 2005); however, little is known about the dynamics of departmental climates that support retention and completion of engineering degrees for women and underrepresented minorities.

1.1 Departmental "Climate" for Retention

In this study, a *department* refers to a division within a college devoted to a particular academic discipline through which students work to fulfill the requirements of a degree. For example, within the College of Engineering there may be a Department of Civil and Electrical Engineering that houses two programs, Civil Engineering and Electrical Engineering. An academic *program* refers to a set of core and elective courses designed to help students develop academic skills. An engineering department is thus viewed as an organization with members including students, faculty, and support staff who interact with one another on a regular basis, creating practices and routines that may be unique to a particular department or its programs.

We employ the construct, climate, to uncover what happens in undergraduate engineering departments that may contribute to a student's retention to graduation. We focus on characteristics of the departments perceived to contribute to a "climate for retention" to graduation, particularly for women and underrepresented minority students. Ostroff et al. (2003) refer to climate as the experiential descriptions of *what happens* in the department. In this paper, we define department *climate* as the members' perception of "what it is like" to be in the department with respect to practices, policies, procedures, routines, and rewards. Other aspects of climate may include a sense of belonging and identifying with members of one's department. These constructs often are examined from a psychological framework, especially in industrial/organizational psychology (Glick, 1985), by using quantitative techniques, for example, administering Likert scale surveys to members of the department.

Consistent with previous research that certain aspects of climate such as active learning, collaboration, participation, and mutual respect are related to student retention, we adopt the "climate-for" approach and posit that a "climate for student retention to graduation" can exist in engineering departments/programs. Throughout the 1970s, a great deal of the research regarding climate focused on determining the dimensions of climate such as structure, warmth, and support that were associated with organizational effectiveness. However, with the rapidly growing list of dimensions that researchers posit as important dimensions of climate, Schneider (1975) argued that the concept was too vague and instead proposed that climate be studied as a construct reflecting an organization's goals. In this way, climate acted as a specific outcome, for instance, "climate *for* service" (Schneider, 1990). The "climate-for" approach has gained a great deal of support in recent years, with some researchers studying climate for safety (Neal and Griffin, 2006; Neal et al., 2000), climate for service (Salvaggio et al., 2007; Schneider et al., 1998), and climate for justice (Naumann and Bennett, 2000; Yang et al., 2007). In this paper we seek to understand what constitutes a climate conducive to keeping women and underrepresented minorities enrolled in engineering programs until they graduate. This investigation is a response to the call made to researchers by Kimball et al. (2008) and Newbill and Cennamo (2008) regarding the need to focus on the campus and classroom climate in order to understand factors that influence the success of women and students of color in the sciences.

2. CONCEPTUAL FRAMEWORK

Several theories and models inform our understanding of aspects of climate in the engineering departments that support the retention and graduation of women and underrepresented minority students. According to Tinto's retention/dropout model (1975, 1993), students' levels of academic and social integration into their departments influence their levels of commitment to their goals and institutions, which in turn influence persistence to degree completion.

Building on Tinto's theory is Astin's (1984, 1999) model in which students' level of involvement increases their satisfaction with their college experience (e.g., interactions with faculty members and participation in student organizations), thus increasing their likelihood of persistence to graduation. Although Tinto's model highlights the importance of college students' academic and social involvement with their institutions, a major criticism to Tinto's conceptualization is its lack of recognition of the importance of cultural variables, especially when applied to minority [underrepresented] student success (Guiffrida, 2005; Hurtado, 1997; Kuh and Love, 2000; Rendon et al., 2000; Tierney, 1999). The theory asserts that for students to become integrated into the social and academic systems of the college, they must detach from past associations and traditions. As pointed out by Tierney (1992), Van Gennep's (1960) transitional model upon which Tinto's notion of "breaking away" was based did not apply to underrepresented minority students. Van Gennep's model was not intended to describe cultural assimilation, that is, the domination of minority students' cultural backgrounds by the prevailing culture of the institution. Others contend that it is possible for underrepresented minority students to succeed through bicultural integration or by being a part of both the majority and minority cultures at college (Kuh and Love, 2000; Rendon et al., 2000).

According to Rendón's (1994) validation theory, underrepresented minority students tend to encounter invalidating situations such as detachment of faculty from students and promotion of excessively competitive academic environments that make them feel disconnected from the college environment. However, if faculty and other members of this community recognize that students do not have to learn in a similar way in order to succeed, then these students "can be transformed into full members of the college academic and social community" (Rendón, 1994, p. 51). Student diversity is thus viewed as a strength that can be harnessed for the benefit of all students, provided the college environment fosters students' creativity for learning and validates students' beliefs.

Bourdieu's (1977) practice theory examines individuals' social engagements within their usual settings. In the context of the current study, we can think of the presence of female and underrepresented minority student engagement within engineering departments/programs. The theory allows us to focus on students and their positions in different institutional contexts; for example, how much cultural and symbolic capital do female and underrepresented minority students bring to the engineering departments/programs? Student perceptions of their own power and agency over their individual educational trajectories are critical to their success (Foucault, 1980; Gramsci, 1971). They cannot be understood as separate from the social and physical setting because they are in fact inextricably embedded within it. This approach affords students some agency in the involvement process (Astin, 1984) or integration process (Tinto, 1993) rather than regarding them as passive members of the system. As they try to understand and fit into their departments, they influence and are influenced by them.

Finally, Treisman's (1992) model recognizes the role of [underrepresented] minority students in their success, for instance, by being active in small group discussions. According to this model, rather than attributing student failure to such factors as low income, lack of motivation, insufficient academic preparation, or lack of family support—factors over which institutions do not have control—the success of students should be viewed as a collective responsibility of the departments, especially faculty who are expected to initiate interaction with students. As an example, at Berkeley, with the support of faculty, these students realized tremendous success in studying college calculus (Treisman, 1992).

2.1 The "Chilly" Climate

Hall and Sandler (1982) originally coined the term "chilly climate" to describe faculty members' often unconscious behaviors that contribute to classroom environments disadvantageous to women. These include behaviors such as professors calling on male students more often than female students, paying more attention when men speak, and focusing more on women's appearance than on their accomplishments. Later, they expanded this idea beyond the classroom to the "chilly campus climate" (Hall and Sandler, 1984). Prior research suggests that such behaviors and the environment they create often go unnoticed because they reflect socially accepted patterns of communication and the long-held belief that men are more capable of working in the fields of hard science (Sandler et al., 1996; Brady and Eisler, 1999). Seymour and Hewitt (1997) built upon this idea, suggesting that the chilly climate has led to increased self-doubt in women, resulting in their attrition from engineering fields. African American students tend to have positive attitudes regarding their ability to succeed in college if they attend historically Black colleges or universities (HBCUs) but are skeptical of their abilities if they attend predominantly White institutions (Brown, 1994). White women and underrepresented minority women often feel alienated in predominantly White institutions (Wolf-Wendel, 2000).

2.2 Using the r_{wg} Statistic to Measure Program Climate

The construct, climate, was introduced in the 1960s following the work of Lewin (1951) who studied the climate created by different leadership styles influencing the behaviors and attitudes of group members. He argued that climate is perceived by individuals yet can be measured and studied separate from them. According to Schneider and Bowen (1985), groups within departments may develop different climates, that is, the *content* of climate can vary across groups within the organization.

In the 1960s and early 1970s, much of the research on organizational climate focused on the relationships between climate and organizational outcomes such as performance, satisfaction, stress, commitment, turnover intentions, absenteeism, and involvement (Ostroff et al., 2003). In the 1980s controversies arose regarding the objective versus perceptual nature of climate, the appropriate level of analysis for addressing climate, and the aggregation of climate perceptions (Ostroff et al., 2003). Following these debates, it is widely accepted today that the measurement of climate must begin at the individual level (referred to as psychological climate) but can be meaningfully aggregated to represent organizational climate when there is consensus among individual perceptions of climate (James, 1982).

In this study, departmental climate for retention is present if there is an acceptable level of agreement among students across all dimensions of climate (Kozlowski and Klein, 2000; Lindell and Brandt, 2000). However, no consensus currently exists among researchers regarding a suitable statistical index for assessing it. We used r_{wg}, a measure of interrater agreement (or variability) developed by James et al. (1984, 1993) to determine if student ratings were sufficiently homogeneous to justify aggregation. This index compares the observed within-group variances to a theoretical reference distribution, that is, $r_{wg} = 1 - (S_x^2 / \sigma_e^2)$, where S_x^2 is the variance of the observed ratings, and σ_e^2 is the expected variance when there is no agreement among the raters. Values of r_{wg} equal to 0 indicate no agreement among raters, values of 1.0 indicate perfect agreement, and values greater than 0.70 are considered sufficiently high to justify aggregation of individual responses to group-level measures.

3. METHOD

3.1 Study Design

We employed a mixed methods approach to understand the aspects of climate in the engineering departments or programs that enhance student retention to graduation for women and underrepresented minorities. To collect quantitative data in a cost-effective manner from a large group of students who are typically busy, we used surveys in the quantitative component of our investigation to collect data from students at four selected Florida engineering programs in the fall of 2007 and spring of 2008. To obtain detailed insights regarding the perceptions, attitudes, and opinions of students regarding their experiences while pursuing engineering degrees, the qualitative component involved face-to-face individual interviews and focus groups with students at the same institutions during the same period. Thus, a partially mixed concurrent equal status design was employed whereby both components were undertaken concurrently and were weighted equally in addressing issues related to climate in the engineering programs, and mixing occurring at the data interpretation stage (Leech and Onwuegbuzie, 2009). The words and narratives obtained from thematic analysis of the qualitative data provided a strong complement to the quantitative findings, thus increasing the validity and accuracy of our findings.

The data collection team included two faculty members with experience in qualitative research, two research associates with training in educational measurement, and three senior graduate students in anthropology. Similar protocol and questioning routes were used in all interviews and focus groups, respectively. These instruments included structured and open-ended questions which prompted students to share their educational experiences.

3.2 Institutional Context

Our investigation focused on the climate of four undergraduate engineering departments housed in five public universities in Florida. The University of Florida (UF) in Gainesville is the state's flagship university. Founded in the last century, UF boasts the largest engineering program in the system. Florida State University (FSU) and Florida Agricultural and Mechanical University (FAMU), an HBCU in the state, both in the capital city, Tallahassee, were founded before 1956. These two institutions share the FAMU-FSU College of Engineering, located equidistant from both campuses. Each university hires its own faculty but shares courses and facilities. The University of South Florida

(USF), with a main campus in Tampa, was founded in 1956. It is designated as a Hispanic serving institution with a population of 12.9% undergraduate Hispanic students in 2007. Florida International University (FIU) in Miami boasts a majority-minority student population, including 63.8% undergraduate Hispanic students in 2007. These four public university engineering programs (i.e., FAMU-FSU, FIU, UF, and USF) were selected to provide diverse perspectives of the climate of engineering department/programs in the state of Florida.

3.3 Participants

Data were obtained from two major sources. Quantitative data included a survey with 881 students enrolled in engineering programs (25% female), the majority (86%) of which were either in their junior or senior years. Survey participants were predominantly White (43%), 27% Hispanic, 18% African American, and 7% Asian/Pacific. Qualitative data included 44 student interviews (36% female) and 6 student focus groups comprised of 29 participants (21% female). Five of the six focus groups had five participants, while the last focus group had four participants. Prior to data collection, arrangements were made with the deans of the colleges of engineering, department chairs, and/or faculty to encourage students to participate. Students were offered a $20 stipend to participate. Besides posters which were placed in convenient locations to inform potential participants about the study, a snowball technique was employed where students who had participated informed others about the study. The response rates in the quantitative and qualitative components were 38% and 61%, respectively.

3.4 Quantitative Analysis: Climate Measures and Analysis Procedures

The 73-item student survey contained the following nine subscales which, according to prior research (O'Reilly et al., 1991; Ostroff et al., 2003), constitute 9 theoretical measures of climate used to evaluate student retention to graduation. Next we describe the nine subscales, "intent to leave," the outcome of interest, and the corresponding internal consistency of each subscale in our sample as measured by Cronbach's alpha (α).

Involvement, defined in this study as a measure of students' perceptions of faculty involvement in academic life of the department, was developed using five items anchored on a five-point Likert-type scale (1 = strongly disagree to 5 = strongly agree). Students indicated their level of agreement with items capturing faculty availability and help to students, responsibility for student success, and enthusiasm about teaching. Examples of items included "Faculty and staff help students achieve professional goals" and "Faculty members are enthusiastic about teaching." The involvement scale had internal consistency of 0.70.

Faculty support was measured with four items for which students were asked to indicate, on a five-point Likert scale, their level of agreement with statements about types of assistance provided by faculty to help them master knowledge in engineering and develop creative capacities. An example of an item in this scale was "Faculty and staff provide students with strong academic and professional role models." Related to faculty support was *institutional support,* defined as the support and services provided by institutions to help students succeed in school (e.g., "pre-college outreach or training" or "tutoring support"). Students responded to eight items by indicating how helpful they found the listed service using scale anchors ranging from 1 = very unhelpful to 5 = very helpful. They also indicated whether "they did not participate in the service but it was available" or "their institution did not offer the service." The internal consistency of the faculty support and institutional support scales were 0.76 and 0.72, respectively.

Six items were used to assess *helpfulness,* the extent to which students perceived members of the department were helpful by indicating their level of agreement on a five-point Likert scale with items such as "People generally care about student wellbeing" and "Faculty and staff make students feel inferior." The internal consistency of this scale was 0.71.

Diversity, the extent to which students perceived members of their department embrace diversity, was captured by 12 items. With the first set of nine items, students indicated their level of agreement on a five-point Likert scale to statements about what happens in the department. With the last three items, they indicated the frequency (1 = never to 5 = very often) with which they engaged in activities such as "Working in small, ethnically diverse groups with other students in the department" or "Socializing with someone of another race or ethnic group." This scale's internal consistency was 0.74.

Six items captured *integration,* the extent to which students perceived they were integrated in their department by indicating, on a five-point Likert scale, their level of agreement with statements such as "Students share strategies for success with each other" and "Students often learn from each other." The scale's internal consistency was 0.65.

The extent to which students perceived they *fit* in their department was assessed by students indicating their level of agreement, on a five-point Likert scale, to two items: "I feel like I fit in well," and "I sometimes feel out of place." The scale's internal consistency was 0.61.

Engagement, the extent to which students perceived they were engaged in their academic work, was assessed by having students indicate their level of agreement to two statements including "Students are highly engaged in coursework" and "There is an emphasis on developing vocational and occupational competence." The scale's internal consistency was 0.6.

Student perceptions of the *importance* of their field was assessed by indicating their level of agreement on a five-point Likert scale to seven items including "Students have to study very hard to succeed" and "Individuals getting a degree in my major are respected by most people." The scale's internal consistency was 0.73.

Intent to leave, a measure of student retention in the program, was assessed by students responding to the statement, "Given an opportunity to enroll in the same degree program at a different but equally ranked university, I would…" by indicating whether they would (a) <u>definitely</u> maintain enrollment at their university, (b) <u>probably</u> maintain enrollment at their university, (c) don't know—no opinion, (d) <u>probably</u> enroll at the alternative university, or (e) <u>definitely</u> enroll at the alternative university. Because neutral cases comprised a very small proportion of the students (3.4%), we dichotomized this item into "not leave" (i.e., definitely or probably maintain enrollment at their university) and "leave" (i.e., probably or definitely enroll elsewhere). This also allowed for performing logistic regression analysis with the dichotomized variable as the dependent variable.

Quantitative analysis focused on the comparison of student responses as measured by the nine theorized measures of climate and classifying these by institution, gender, and race/ethnicity. To do this, we computed Cronbach's alpha, a numerical coefficient of reliability in which higher values indicated more reliable scores. Next, and more importantly, we computed r_{wg}, a measure of interrater agreement to determine if student-level data were sufficiently homogeneous to justify aggregation. To determine if our data supported the hypothesized relationship between the observed variables (questions in the survey) and the underlying latent constructs (the theorized nine measures of climate), we conducted a confirmatory factor analysis (CFA). A CFA is a theory-testing model in which the researcher hypothesizes a priori which variables are correlated with which factors and which factors are correlated with each other. Factors obtained in the theory-based factor analysis were not predictive of retention. Finally, data-driven factor analysis yielded three factors that were predictive of student retention based on logistic regression.

3.5 Qualitative Analysis Procedures

Four members of the research team used ATLAS.ti, a qualitative data analysis software package, to analyze textual segments of interview and focus group transcripts. They constantly compared codes to ensure themes were consistent and nonoverlapping. Themes were reviewed and discrepancies discussed to reach consensus. Researchers also reviewed each other's write-ups to ensure accurate reflection of the thematic analysis. Results from quantitative and qualitative data analyses were integrated in a coherent set to illuminate the understanding of program climate enhancing retention to graduation in engineering.

4. FINDINGS

The first part of our findings is based on survey data. We present correlations among the climate measures, the degree of agreement on climate measures by institutions and by programs, and the differences in the measures by institution, gender, and race/ethnicity. Next, qualitative and quantitative findings are integrated into one set of a coherent whole in explaining how institutional support, personal agency and peer support, and perception of social and academic fit are related to student retention in engineering programs. We also discuss the extent to which our findings on the climate of engineering programs that support student retention in engineering are consistent with the literature on student retention.

4.1 Findings Based on Survey Data

Table 1 shows that about two-thirds (61.1%) of the 36 bivariate positive correlations among theorized climate measures were at least moderate, ranging from 0.40 to 0.73, indicating that these measures were generally moderately related. The largest correlation,

TABLE 1: Correlation among theorized climate measures (n = 881)

Measure	F1	F2	F3	F4	F5	F6	F7	F8	F9
F1 Involvement	-								
F2 Faculty support	0.729	-							
F3 Institutional support	0.176	0.172	-						
F4 Helpfulness	0.557	0.596	0.117	-					
F5 Diversity	0.422	0.432	0.113	0.572	-				
F6 Integration	0.284	0.292	0.086	0.521	0.458	-			
F7 Fit	0.259	0.310	0.086	0.486	0.400	0.484	-		
F8 Engagement	0.491	0.529	0.103	0.531	0.503	0.438	0.321	-	
F9 Importance	0.483	0.497	0.208	0.472	0.486	0.402	0.334	0.618	-

the correlation between "involvement" and "faculty support," suggested that students were more likely to perceive faculty as being supportive if faculty were involved in their academic lives.

After establishing that the measures were correlated, we computed the r_{wg} values, a measure of interrater agreement to determine if student-level data were sufficiently homogeneous to justify aggregation. As shown in Table 2, except for "Social and academic fit," where the r_{wg} values at each institution ranged from 0.63 to 0.67, the remaining climate measures had r_{wg} values of at least 0.82, indicating that sufficient agreement existed among students to justify aggregation. Although a perfect agreement on "Institutional support" was noted at the four programs, interestingly, there was no agreement in two programs at FIU (electrical and civil) and four programs at UF (civil, mechanical, other, and electrical).

Having established that the nine theorized climate measures were related (from correlation results) and that student data could be aggregated (from the r_{wg} values), we conducted a CFA, specifying nine factors in the model. The results of the CFA, however, did support our expected factor structure. In an effort to obtain easily interpretable factor loadings, that is, factors that are clearly marked by high loadings for some variables and low loadings for others, we conducted what we refer to as "data-driven" factor analysis which yielded nine factors. We then correlated these factors with the theorized measures to determine if these two sets of measures were related. Except for three factors from the data-driven results that did not distinctively capture specific theorized climate measures, over half (42) of the 81 zero-order correlations were at least moderate, ranging from approximately 0.40 to 1.0. This finding suggests that the results of the two factor analyses were related. For instance, factor 1 of the data-driven result, which had 13 items, included "involvement" and "faculty support" of the theorized measures. Next, we examined differences in the measures.

As shown in Table 3, there were no significant institutional or gender differences in the theorized climate measures; the mean values were almost equal. "Importance" had the largest mean (≈ 4.0) in each of the four institutions, indicating that the students

TABLE 2: Agreement on climate measures among students by institutions and programs (*n* = 849)

Institution/ department	n*	Theorized climate measures									Intent
		F1	F2	F3	F4	F5	F6	F7	F8	F9	
FAMU / FSU	**237**	**0.88**	**0.86**	**1.00**	**0.87**	**0.90**	**0.86**	**0.64**	**0.83**	**0.91**	**0.22**
1. Civil	48	0.91	0.90	0.21	0.88	0.91	0.87	0.76	0.83	0.91	0.38
2. Mechanical	67	0.88	0.85	1.00	0.85	0.90	0.89	0.72	0.84	0.90	0.26
3. Electrical	44	0.85	0.84	1.00	0.88	0.91	0.85	0.60	0.79	0.91	0.18
4. Other	22	0.88	0.90	1.00	0.88	0.90	0.87	0.43	0.88	0.91	0.16
5. Computer	17	0.85	0.87	1.00	0.87	0.90	0.86	0.72	0.86	0.91	0.13
6. Chemical	31	0.84	0.77	1.00	0.87	0.92	0.89	0.59	0.85	0.94	0.00
7. Computer/other	6	0.88	0.88	1.00	0.80	0.75	0.37	0.60	0.74	0.90	0.00
FIU	**183**	**0.85**	**0.82**	**1.00**	**0.85**	**0.92**	**0.86**	**0.63**	**0.82**	**0.90**	**0.20**
8. Computer	26	0.83	0.83	0.28	0.83	0.90	0.90	0.58	0.84	0.91	0.49
9. Other	43	0.88	0.86	1.00	0.86	0.90	0.84	0.56	0.81	0.89	0.25
10. Electrical	40	0.88	0.82	0.00	0.85	0.93	0.88	0.65	0.86	0.91	0.16
11. Mechanical	35	0.85	0.83	1.00	0.88	0.92	0.79	0.72	0.76	0.87	0.14
12. Civil	33	0.82	0.75	0.00	0.78	0.90	0.85	0.59	0.78	0.89	0.04
UF	**213**	**0.88**	**0.87**	**1.00**	**0.88**	**0.91**	**0.89**	**0.63**	**0.86**	**0.92**	**0.65**
13. Environmental	8	0.72	0.51	1.00	0.64	0.61	0.74	0.30	0.56	0.43	0.88
14. Civil	124	0.89	0.90	0.00	0.90	0.93	0.90	0.67	0.86	0.93	0.77
15. Chemical	8	0.87	0.79	1.00	0.89	0.95	0.91	0.43	0.84	0.92	0.75
16. Mechanical	23	0.86	0.86	0.00	0.89	0.90	0.90	0.47	0.86	0.94	0.73
17. Computer/ other	9	0.90	0.82	1.00	0.84	0.83	0.81	0.58	0.95	0.88	0.50
18. Other	31	0.90	0.85	0.00	0.88	0.91	0.88	0.63	0.86	0.91	0.50
19. Computer	7	0.86	0.80	1.00	0.62	0.94	0.77	0.43	0.89	0.94	0.25
20. Electrical	11	0.83	0.80	0.00	0.84	0.92	0.93	0.63	0.87	0.95	0.19
21. Undecided	5	0.82	0.77	0.24	0.90	0.95	0.93	0.73	0.89	0.95	0.00
USF	**216**	**0.88**	**0.86**	**1.00**	**0.87**	**0.91**	**0.86**	**0.67**	**0.84**	**0.92**	**0.45**
22. Computer	16	0.92	0.91	1.00	0.83	0.90	0.72	0.58	0.90	0.94	0.61
23. Mechanical	64	0.89	0.89	1.00	0.91	0.93	0.89	0.70	0.86	0.91	0.48
24. Electrical	52	0.86	0.84	1.00	0.84	0.92	0.89	0.74	0.80	0.91	0.43
25. Other	13	0.85	0.91	1.00	0.83	0.88	0.76	0.52	0.84	0.92	0.43
26. Chemical	40	0.88	0.83	1.00	0.90	0.94	0.93	0.76	0.85	0.94	0.42
27. Civil	20	0.84	0.87	1.00	0.80	0.88	0.84	0.44	0.89	0.94	0.28

Note: ***n****Departments with fewer than five respondents were not included in this analysis
F1= Involvement, **F2**= Faculty support, **F3** = Institutional support, **F4** = Helpfulness, **F5** = Diversity, **F6** = Integration, **F7** = Fit, **F8** = Engagement, **F9** = Importance.

TABLE 3: Means and standard deviations of climate measures by institutions and gender (n = 881)

Measure	Institutions				Gender	
	FAMU/ FSU	**FIU**	**UF**	**USF**	**Female**	**Male**
Involvement	3.51 (0.60)	3.53 (0.67)	3.71(0.59)	3.49 (0.60)	3.68 (0.56)	3.52 (0.63)
Faculty support	3.46 (0.67)	3.49 (0.80)	3.71(0.65)	3.53 (0.65)	3.65 (0.69)	3.52 (0.70)
Institutional support	2.73 (0.98)	2.78 (1.10)	3.03(0.92)	2.70 (0.98)	2.90 (1.03)	2.79 (0.99)
Helpfulness	3.55 (0.59)	3.57 (0.67)	3.77 (0.61)	3.56 (0.61)	3.73 (0.62)	3.58 (0.62)
Diversity	3.64 (0.51)	3.73 (0.58)	3.70 (0.52)	3.63 (0.51)	3.63 (0.54)	3.68 (0.52)
Integration	3.95 (0.62)	3.96 (0.57)	4.10 (0.56)	3.95 (0.61)	4.05 (0.59)	3.97 (0.59)
Fit	3.65 (0.86)	3.69 (0.83)	3.66 (0.92)	3.66 (0.84)	3.68 (0.89)	3.66 (0.86)
Engagement	3.89 (0.62)	3.81(0.72)	3.96 (0.60)	3.78 (0.62)	3.92 (0.58)	3.84 (0.66)
Importance	3.91 (0.52)	3.91(0.65)	4.18 (0.55)	4.00 (0.52)	4.07 (0.57)	4.00 (0.56)

surveyed viewed the engineering major as being very important. For instance, although they agreed that they had to "study very hard to succeed," they also agreed that "the degree they were working on *was* in an exciting field," "individuals getting a degree in their major are respected by most people," and "their future occupation makes an important contribution to society."

Similarly, there were no significant race/ethnic differences in the theorized climate measures (Table 4). "Institutional support" had the lowest mean (≈ 3.0), indicating that, on average, students across the racial/ethnic groups had mixed perceptions regarding support received from their institutions. African Americans and students classified as "Other" had a mean perception of "social and academic fit" of slightly less than 4.0, indicating that compared to other racial/ethnic groups, these two subgroups of students perceived a poor fit in the engineering departments. However, these results were not statistically significant.

Of the nine data-driven factors in Table 5, three were predictive of "intent to leave" based on logistic regression analysis. The first factor, "Institutional support," was defined as the support and encouragement provided by faculty and nonfaculty staff to students in order for the latter to succeed academically, acquire research skills, and achieve professional goals. The academic emphasis was captured by faculty members' enthusiasm about teaching, availability to students outside class hours, and help to students to master knowledge and develop creative capacities. Emphasis on research skills was captured by providing students with opportunities to work on research projects, whereas the emphasis on professional goals was evidenced by providing students with strong academic and professional role models.

The second factor, "Social and academic fit," referred to the extent students perceived their fit within the department. Such perceptions included the extent students felt

TABLE 4: Means and standard deviations of climate measures by race/ethnicity (n = 881)

Measure	Asian	African American	Hispanic	Other	White
Involvement	3.58 (0.66)	3.53 (0.69)	3.57 (0.59)	3.30 (0.74)	3.60 (0.57)
Faculty support	3.55 (0.69)	3.45 (0.74)	3.58 (0.70)	3.14 (0.81)	3.63 (0.64)
Institutional support	2.67 (0.88)	3.09 (1.12)	2.87 (1.03)	2.66 (0.99)	2.71 (0.92)
Helpfulness	3.56 (0.60)	3.48 (0.60)	3.64 (0.64)	3.41 (0.72)	3.69 (0.60)
Diversity	3.67 (0.51)	3.63 (0.51)	3.78 (0.57)	3.51 (0.61)	3.64 (0.48)
Integration	3.95 (0.57)	3.81 (0.60)	3.96 (0.60)	3.81 (0.71)	4.11 (0.55)
Fit	3.60 (0.80)	3.37 (0.89)	3.77 (0.84)	3.43 (0.89)	3.76 (0.84)
Engagement	3.78 (0.67)	3.80 (0.60)	3.88 (0.65)	3.69 (0.63)	3.91 (0.64)
Importance	3.90 (0.59)	3.99 (0.54)	4.08 (0.54)	3.83 (0.58)	4.04 (0.58)

identified as "one of the gang," a feeling of being emotionally attached to the department, and a feeling that they represented their department's values. The third factor, "Personal agency and peer support," referred to a student's active involvement in the learning process and the supportive atmosphere created by peers that encourages student success. Examples of personal agency included the extent to which students felt they had "learned the ropes" of being a student in their respective departments or the extent they had developed appropriate skills and abilities to succeed. Peer support included the extent to which peers created a friendly atmosphere, characterized by concern for others and healthy academic competition.

Before comparing scores on these three factors, we inspected the level of agreement at the institution level to determine if data aggregation based on data-driven factors was justified. In each of the three factors, r_{wg} values ranged between 0.85 and 0.95, indicating very strong agreement existed among students at these institutions regarding these factors.

As shown in Table 5, based on the item loading of at least 0.5 on each factor, the set of items adequately captured the factors. Considering the first item in each factor (i.e., the item with the largest loading) to be representative of the factor, "Institutional support" and "Personal agency and peer support" each had a mean of approximately 4.0, implying that students agreed that support, whether institutional or from peers, was important for their success. However, logistic regression analyses revealed no gender or racial/ethnic differences on how these factors predicted "Intent to leave."

4.2 Integrated (Quantitative–Qualitative) Findings

In this study, we sought to understand the climate in engineering programs/departments that promotes student retention to graduation in engineering, especially for females and members of underrepresented minorities. Although no statistically significant gender or racial/ethnic differences in student perceptions of departmental climate associated with student retention were found, we established that "Institutional support," "Personal

TABLE 5: Means, standard deviations, and item loadings on data-driven climate factors (*n* = 881)

Factor/item	Loading	Mean	SD
Factor 1: Institutional Support (α=0.87)		3.57	0.579
Faculty and staff are generally encouraging toward students.	0.696	3.78	0.870
Faculty and staff go out of their way to help students master the knowledge in their discipline.	0.676	3.30	0.957
Faculty are enthusiastic about teaching.	0.647	3.60	0.925
Faculty and staff help students achieve professional goals.	0.643	3.65	0.836
Faculty and staff help students develop creative capacities.	0.641	3.44	0.896
Faculty and staff provide opportunities for students to work on research projects.	0.637	3.55	0.897
Faculty and staff provide students with strong academic and professional role models.	0.612	3.68	0.912
Faculty and staff are often available for students to see outside of regular office hours.	0.557	3.67	0.993
Factor 2: Social and academic fit (α=0.768)		3.49	0.665
Within my department, I would easily be identified as "one of the gang."	0.615	3.32	1.09
I sometimes feel out of place.	0.562	3.46	1.12
I do not feel "emotionally attached" to my department. (R)	0.562	3.17	1.09
I would be a good example of a student who represents my department's values.	0.512	3.66	0.894
Factor 3: Personal agency and peer support (α=0.659)		**3.81**	**0.626**
I have not yet "learned the ropes" of being a student here. (R)	0.646	4.08	0.990
Students are often too concerned with their own success to help each other.	0.571	3.45	1.07
I do not consider any of my fellow students as my friends. (R)	0.548	4.36	0.966
I have not fully developed the appropriate skills and abilities to perform successfully as a student. (R)	0.545	3.91	1.06

Note: α = Cronbach's alpha; R= the item is reverse coded.

agency and peer support," and "Social and academic fit" were predictive of the "Intent to leave," our measure for student retention in this study. How these factors relate to student retention is discussed next.

Institutional Support. As defined earlier, institutional support refers to the support and encouragement provided by faculty and staff to students. It enables students to succeed academically, acquire research skills, and achieve professional goals. Institutional support also includes resources such as laboratory, tutoring, advising, and other college or university-wide services.

As shown in Fig. 1, a grand mean of 3.52 suggests an overall agreement that students received institutional support at their respective engineering departments. Closer examination of the lower-outlying observations (tending toward strong disagreement) indicated that more minority students (*n*=15), excluding one Asian, compared to Whites (*n*=11), perceived lack of institutional support. Additionally, 6 out of 15 outliers (40%) were females, which was greater than 25%, the proportion of females surveyed. This result suggests that the lack of institutional support might be more pronounced among women than men.

Student perceptions of faculty support took various forms, including classroom interactions, office hours, research and lab experiences, and mentoring/advising services. A discussion of the extent to which students experienced each of these aspects of support follows.

Faculty support in the form of classroom interaction emerged as an important factor in student progress in the engineering program. To most students, the classroom was the main forum for interaction with faculty. Students surveyed agreed that "faculty members were enthusiastic about teaching," but they were neutral about faculty "going out of their way to help them master the knowledge" or "helping them develop creative capacities." On the contrary, whereas almost all students interviewed believed the professors were knowledgeable about the materials, they felt that some lacked the pedagogical skills, the interest in teaching (compared to research), or proficiency in the English language (especially foreign professors). Whereas most students interviewed, regardless of gender or race/ethnicity, stressed the importance of not over-relying on faculty support (e.g., "I basically have grown to accept the fact to not expect anything

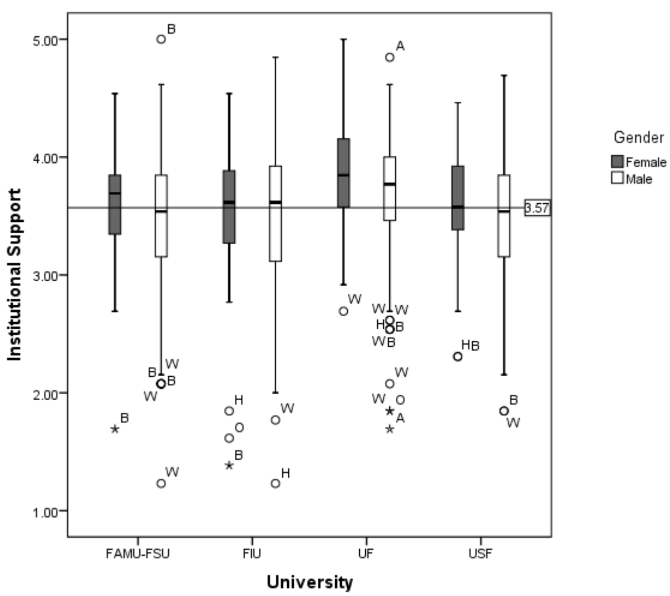

FIGURE 1: Perceptions of institutional support (outliers identified by race/ethnicity)

from your professors and you just gotta work at it by yourself …"), they reported that some professors were exceptionally enthusiastic and supportive, "… professors who are into their thing… willing to help out more … really into making sure that the students know."

Student comments suggested that faculty support in the form of advising and mentoring was important for student retention in engineering programs. Students surveyed agreed that faculty were often available for students to see outside of regular office hours. Similarly, qualitative analysis revealed that professors were available but few students made use of the time to seek help, partly because the office hours conflicted with student work schedules. Other students were uncomfortable with professors and preferred to seek help from peers or teaching assistants (TAs), treating professors as the last resort. In one White male focus group, a student narrated how a professor whom he had gone for help stopped typing and pretended not to be inside the office. It may be that some professors find it difficult to cope with the after-class needs of students, perhaps due to other obligations. On the contrary, some students explained how professors were much more personable, patient, and willing to answer their questions and work through problems with them during office hours. In the same White male student focus group, it was noted that whereas most professors were foreign, they explained the concepts much better when speaking with a single student.

Students surveyed agreed that faculty provided them with strong academic and professional role models. Similarly, interviewees and focus group participants felt that they had to be proactive and take charge of their own academic experiences rather than expecting faculty to "hold their hand" throughout their time in the program. Although interviewees' comments suggested they valued mentoring, they lacked the opportunity to form that type of relationship with faculty. Those who had mentors identified with them because they shared something in common; for example, one student in the military talked about how he had a closer relationship with a professor who also had military background. Overall, students felt it was their role to initiate relationships with faculty. This finding seems to contradict validation theory, which posits that institutional agents rather than students should take the lead, promote involvement, and affirm students as valuable members of the learning community (Rendón, 1994).

Comments from students indicated that support from nonfaculty staff enabled them to make progress. Students surveyed agreed that [nonfaculty] staff generally encouraged and assisted them to achieve their professional goals. Similarly, most interviewees mentioned that department secretaries were friendly, helpful, and took time to speak with them when they visited their offices. To students, this simple day-to-day type of assistance, such as assisting with information about next semester's class schedule, was an expression of care and support: "A bunch of secretaries that always help me out with small tasks so I have much support."

Student comments also revealed the centrality of structural support in student retention in engineering. Engineering curricula tend to be structured in terms of course sequence. Many students interviewed felt their department did not care about them. For instance, offering a course at one meeting time for one semester per year compelled students to wait for an entire year. Another form of support structure for students was the undergraduate engineering organizations such as the Institute of Electrical and Electronics Engineers (IEEE). In these forums, students expected to interact with professors outside class time; however, few professors participated in these organizations, thus denying students the benefits of mentorship and advising.

Personal Agency and Peer Support. By *personal agency* we refer to students' active involvement in their learning process, whereas *peer support* represents the atmosphere created by peers that encourages student success. Bonous-Hammarth (2000) noted that "student agency and peer group influences combine into a dynamic model to guide students successfully or unsuccessfully throughout their academic experiences" (p. 95). In this study, students surveyed agreed that they had developed appropriate skills and abilities to perform successfully as students; "learned the ropes" of being students in the department; and that their peers were friendly and ready to help others succeed.

Fig. 2 shows a grand mean of 3.49, suggesting that overall, students agreed that they had personal agency and/or received peer support at their respective engineering departments. Examinations of the lower-outlying observations indicated that more minority students (*n* = 5) compared to White students (*n* = 1) perceived lack of personal agency and peer support.

An interesting finding was that because students tended to fend for themselves rather than rely on faculty, this led most of them to value peer support more than faculty support. When asked where they went for help, almost all students responded that they would first go to other students before they sought out help from faculty or administrators. A White male at FAMU, who may be considered a minority at this HBCU, said, "I

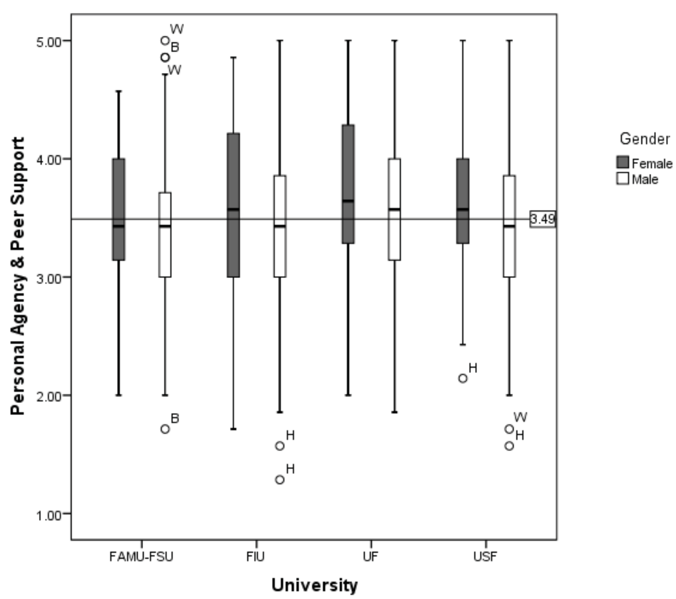

FIGURE 2: Perceptions of personal agency and peer support (outliers identified by race/ethnicity)

think the biggest thing that has got me through is just the friends I've had." Rather than seeking help with course content, most students approached faculty about grades and progress in class: "If I'm trying to figure out where I'm at with my grade, I'll go to the teachers, ask them what I can do to boost my grade up in the class. If it's material-wise I'll always go to my peers first to see if they understand it."

Psycho-emotional support in the form of relationships with other students helped students feel that they were not alone in what they were going through and that other students cared about them. A Hispanic female student at UF described her relationships with other students: "It doesn't appear like you're the only one studying until three o'clock in the morning for a test… somebody in that same class is doing the same thing at that time so you don't feel that you're the only one fighting…" Overwhelmingly, students mentioned that friendships with other students helped them through the program. They generally defined their interaction as collaborative. One African American female from FAMU said: "… especially in my class everybody works together….my little group, my friends that I've met… it's more like trying to help each other because you know you can't always get it by yourself."

Students commented that a *friendly but competitive climate* helped them persist in the engineering program. A White female student at UF said that her favorite thing about the program and other students was that "it is competitive… they [peers] keep me on my toes." A Hispanic male at FIU had a similar experience: "I do well when I'm competing. I don't do well when I'm all by myself." The creation of a friendly but competitive climate highlights students' ability to create their own microclimate in the department that helped them to succeed.

Comments from students suggested that *group work* was very instrumental in success in engineering. Frequently cited places to meet and form study groups included the library, the fishbowl, and the atrium (at FAMU/FSU). Students recognized faces of peers from previous classes or recognized peers reading a textbook used in specific classes. Knowing one personally was not a requirement in the formation of groups. Student perceptions on group work varied. A prevailing notion was that group work provided the opportunity to solve problems together. A few students noted the need for preparation prior to group discussion, using group work as a check for their assignments. These findings are consistent with Treisman's (1992) model in which students were expected to begin working on problems individually prior to small group discussion sessions. As in Treisman's study, study groups functioned as opportunities for students to critique one another's work and ensure success for everyone.

Group work reinforces student efforts outside class (Heppner et al., 2010). In this study, students noted that most faculty members encouraged group work as it mimics what engineers do in industry: "they encourage us to work in groups," "working as a team which is part of what they [faculty] try to teach you in engineering," and "they [faculty] always preach … when you get on the job site you're going to have to work as a team." It is also viewed as a source of emotional support to students, "It's good to have people that encourage and say well, just stick it out man, you know it will be all right." These qualitative findings support Goodman's (2002) finding that participating in study groups was both a source of academic and social support to female students.

Other research shows that small group learning and peer support are crucial for increasing minority program efficacy in undergraduate engineering programs (Campbell et al., 2002; Pascarella and Terenzini, 2005).

Social and Academic Fit. Research on organizational climate shows that the concept of fit is important in determining the success of an individual in an organization. Ostroff and Schulte (2007) defined person–environment fit as the degree of congruency between an individual's goals and values and those of the organization, whereas they viewed person–person fit as the extent to which attributes such as knowledge, skills, needs, perceptions, values, preferences, attitude, and demographic characteristics of an individual are similar to the same attributes of another individual or to those of other individuals in the organization in an aggregate form. In this study, we hypothesized that student perceptions of the degree of fit in the engineering departments were related to their retention in the program. We viewed the concept of fit as having social and academic dimensions.

Four questions in the survey examined the social aspect of fit. Students were neutral regarding perceptions of whether they felt they identified as "one of the gang," out of place in the department, emotionally attached to their department, or represented their department's values. The qualitative question, "How well do you feel you fit in this department?" although purposely designed to elicit the widest range of responses, yielded little response from students upon initial review. Most students responded that they "fit in fine." A grand mean of 3.81 (Fig. 3) suggests that, overall, students perceived that they fit in their respective engineering departments. However, examinations of the lower-value outliers indicated that more minority students ($n = 9$) compared to Whites ($n = 1$) perceived lack of social fit in the departments.

A Hispanic male at FIU commented, "Well, I feel good about being here. The first year was super difficult…I didn't know any person…but as time passed that changed definitely," whereas a White male student at UF commented, "I don't feel outcast but I mean I don't feel like I'm unique at the same time." A female Hispanic student at FAMU responded in terms of academic fit, "I am not at the bottom… electronics, circuits, I know that really well, other things, don't ask me about it!" Generally, students did not respond strongly for either fitting in or not; a common response was that they are in the middle or "half and half" as one student put it.

It may be that addressing social and academic dimensions of fit with one question is complicated. Perhaps there is a much more complex reason for why most students claimed they "fit in fine." Further probing, asking students whether they expected to fit in prior to joining the program, provided additional insights on what constitutes "fitting in just fine." Striking differences were noted in the expectations of fit prior to entering a program. For Tyson et al. (2010), retrospective interviews with students who left engineering indicated that not fitting might have led to the decision to leave engineering. Having left, switchers had time to reflect and articulate the reasons behind their actions. It may be that *not* fitting in is important only to students who leave. Those who persist are assumed to fit in, come with the cultural capital needed to succeed, or strategize on how to fit in and succeed.

The process of fitting is integral to understanding why engineering remains a predominately White and male discipline. Female and minority students interviewed re-

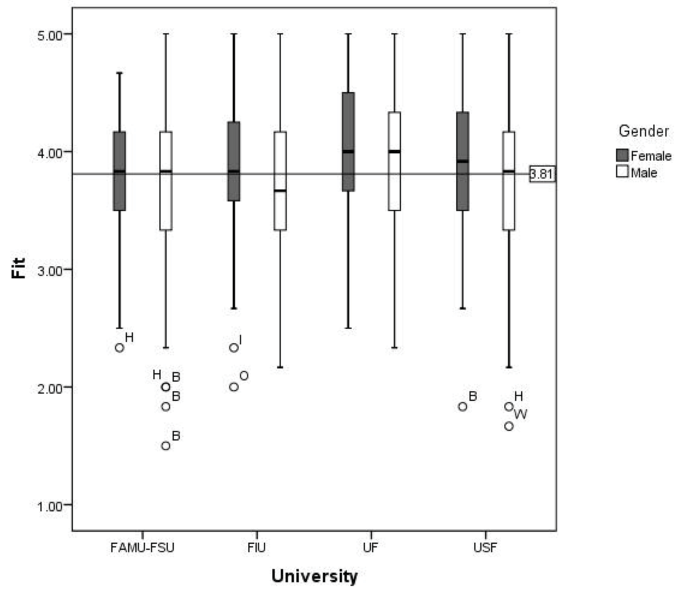

FIG. 3: Perceptions of social and academic fit (outliers identified by race/ethnicity)

called feeling more trepidation at fitting in than their nonminority counterparts, especially in terms of academic fit. For example, an African American male student at FAMU thought the department would be "a bunch of geeks," and a Hispanic male in the same program worried that being an international student, he would not be able to keep up academically. A female student at FAMU remarked, "At first I thought I'm a minority in every way. I'm a woman. I'm Hispanic. I really didn't think I was going to fit in, but eventually you realize you're not the only one." An African American female at UF said, "I really questioned my ability to actually be here and succeed…"

Students who seemed to have a high degree of social capital prior to entry into the program expressed less consternation. One African American male student at FIU attributed his comfort with fitting in to his high school experience: "I wasn't in a state of shock when I saw people that don't look like me." Having interacted with student from diverse racial/ethnic backgrounds while in high school, this student was not intimidated by being among non-African American students. An international student felt he would "fit in fine" because he could "do math, sciences, and the topics that are required." Math skills are critical for success in an engineering program, and those who enter with adequate math skills from high school seemed to have an advantage.

A chilly climate may not necessarily be in the form of blatant racism or sexism but a matter of fitting a mold, either because one comes with it or one gains it along the way. Female and underrepresented minority students used words or phrases such as "adapt," "get used to," and "it's a slow process" to describe the fitting in process. Whereas a White female student at UF commented, "I fit in… it's not like I *try* to fit in," in contrast, one female student stated outright that she felt like an outsider. One Hispanic male at

FIU who changed majors several times to ensure he fit in highlights the agency students can have in defining their experience.

Many female and underrepresented minority students credited their participation in student organizations with their fitting in to their programs. A Hispanic male at FIU commented, “Once I got more involved with the societies…I saw the opportunity to do more … I never spent one semester without being involved with clubs, societies…so I never had a concern for being scared, not fitting in at all.” According to Forde et al.’s (2010) work on organization culture, students who enter the program with less cultural capital rely on their social networks such as student organizations to gain it.

5. DISCUSSION

While quantitative analyses suggest that there were no statistically significant differences in the perceptions on program climate associated with retention to graduation among female and underrepresented minority students, the qualitative analyses suggest that there was a need for further research into individual experiences to gain insight into climate for retention in engineering programs. Qualitative data do not negate the quantitative findings but underscore the complexity of issues of gender and race/ethnicity as they relate to the retention of women and underrepresented minorities in engineering.

University demographics vary widely in Florida. The traditional racial/ethnic minority group such as African Americans is not the majority in the FAMU/FSU engineering program. For instance, in response to the question asking about one great thing about their department, students in a focus group consisting of White males commented, “The most diverse in the country,” whereby White males are viewed as the minority (“less than 50%”), a scenario that changes the meaning of the question, “Are minority students treated differently?” While many students reported that students were not treated differently, further probing yielded either elaboration on stories where students were, in fact, treated differently or encountered challenges.

These data suggest that women and underrepresented minority students are marked as different, they are preferentially treated as the hardest workers in class, and their behavior is susceptible to scrutiny. An African American female student at FAMU/FSU described this feeling, “It’s kind of hard for other students to look at you as maybe a leader in a class because in part you’re Black and you’re a female so they’re like, ‘She’s probably not that smart.’” In a focus group at UF, three African American students reflected on how they do not realize they are a minority until they go to the football games: “You get to the Swamp [*UF’s stadium*] and you’re like, ‘Wow! There are only like 6% of us here, right?’” Indeed, it can be argued that the fact that they are a minority may be an important negative experience, more so than overt racism or sexism. As such, a chilly climate may manifest itself in very subtle ways. This aligns with Bourdieu’s contention that habitus is naturalized and that the challenges facing women and minority students may not be visible to people in the majority. Thus, interventions levied at creating more gender and racial parity in engineering should consider the subtlety of experiences and the heterogeneity of students.

These data suggest that minority students, perhaps because of their social positioning, tend to rely more on the social capital of other students than on institutional support. This reflects a strategy for students who feel marked as different to not only gain the necessary social capital to succeed in the program, but to also form friendships that make them feel like they are not alone in being an underrepresented minority. Perhaps disaggregating the data may prove useful in exploring student perceptions of program degree climate associated with retention of female and minority students in engineering. Women and underrepresented minority students may experience a chilly climate differently than would majority students. What appears to be a superficially contradictory finding may in fact be an indication of existing complexities related to gender and race. Our data underscore the need to triangulate data in addressing a sensitive topic such as racism or sexism. This paper illustrates how a mixed methods approach is employed to examine the complex issue of gender and race in the context of climate for retention to degree in engineering. We caution that our findings may not extrapolate to undergraduate engineering students in some public universities because we relied on a convenience sample of students surveyed, interviewed, or those who participated in focus groups.

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EMPOWERING WOMEN FACULTY IN STEM FIELDS: AN EXAMINATION OF HISTORICALLY BLACK COLLEGES AND UNIVERSITIES

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This study examines components of the academic work environment that contribute to science, technology, engineering, and mathematics (STEM) faculty members' perceptions of empowerment in the Historically Black Colleges and Universities (HBCUs) organizational setting. Findings are based on data derived from a national sample of STEM faculty members at HBCUs. Among the work environment variables examined in this study, organizational trust had significant effects on both psychological and structural empowerment for male faculty, and a significant effect on psychological empowerment for women faculty. Support for innovation had a significant effect on structural empowerment for all faculty members. The junior faculty variable had a negative effect on psychological empowerment for women faculty only, and a negative effect on structural empowerment for male faculty. Years at current institution and the non-tenure-track variable had negative effects on psychological empowerment for women faculty. Study findings point toward organizational changes that may create work environments that strengthen faculty perceptions of empowerment. Several of these actions have the potential to profoundly impact the academic work environment for women in academic STEM disciplines.

KEY WORDS: *women faculty, HBCU, empowerment, STEM disciplines*

1. INTRODUCTION

Gender disparities in academic science, technology, engineering, and mathematics (STEM) disciplines are well documented and most prominent beyond the baccalaureate degree level. According to recent data from the National Science Foundation (NSF) (2009), nearly equal numbers of men and women earned STEM bachelor's degrees in 2006. However, women earned only 45% of all STEM master's degrees, and only 38.4% of STEM doctoral degrees [percentages include both United States (US) and international degree recipients]. The underrepresentation of women in academic STEM disciplines is particularly pronounced in engineering, computer sciences, the physical sciences, and mathematics, where the percentages of doctorates awarded to women are 20.2%, 21.3%, 27.8%, and 29.6%, respectively. A similar trend is evident beyond the doctoral degree level where women comprise only one-third of all STEM postdoctoral positions and only 31% of STEM doctorates who are employed as faculty in US universities and four-year colleges (NSF, 2009).

The underrepresentation of women faculty in the STEM disciplines is both attributed to and further exacerbated by overt and covert forms of discrimination in the academic workplace, including wage disparities, delayed promotions, and fewer opportunities for senior leadership positions (Valian, 2004; Renzulli et al., 2006; NSF, 2009). Women faculty frequently report hostile or chilly workplace climates that produce feelings of social isolation, lower levels of job satisfaction, and higher levels of turnover (Settles et al., 2007; Xu, 2008). Lack of appropriate mentoring is also a primary concern for women faculty and graduate students in STEM disciplines (Sabatier et al., 2006). Fassinger et al. (2004, p. 299) suggested that women in the academic STEM disciplines encounter a continuous stream of micro-inequities, which they define as “small devaluations of women (e.g., having less lab space, being overlooked for awards) that may appear insignificant in isolation, but add up over time to result in cumulative disadvantage for women.” Valian (2004), for example, found examples of micro-inequities in course assignment decisions; men were more likely to teach advanced courses related to their research specializations, while women were more often teaching large introductory courses that required more preparation and grading time. These cumulative disadvantages are believed to put women faculty in STEM disciplines in a perpetual “catch up” mode, in which they must work harder to remain competitive with their male colleagues (Leggon, 2006).

These conditions that characterize a “chilly” workplace climate for women STEM faculty are manifested in all types of institutions of higher education, including Historically Black Colleges and Universities (HBCUs). However, current literature represents a dearth of data or focus on women faculty at these unique institutions.

While HBCUs constitute less than 3% of higher education institutions, they produce a disproportionately high number of minority college graduates, particularly in the STEM disciplines (Schexnider, 1998). A recent report of the NSF (Burrelli and Rapoport, 2008) noted that in 2006, a third of the Black science and engineering doctorate recipients earned their bachelor’s degrees from an HBCU. Thus, HBCUs appear to be particularly successful in terms of preparing students for careers in engineering and science where minorities are underrepresented, and in raising aspirations for post-baccalaureate study (Wenglinsky, 1997). Reported perceptions of educators also suggest other unique advantages may result from HBCUs, including—but not limited to—more opportunities for students to identify with and relate to positive and culturally competent role models, better access to experiences that enhance student capacity to strengthen self-esteem, and the opportunity to study in an affirming cultural context (Frierson, 1993; Turner, 2001). The potential for this distinct set of strengths to translate to the faculty experience is significant, particularly as it relates to addressing issues of gender equity and providing an equally supportive and productive environment for women faculty.

In order to effectively address acknowledged obstacles to career success for women STEM faculty, it is important to identify constructs that may moderate the effects of negative workplace climates (Settles et al., 2007). Specifically, empowerment has been defined as "a process of enhancing feelings of self-efficacy among organizational members through the identification of conditions that foster powerlessness and through their removal by both formal organizational practices and informal techniques of providing efficacy information" (Conger and Kanungo, 1988). This conceptualization of empowerment may have important implications for colleges and universities and their administrators who can engage in efforts to reshape faculty work environments in an attempt to promote higher levels of empowerment. Several authors have suggested the important benefits of empowerment, particularly for faculty from traditionally underrepresented groups such as women and racial and ethnic minorities (Turner, 2002; Evans and Chun, 2007).

Here, we suggest that empowerment may serve as an important role in promoting perceptions of personal agency and self-efficacy among women STEM faculty in the academic workplace. Perceptions of empowerment may also foster higher levels of motivation and satisfaction (Conger and Kanungo, 1988; Wang and Lee, 2009), reduce turnover intentions (Spreitzer and Mishra, 2002), and strengthen individual and organizational capacities for change (Bartunek et al. 1999). Empowered organizational members report that they are more effective in their work tasks, more satisfied in their jobs, and more committed to their organizations (Spreitzer et al., 1997; Koberg et al., 1999). Studies have also suggested that feelings of empowerment can mitigate the negative effects of a stressful work environment (Spreitzer et al., 1997).

Recent empirical research on faculty empowerment appears to be limited, nonetheless, to a few relevant studies (Moye et al., 2006; Norman et al., 2006; Settles, et al., 2007). Only a small number of academic workplace variables have been examined in terms of their effects on faculty empowerment. The available literature provides minimal information for leaders who seek to create more empowering work environments, and none of the available studies examines empowerment in the specific institutional contexts of HBCUs.

In this study, we identified components of the academic work environment that contribute to STEM faculty members' perceptions of empowerment in the HBCU organizational setting. We have also identified work environment variables that have been shown to be critical components of faculty professional fulfillment and career success, and are also conceptually important for faculty careers in STEM disciplines. These variables include organizational support for innovation, organizational trust, and interpersonal conflict.

Innovation is a particular concern for STEM faculty (Fassinger et al., 2004). Organizational support for innovation, demonstrated through structural and cultural receptivity to change, can strengthen faculty agency, self-efficacy, and commitment to the institution (Curry, 1992; Dee, 2004). Trust in the systems and processes of an organization, similarly, can provide faculty members with structural and cultural assurances that their investments of effort toward achieving goals endorsed by the institution will be recognized and rewarded (Kezar, 2004; Tierney, 2006). Finally, conflict, an organizational inevitability manifest through the interpersonal behaviors of organizational members, can shape the academic work environment in productive or detrimental ways, depending on how conflict is managed and regulated by formal processes and by the informal norms of the academic unit (Bess and Dee, 2008; Gelfand et al., 2008). This study explores the relationship between these work environment variables and empowerment for STEM faculty in HBCUs.

In the following sections, we discuss theoretical and empirical literature associated with each of our study variables and present the findings of our national study on the empowerment of STEM faculty in HBCUs.

2. FACULTY EMPOWERMENT

Characterizations of faculty roles as largely autonomous and self-defined may lead to the perception that faculty members routinely possess high levels of empowerment. For the most part, this is not the case. Institutional decision making in some institutions of higher education has become more centralized, as leaders have responded to increasing pressures from external stakeholders for accountability and efficiency. These forms of managerial control have reduced faculty authority over domains traditionally within their purview, including curriculum change and academic program development (Bess, 2006; Toma, 2007).

Many scholars and researchers (Turner, 2002; Norman et al., 2006; Evans and Chun, 2007) have called for institutions of higher education to promote higher levels of faculty empowerment; especially among traditionally underrepresented groups that include women in STEM disciplines. Research suggests significant individual benefits of empowerment, including enhanced job satisfaction and self-efficacy, which contribute to higher levels of productivity and performance (Spreitzer, et al., 1997; Koberg, et al., 1999).

Similarly, organizations also benefit from the contributions of empowered employees because they are more likely to engage in organizational citizenship behaviors (defined as discretionary actions) that contribute to the overall effectiveness of the organization (Menon, 1999). In higher education organizations, faculty perceptions of empowerment may constitute an important prerequisite for effective shared governance where faculty members are able to exercise their professional authority compatibly with administrative authority (Birnbaum, 2004).

Conceptualizations of empowerment have focused on two important dimensions; specifically, structural and psychological empowerment (Quinn and Spreitzer, 1997). Structural empowerment refers to the process through which leaders redistribute power and resources to lower levels in the organizational chart. Decentralization and delegation of authority are associated with higher levels of structural empowerment (Bowen and Lawler, 1992; Lawler, 1992). Under such conditions, leaders allow individuals, groups, and teams to establish their own goals and action plans in relation to larger organizational missions. Organizational members can perceive high levels of structural empowerment when their decisions are routinely considered, and when resources are available to support the implementation of policies and projects that they design. Consequently, from the perspective of organizational leaders, structural empowerment entails sharing power and authority with others to make important policy and resource decisions. For organizational members (in this study, faculty members), structural empowerment involves perceptions of the ability to influence the direction of the organization, and a prevailing sense that leadership is shared and widely distributed throughout the institution.

In contrast, psychological empowerment emanates largely from the intrinsic rewards of the work itself. Empowerment, as a psychological state, refers to “a subjective state of mind where an employee perceives that he or she is exercising efficacious control over meaningful work” (Potterfield, 1999). Using a psychological conceptualization, Thomas and Velthouse (1990) suggested that empowered organizational members exercise control over meaningful tasks, have significant autonomy in terms of initiating and managing their actions, and have the ability to shape or influence important organizational outcomes. Work that enables organizational members to obtain these types of the intrinsic benefits is likely to be viewed as empowering (Spreitzer, 1995; Menon, 1999).

While empirical research on faculty empowerment may be limited, it does provide some insights related to women in academic STEM disciplines. Settles et al. (2007) examined the concept of voice as a key component of empowerment for women faculty. Similar to conceptualizations of structural empowerment, voice has been defined as having input or influence in organizational decision making, and is viewed as a precondition for developing a sense of personal agency and self-worth (Gilligan, 1988). Among a sample of women STEM faculty at a large research university, Settles et al. (2007) found that women who reported higher levels of voice in departmental matters had higher levels of job satisfaction than those who reported having less voice. In addition, “voice buffered job satisfaction from the negative effect of a poor workplace climate” (Settles et al., 2007). A negative workplace climate had a less detrimental effect on job satisfaction when women faculty reported having more voice within their departments. Voice may diminish the negative effects of a poor work environment because under these conditions women may feel empowered to change “the very environment that they find negative, for example, by helping to implement procedures that acknowledge issues of work and family balance” (Settles et al., 2007). This study is consistent with the finding by Spreitzer et al. (1997) that empowerment can mitigate the negative effects of a stressful work environment.

3. ORGANIZATIONAL SUPPORT FOR INNOVATION

Perceptions of empowerment are shaped by many antecedent conditions in the organizational work environment (Dee et al., 2003). Organizational support for innovation, we suggest, may play an important role in determining how STEM faculty members form their perceptions regarding empowerment. Siegel and Kaemmerer (1978) defined organizational support for innovation as the extent to which the institution facilitates the development and use of new ideas among its members. Successful adaptation to complex external expectations and market forces may depend, in large part, on organizational receptivity to change (Brown and Eisenhardt, 1997). Thus, organizational support for innovation may be a requisite element of effective institutional performance in turbulent external environments.

Organizational support for innovation has both structural and cultural dimensions. Structurally, organizations that support innovation provide venues and resources to convene innovators on campus who can build institutional capacity for change (Kezar and Lester, 2009). Put simply, the institution invests its human and financial resources in innovation. Culturally, the organizational value system embraces change and demonstrates a resistance toward maintaining the status quo. Prevailing norms reinforce behaviors associated with searching and scanning the external environment for new ideas to implement (Siegel and Kaemmerer, 1978).

Support for innovation may be especially important for STEM faculty members who devote significant attention toward facilitating and promoting innovative activity in research and teaching contexts. In a study of women faculty in chemistry departments (Fassinger et al., 2004), the ability to innovate and keep pace with changes in the scientific community was the most prominent career concern reported by study participants. The stakes are high, moreover, in the race toward innovation in all STEM academic disciplines. Scientific innovations in many disciplines require extensive funding to equip laboratories and support graduate student researchers. Tenure, promotion, and career advancement often depend on the ability of STEM faculty members to attract suitable grant support for their research agendas (Tierney and Bensimon, 1996). Organizational support for innovation may signal to faculty members that the institution values innovation, and that their attempts to take risks and experiment with new processes and procedures will be recognized and rewarded.

Orpen (1990) examined perceived organizational support for innovation among employees in engineering firms. Engineers who reported higher levels of support for innovation also experienced higher levels of job satisfaction, work motivation, and job involvement than engineers who reported having less support. Henkin and Holliman (2009), in a study of urban school teachers, found that support for innovation was associated with higher levels of organizational commitment. In a higher education study, Dee (2004) found that community college faculty members who reported higher levels of support for innovation had lower levels of turnover intent than faculty who perceived less support. Support for innovation appeared to strengthen faculty members' attachment to their employing institutions.

4. ORGANIZATIONAL TRUST

Research suggests that trust may serve as another important antecedent of empowerment. Gomez and Rosen (2001), for example, found positive relationships between trust and employee empowerment. High levels of trust may foster the development of a workplace climate that not only endorses individual and collective agency, but also promotes empowered action on behalf of organizational goals. Trust, moreover, has been posited as a requisite condition for effective shared governance in colleges and universities (Kezar, 2004; Tierney, 2006). The quality of the academic work environment may be predicated on the extent and depth of trust found within the organization (Hoy and Miskel, 2008).

Trust refers to an individual's faith and confidence that a particular entity will act in ways that are beneficial to him or her. It also refers to that individual's willingness to expose him/herself to some degree of risk and uncertainty by engaging in interactions and exchanges with that entity (Mayer et al., 1995). Individuals perceive and experience trust with respect to many different entities (Tierney, 2006). Important foci for trust include trust in co-workers and colleagues and trust in the systems and processes of the organization as a whole. In order to examine relationships between the academic work environment and faculty empowerment, we selected organizational trust as the focal point for investigation.

McKnight et al. (1998) defined organizational trust as an employee's perception that the rules, regulations, policies, and procedures of the organization are reliable, consistent, and fair. Instead, organizational trust may contribute to fostering more pro-social behaviors among organizational members, including collaboration and the sharing of knowledge and resources (Tyler, 2000). These types of pro-social behaviors may yield an academic work environment that fosters high levels of faculty empowerment. Moye et al. (2006), for example, found positive associations between organizational trust and perceptions of empowerment among community college faculty.

Trust in the organization may be especially important for STEM faculty who engage in many uncertain, risk-laden ventures to advance scientific research. Lewis and Weigert (1985, p. 971) described trust as the "undertaking of a risky course of action on the confident expectation that all persons involved in the action will act competently and dutifully." To achieve their research and teaching goals, STEM faculty depend on many other organizational units, including campus research centers, grants administration offices, and budget managers. If each component of the knowledge production process performs reliably and consistently over time it is expected that scientific progress can be made in laboratories, classrooms, and field sites.

5. CONFLICT

Conflict is an inevitable occurrence in academic work environments, given differences of perspective and emphasis regarding academic goals and priorities (Bess and Dee, 2008). Intense, unregulated conflict may stifle departmental performance and silence faculty members who seek greater involvement in academic decision making. As such, conflict-ridden work environments may be inhospitable toward empowerment. In contrast, moderate levels of well-managed conflict can signal openness to new ideas and indicate that organizational members can feel free to express their concerns and criticisms without fear of reprisal (Robbins, 1974; Jehn, 1995).

Effectively managed conflict may enhance employee involvement in organizational decision making and yield dividends in terms of productive change (Amason et al., 1995; Rahim, 2001). Higher education administrators, however, may seek to avoid conflict or abdicate their conflict management roles (Graff, 1998). Academic department chairs, for example, are typically not provided with training in the management of conflict. Without appropriate venues for the expression of conflict and without effective leadership in the management of conflict, even minor issues can fester and eventually destabilize professional relationships within the academic work environment.

6. RESEARCH DESIGN

6.1 Conceptual Model

The conceptual model for this study examines the relationship between the academic work environment (exogenous variables) and psychological and structural empowerment (endogenous variables). The underlying conceptual logic of the study suggests that exogenous variables (factors external to the individual) influence perceptions and cognitions regarding endogenous constructs (factors that emanate from within the individual). In this case, work environment variables may positively or negatively affect perceptions of empowerment in the workplace. The conceptual logic of exogenous variables affecting endogenous variables is well supported in the organizational behavior literature (Kim et al., 1996; Price, 1997; Rosser, 2004). We do acknowledge, however, the potential for reciprocally causal effects, in that empowerment may also shape perceptions of exogenous constructs, such as support for innovation, organizational trust, or conflict. The experience of being empowered, for example, may lead an individual to perceive higher levels of support and trust, and lower levels of conflict. But again, the preponderance of empirical research in the field of organizational behavior suggests that we use exogenous variables (work environment) as predictors of endogenous variables (empowerment).

6.2 Data Collection

Data were collected through an online survey distributed to all faculty members at the 73 HBCUs that agreed to participate in the study. The institutional participation rate represents 71% of all HBCUs (73 of 103). Approximately 19,000 faculty members were invited to participate in the study, and 3,004 completed the survey, yielding a 15.3% response rate. Online survey response rates tend to be lower than response rates for hard-copy mailed surveys (Shih and Fan, 2008), although response rates for mailed surveys are also on the decline (Evans and Mathur, 2005).

Online surveys provide an efficient mechanism to collect data from large populations. Moreover, the lower response rates of online surveys do not necessarily translate into nonresponse error (Schalm and Kelloway, 2001). Nonresponse error occurs only if nonrespondents would have provided substantially different answers to survey items than those who did respond. Generally accepted ways to detect nonresponse error include comparisons of demographic characteristics between survey respondents and the population being studied, and the use of a wave analysis in which survey data from early responders are compared to data from those who submitted the survey much later. The assumption with the wave analysis is that late responders approximate nonrespondents (Creswell, 1994).

For this study, the demographic characteristics of the survey respondents were consistent with those found within the faculty population of HBCUs (Provasnik and Shafer, 2004). We also conducted a wave analysis and determined that early respondents did not differ from late respondents in their perceptions of work environment variables or in their reported levels of empowerment.

The analyses for this study were conducted using a subset of the respondents, specifically, faculty members who reported that their academic appointments were in STEM fields. Definitions of STEM vary within the literature. We defined STEM in terms of natural and physical sciences, technology, engineering, and mathematics; thus, we did not include social science fields within our definition of STEM. This subset contained 654 of the 3,004 total respondents.

6.3 Measures

We used the Spreitzer (1995) 12-item measure of empowerment. Among the limited number of empowerment measures, Spreitzer's has been subject to the most extensive testing and validation. Construct validity has been demonstrated through studies that show that scores on Spreitzer's measure are positively associated with predicted correlates of empowerment, including self-efficacy, job satisfaction, organizational commitment, and intent to stay (Spreitzer et al., 1997; Spreitzer and Mishra, 2002). Extensive research also shows high levels of reliability; in related studies, Cronbach alpha coefficients have ranged between 0.72 and 0.92.

Previous research has pointed toward a four-factor structure within Spreitzer's empowerment measure. These four factors have been identified as meaning, competence, self-determination, and impact (Spreitzer, 1995). Our data, however, produced a different underlying factor structure. Using principal components analysis with varimax rotation, we found that six survey items loaded with a factor that can be defined as psychological empowerment, and three survey items loaded with a factor that can be described as structural empowerment. Each of the six psychological empowerment items referred to intrinsic rewards from the work itself, while each of the three structural empowerment items referred to extrinsic characteristics of the organization. The factor loadings for these items ranged between 0.726 and 0.879. Three of the 12 empowerment items did not load with either psychological empowerment or structural empowerment; consequently, those three items were not used in the construction of study variables. Regarding reliability, we obtained Cronbach reliability coefficients of 0.92 for psychological empowerment and 0.91 for structural empowerment.

Organizational support for innovation was examined using the Scott and Bruce (1994) 22-item climate for innovation measure. The theoretical foundations for this measure include the Kanter (1989) research on innovative behavior in organizations, the Jabri (1991) measures of organizational problem solving, the Graen et al. (1982) research on leader–member exchange, and the Siegel and Kaemmerer (1978) climate for innovation research. The survey items assess the extent to which employees perceive their organizations to be open to change and supportive of new ideas from members. In their survey development research, Scott and Bruce (1994) reported Cronbach alpha coefficients between 0.77 and 0.92. Our data indicated that 13 items loaded with the support for innovation factor (loadings ranged between 0.584 and 0.762). For these items, we obtained a Cronbach alpha coefficient of 0.92. Nine of the 22 survey items did not load with this factor and they were omitted from the analysis.

We used the Bryan (1995) seven-item measure of organizational trust. This scale measures an organizational member's perceptions of trust in the systems and processes of the institution. Bryan (1995) developed this measure to examine trust within higher education organizations. Consequently, this measure is considered to be an appropriate choice for this study, which also examines perceptions of college and university employees. Bryan's research reported a reliability coefficient of 0.88. Our principal components analysis indicated that all seven items loaded with the organizational trust factor (loadings ranged between 0.531 and 0.750), and we obtained a Cronbach alpha of 0.92.

Respondents also reported on the intensity of conflict within their academic units. Specifically, they reported the extent of conflict between faculty, between faculty and administrators, and among administrators. We used these three items as a measure of perceived conflict intensity in the academic work environment.

6.4 Statistical Procedures

We ran three ordinary least-squares (OLS) regression analyses using psychological empowerment as the dependent variable, and three OLS regression analyses with structural empowerment as the dependent variable. Separate analyses were conducted for all STEM faculty, male STEM faculty, and female STEM faculty. The independent variables included support for innovation, organizational trust, and conflict. The model also contained the following demographic variables: gender (only for the analysis with all STEM faculty), age, race/ethnicity, academic rank, years of faculty experience, and years at current institution.

The use of OLS regression is contingent upon meeting assumptions related to multicollinearity, normality, linearity, homoscedasticity, and independence of residuals (Kleinbaum et al., 1988). First, examination of covariance indicated that the assumption of multicollinearity was not violated. Second, the normality assumption was supported by the probability–probability plot. Third, the assumption of linearity was confirmed by curve fitting with *R*-squared difference tests. Finally, the Goldfeld–Quandt test supported the homoscedasticity assumption, and the Durbin–Watson coefficient confirmed the independence of residuals.

6.5 Respondent Characteristics

Within the subset of STEM faculty, the majority of respondents (58.8%) were male. Data regarding race and ethnicity indicated that 47.8% of respondents were African American, 31.4% were White, 9.3% were Asian or Pacific Islander, 2.6% were Hispanic, and 8.9% reported other racial/ethnic identifications. Regarding age, 20.5% were in their 20's or 30's, 27.8% were in their 40's, 31.8% were in their 50's, and 19.9% were 60 or older.

In terms of academic rank, the largest group included non-tenure-track faculty (30.1%). Assistant professors constituted 22.3% of respondents, while associate professors and professors comprised 24.8% and 22.8%, respectively. The majority of respondents (59.2%) had more than 10 years of faculty experience; only 7.3% were in their first year as a faculty member. Data regarding length of service at current institution showed that 38.1% had been employed by their current institution for more than 10 years, while only 12.8% were in their first year at their current place of employment. Respondent characteristics are displayed in Table 1.

Table 1: Respondent characteristics

Characteristic	Number of faculty	Valid percent
Gender		
Male	378	58.8
Female	265	41.2
Missing	11	
Age		
20–39	132	20.5
40–49	179	27.8
50–59	205	31.8
60 or more	128	19.9
Missing	10	
Race		
African American/Black	289	47.8
Caucasian/White	190	31.4
Asian Pacific Islander	56	9.3
Hispanic	16	2.6
Other	54	8.9
Missing	49	
Rank		
Assistant professor	144	22.3
Associate professor	160	24.8
Professor	147	22.8
Nontenure track	194	30.1
Missing	9	
Years teaching experience		
1 year or less	45	7.3
2–4 years	65	10.5
5–7 years	86	13.9
8–10 years	57	9.2
11 or more years	367	59.2
Missing	34	
Years at current institution		
1 year or less	79	12.8
2–4 years	152	24.6
5–7 years	95	15.3
8–10 years	57	9.2
11 or more years	236	38.1
Missing	35	

7. STUDY FINDINGS

Study participants reported high levels of psychological empowerment (mean = 4.64)) and structural empowerment (mean = 4.09) on five-point scales. Faculty indicated moderate levels of support for innovation (mean = 2.98), organizational trust (mean = 3.18), and conflict (mean = 2.91). Descriptive statistics (Table 2) indicated that women and men reported similar perceptions of these academic work environment variables. Women reported higher levels of organizational conflict than men, although mean scores for both men and women were in the moderate range. Differences by gender were not significant for psychological and structural empowerment, support for innovation, and organizational trust.

In our OLS regression analyses, we first examined psychological empowerment for all STEM faculty respondents. In the first specification of the model, we entered the demographic variables, and found a positive effect for African American faculty. This coefficient became nonsignificant, however, after the work environment variables entered the model. In the second specification, organizational trust had a positive effect on psychological empowerment. The model explained 7.9% of the variance in psychological empowerment (see Table 3).

Next, we conducted a regression analysis for structural empowerment with all STEM faculty respondents. We found three demographic variables with significant effects in the first specification of the model: a positive effect for African American, a negative effect for assistant professor, and a negative effect for years at current institution. Again, the effect for African American became nonsignificant when the work environment variables entered the model, but the effects for assistant professor and years at current institution remained significant in the final model. In terms of work environment variables, support for innovation and organizational trust had significant positive effects on structural empowerment. The final model explained 17.2% of the variance in structural empowerment (see Table 4).

It is important to note that gender did not have a significant effect on either form of empowerment. An encouraging interpretation of this result is that both male and female STEM faculty may be able to perceive and experience empowerment in the HBCU work

TABLE 2: Descriptive statistics for study variables

Variable	Men (mean)	Women (mean)	t
Psychological empowerment	4.62	4.67	−0.99
Structural empowerment	4.10	4.07	0.38
Organizational conflict	2.86	2.95	−2.00[a]
Support for innovation	2.97	2.99	−0.27
Organizational trust	3.16	3.19	−0.39

[a] $p < 0.05$.

TABLE 3: Work environment variables regressed on psychological empowerment: All STEM faculty

Variable	Specification 1 β	Specification 2 β
Demographic		
Age	−0.023	−0.035
Race (African American)	0.148[a]	0.085
Race (other minority)	0.092	0.069
Rank (assistant professor)	−0.120	−0.106
Rank (associate professor)	−0.056	−0.045
Rank (nontenure track)	−0.091	−0.113
Gender (female)	0.050	0.047
Years of experience	0.115	0.120
Years at current institution	−0.112	−0.137
Conflict		0.098
Innovation		−0.087
Trust		0.289[b]
R-squared	0.033	0.079

Note: White was the reference group for race/ethnicity; professor was the reference group for rank.
[a]$p < 0.01$; [b]$p < 0.001$

environment. Our subsequent analyses will demonstrate, however, that the factors that affect empowerment differ somewhat for male and female faculty.

Next, we examined psychological empowerment for male STEM faculty. In the first specification of the model, African American had a significant positive effect, but again, this variable became nonsignificant when the work environment variables entered the model. In the second specification of the model, organizational trust had a significant positive effect on psychological empowerment. The final model explained 8.6% of the variance in psychological empowerment for male STEM faculty (see Table 5).

In terms of structural empowerment for male STEM faculty, we found two demographic variables with significant effects in the first specification of the model. African American had a significant positive effect, and assistant professor had a significant negative effect. As with previous analyses, the coefficient for African American became nonsignificant when the work environment variables entered the model, but the effect for assistant professor remained statistically significant. Among the work environment variables, both support for innovation and organizational trust had positive effects on structural empowerment. The final model explained 20.4% of the variance in structural empowerment for male STEM faculty (see Table 6).

TABLE 4: Work environment variables regressed on structural empowerment: All STEM faculty

Variable	Specification 1 β	Specification 2 β
Demographic		
Age	−0.024	−0.058
Race (African American)	0.107[a]	0.045
Race (other minority)	−0.039	−0.052
Rank (assistant professor)	−0.213[b]	−0.206[b]
Rank (associate professor)	−0.026	0.009
Rank (nontenure track)	−0.083	−0.112
Gender (female)	−0.023	−0.016
Years of experience	0.050	0.054
Years at current institution	−0.159[a]	−0.157[a]
Conflict		−0.028
Innovation		0.201[b]
Trust		0.177[b]
R-squared	0.048	0.172

Note: White was the reference group for race/ethnicity; professor was the reference group for rank.
[a]$p < 0.05$; [b]$p < 0.01$

Focusing now on female STEM faculty, we found three demographic variables with significant effects on psychological empowerment: a negative effect for assistant professor, a negative effect for non-tenure-track faculty, and a negative effect for years at current institution. These effects remained significant after the work environment variables entered the model. In the second specification of the model, organizational trust had a significant positive effect on psychological empowerment. The final model explained 11.8% of the variance in psychological empowerment for female STEM faculty (see Table 7).

Regarding structural empowerment for female STEM faculty, none of the demographic variables had significant effects in either specification of the model. Among the work environment variables, support for innovation had a significant positive effect on structural empowerment. The final model explained 17.3% of the variance in structural empowerment for female STEM faculty (see Table 8).

8. DISCUSSION

Organizational trust had significant effects on both forms of empowerment for male faculty, and a significant effect on psychological empowerment for women faculty. Faculty members' confidence in the reliability and fairness of organizational systems and processes may be important contributors to their perception and experience of empowerment in their work roles in HBCUs. Having faith and confidence in the reliability and

TABLE 5: Work environment variables regressed on psychological empowerment: Male STEM faculty

Variable	**Specification 1** **β**	**Specification 2** **β**
Demographic		
Age	−0.022	−0.034
Race (African American)	0.169[a]	0.107
Race (other minority)	0.111	0.102
Rank (assistant professor)	−0.017	−0.017
Rank (associate professor)	−0.070	−0.059
Rank (nontenure track)	0.000	−0.015
Years of experience	0.081	0.094
Years at current institution	−0.026	−0.056
Conflict		0.108
Innovation		−0.073
Trust		0.292[b]
R-squared	0.031	0.086

Note: White was the reference group for race/ethnicity; professor was the reference group for rank.
[a]$p < 0.05$; [b]$p < 0.01$

fairness of organizational systems may provide STEM faculty with assurances that their important scientific, scholarly, and instructional activities will be supported. This level of confidence, in turn, may enhance faculty perceptions of agency and enable members to move forward with plans and projects that entail multiple exchanges and transactions with complex internal and external systems.

Support for innovation had a significant effect on structural empowerment for all HBCU STEM faculty members. Tangible support for innovation may come in the form of institutional support for research centers, acquisition of external funding and venture capital for scientific endeavors, and flexible tenure and promotion criteria that value multiple forms of scholarly impact. Innovation can also be supported through curriculum committees and other governance bodies that value contributions of new ideas and proposals for change. The same types of structural conditions that support innovation may also contribute to higher levels of structural empowerment among faculty members.

The pre-tenure variable had a negative effect on psychological empowerment for women faculty and a negative effect on structural empowerment for male faculty. Empowerment for assistant professors may be constrained by tenure clock considerations that emphasize with great importance specific types of outcomes, such as grant acquisition and peer-reviewed publications. Departmental norms regarding preferred forms of scholarship may further constrain perceived choice among assistant professors. Some STEM departments, for example, may discourage qualitative research, while others

TABLE 6: Work environment variables regressed on structural empowerment: Male STEM faculty

Variable	Specification 1 β	Specification 2 β
Demographic		
Age	−0.072	−0.105
Race (African American)	0.147[a]	0.072
Race (other minority)	0.002	−0.021
Rank (assistant professor)	−0.230[b]	−0.253[b]
Rank (associate professor)	0.012	0.038
Rank (nontenure track)	−0.045	−0.065
Years of experience	0.049	0.052
Years at current institution	−0.147	−0.145
Conflict		0.012
Innovation		0.191[a]
Trust		0.221[b]
R-squared	0.069	0.204

Note: White was the reference group for race/ethnicity; professor was the reference group for rank.
[a]$p < 0.05$; [b]$p < 0.01$

may discount community-based participatory research or the scholarship of teaching and learning. Rice et al. (2000) found that early-career faculty members often express a desire to engage in multiple forms of scholarship, but feel discouraged by evaluation systems that prioritize traditional empirical research.

Rice et al. (2000) also describe the "overloaded plate" condition for assistant professors who struggle to balance their research, teaching, and service roles. Competing demands such as high teaching loads and extensive expectations for research productivity may consume large quantities of effort, may displace discretionary time that could be used for consideration of new ideas, and may diminish perceptions of agency and choice.

The non-tenure-track variable had a significant, negative effect on psychological empowerment for women faculty. Women are twice as likely as men to hold non-tenure-track positions (Schuster and Finkelstein, 2006). Non-tenure-track faculty often lack job security, and they do not have the same protections of academic freedom that tenured faculty possess. They may also have extensive teaching loads that include many high-enrollment, introductory-level courses. Non-tenure-track faculty may occupy a marginal status within the academy; they may not be invited to participate in departmental meetings, they may not have access to appropriate professional development opportunities to build their skills, and they often lack a voice in governance matters on their campuses (Baldwin and Chronister, 2001). This marginal status may have particularly severe ramifications for women faculty, where these effects may be compounded by departmental cultures that are gender biased or indifferent toward work–life balance issues.

TABLE 7: Work environment variables regressed on psychological empowerment: Female STEM faculty

Variable	Specification 1 β	Specification 2 β
Demographic		
Age	−0.023	−0.031
Race (African American)	0.101	0.044
Race (other minority)	0.027	−0.010
Rank (assistant professor)	−0.331[b]	−0.301[a]
Rank (associate professor)	−0.030	−0.022
Rank (nontenure track)	−0.272[a]	−0.295[a]
Years of experience	0.203	0.200
Years at current institution	−0.332[b]	−0.330[b]
Conflict		0.079
Innovation		−0.097
Trust		0.258[a]
R-squared	0.090	0.118

Note: White was the reference group for race/ethnicity; professor was the reference group for rank.
[a]$p < 0.05$; [b]$p < 0.01$

Years at current institution also had a negative effect on psychological empowerment for women faculty. Previous studies have shown that women faculty at mid- and late-career stages encounter significant extra-role expectations that include mentoring and supporting other women faculty and graduate students (Rosser, 2006). They may also be asked to serve on committees and task forces that deal with gender or diversity issues on their campuses. These activities, although potentially enriching and beneficial for institutions in the long term, are seldom accommodated by a comparable reduction in other faculty responsibilities. In other words, gender work becomes an add-on to the traditional faculty role, and thus it may drain the energies of women faculty who are pulled simultaneously in multiple directions. Table 9 provides a summary of the statistically significant findings of the study.

9. CONCLUSIONS AND RECOMMENDATIONS

This study examined the effects of the academic work environment on perceptions of empowerment among STEM faculty in HBCUs. The use of a large national sample supports generalization of study findings. We acknowledge, however, the limitations of cross-sectional survey research and the need to avoid claims of causality. Nevertheless, study findings point toward specific actions that academic administrators can take to create work environments that strengthen faculty perceptions of empowerment. Several of

TABLE 8: Work environment variables regressed on structural empowerment: Female STEM faculty

Variable	Specification 1 β	Specification 2 β
Demographic		
Age	0.070	0.042
Race (African American)	0.023	−0.007
Race (other minority)	−0.119	−0.096
Rank (assistant professor)	−0.200	−0.143
Rank (associate professor)	−0.097	−0.031
Rank (nontenure track)	−0.141	−0.185
Years of experience	0.035	0.050
Years at current institution	−0.182	−0.197
Conflict		−0.115
Innovation		0.204[a]
Trust		0.126
R-squared	0.045	0.173

Note: White was the reference group for race/ethnicity; professor was the reference group for rank.
[a]$p < 0.05$

TABLE 9: Summary of statistically significant regression findings

	Psychological Empowerment		Structural Empowerment	
Variable	Male	Female	Male	Female
Organizational trust	X	X	X	
Support for innovation			X	X
Rank: assistant professor		X	X	
Rank: nontenure track		X		
Years at institution		X		

Note: X represents statistically significant effect ($p < 0.05$).

these actions have the potential to improve noticeably the academic work environments for women in academic STEM disciplines.

Recent literature suggests that tangible support for innovation can be provided through providing start-up funds for new research initiatives, administrative support for preparing grant applications, reduced teaching loads for faculty engaged in major institutional change initiatives, and developmental grants for faculty to extend discipline-specific networks. However, institutions that are fiscally constrained can also explore other forms of support for innovation that require only a minimal institutional investment of resources. Kezar and Lester (2009), for example, described the benefits of providing venues for faculty innovators to gather, share ideas, and identify common interests and goals. These types of low-cost, informal gatherings can be physical or virtual, and can support the development of innovative collaborative projects that empower faculty—particularly women faculty—to engage in innovation.

Organizational trust can be enhanced when organizational policies and/or practices that foster transparency are implemented (McKnight et al., 1998). Transparency can be fostered through open conversations between administrators and faculty regarding key institutional policies and practices. Open conversations in the form of targeted faculty development workshops that focus on criteria for tenure and promotion, for example, could reduce uncertainties and heighten faculty confidence in the reliability of related evaluation processes.

Assistant professors in HBCU STEM disciplines perceived limitations in their levels of empowerment. This is typical of junior faculty at all institutions of higher education. Institutions may consider revising merit review criteria to include a wider array of scholarly outcomes, which could signal to academic departments in STEM disciplines that additional forms of scholarly accomplishment are valued highly by the institution. Recent trends toward community-engaged scholarship (Lynton, 1995; Boyer, 1996; Colbeck and Michael, 2006) could readily be applied to STEM disciplines in HBCUs. STEM faculty members who focus their research on civic issues have examined topics such as health disparities, climate change, and environmental justice. The scholarly work that STEM faculty perform in their teaching roles, including curriculum development and assessment of student learning outcomes, can also be recognized in faculty reward systems.

Study findings also pointed toward the possibility of declining levels of empowerment for women faculty who have more years of experience. Two factors may explain this result. First, the micro-inequities that women faculty members encounter routinely in the academic workplace (Fassinger et al., 2004) may exact cumulative, long-term effects on empowerment. The micro-inequities and barriers to advancement that put women faculty in perpetual “catch up” mode (Leggon, 2006) may eventually erode individual perceptions of agency and self-efficacy, as the gap between desired and actual conditions is never fully closed. Second, gender-oriented mentoring is often directed toward junior faculty, and senior women faculty members are often expected to provide such support. As Rosser (2006, p. 281) notes, “sadly, the role of mentoring junior women to fill the pipeline may represent just one more burden that leads to burnout for senior women.”

Representation of senior STEM women faculty in academic leadership positions should also be assessed by HBCUs and other institutions that seek to empower academic women. The available evidence suggests that there is an underrepresentation of women from the STEM disciplines in leadership positions. Among those with STEM doctorates who held positions as deans or department chairs in 2006, only 27.5% were women (NSF, 2009). Limited representation of senior STEM women faculty in academic leadership roles may further the perception of constraints on empowerment. Thus, the intersection of gender and leadership in the academic STEM disciplines is an area of future consideration for HBCUs and for institutions of higher education as a whole.

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SIMILARITIES AND DIFFERENCES IN WOMEN'S AND MEN'S PUBLICATION AND CITATION RECORD AMONG ACADEMIC PSYCHOLOGISTS

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Past studies have generated mixed findings as to whether women and men differ with regard to publication rates, with variability depending on academic rank, discipline, and institutional context. In addition to publications, citations are an increasingly important measure of productivity. This study examined publication and citation rates for women and men in Italian academic psychology. Italy was chosen as a case-study country to expand the scope of scientific productivity research beyond Anglophone cultural and institutional contexts. We examined Google Scholar publication rates and three [the h-index, the hi-index, and the age-weighted citation rate (AWCR)] citation indices for the 250 female and 261 male university psychology professors listed in the Italian Ministry of Education, University and Research website. Overall, rank was the best predictor of publications and citations, with full professors being the most published and cited. At the same time, even when rank was considered, men had higher publication productivity and impact than women. Specifically, men had more publications, more co-authored publications, and more publications involving foreign co-authors, even though women and men published at similar rates in subfields where women were the majority, and in Italian outlets. Men also had significantly higher impact values across citation indices except in the AWCR, an index adjusted for the publication's age, and not in all subfields. In conclusion, rank and seniority are important in Italian academic psychologists' publication and citation patterns, with sex of faculty effects smaller, but significant. Being in a majority-female subfield is associated with higher publication productivity among Italian psychology female academics.

KEY WORDS: *women, academia, science, publications, citations*

1. INTRODUCTION

Past studies have generated mixed findings as to whether female and male scholars differ with regard to publication rates, with variability depending on discipline, institutional context as well as academic rank. Citation rates are an increasingly important, but less well-researched, measure of productivity. This study contributes to the literature on gender and scientific productivity by examining publication and citation rates for women and men in Italian academic psychology.

1.1 Background

In the 1970s and 1980s, a gap in the publication productivity of female and male scientists was documented in the United States, with women publishing at significantly lower rates than men (Reskin, 1978; Cole, 1979; Cole and Zuckerman, 1984; see Boice et al., 1985, for an exception; Fish and Gibbons, 1989; Helmreich et al., 1980; Long, 1992). More recent research from around the world has revealed variability in women’s and men’s publication productivity, with a majority of studies reporting small to no gender differences in publication rates (Lemoine, 1992a,b; Noordenbos, 1992; Long and Fox, 1995; Sonnert and Holton, 1996; Ward and Grant, 1998; Xie and Shauman, 1998; Gupta et al., 1999; D’Amico and Di Giovanni, 2000; Maass and Casotti, 2000; Sax et al., 2002; Leta and Lewison, 2003; Joy, 2006; Mauleón and Bordons, 2006; Malouff et al., 2010), especially when other factors (e.g., rank) affecting productivity are taken into consideration, and a few studies still recording significant differences (Goel, 2002; Prpić, 2002; Maske et al., 2003; Symonds et al., 2006). For example, a study of “PsychLit” publication rates by members of the European Association of Social Psychology (EASP) found that men published more than women, but also that men’s per-year production weighted for journal prestige was only slightly higher than that of women. In that study, the publication gap was least pronounced in Southern European countries where the percentage of women in the field was highest (Maass and Casotti, 2000). Similarly, a study of United States’ academic psychologists based on the PsycINFO database found that women published less than men during the pre-tenure stage but not thereafter, with women increasing their publication rates once they attained senior status. In the latter study, a subset of highly productive junior men who were moving to more prestigious universities accounted for much of the gender difference in publication rate (Joy, 2006). By contrast, a survey study of United States’ economists found that women published on average about seven fewer articles than men, with 59% of the differentials unexplained by control variables, such as type of university (e.g., teaching versus research university) (Maske et al., 2003). Similarly, a study of The Web of Science record of British and Australian scientists in ecology and evolutionary biology found that men published on average almost 40% more papers than women (Symonds et al., 2006).

Citation rates are an increasingly important but less-well researched measure of productivity. They are a measure of research impact and, as such, they can be taken as a measure of research quality. As is the case for studies of women’s and men’s publication rates, studies of women’s and men’s citation rates have also generated variable findings, depending on factors such as discipline and measure used. For example, a Nordic countries study using the Google Scholar (GS) database found that female sociologists were cited significantly less than male sociologists, with the difference, however, disappearing when the effect of individual web visibility was added to the model (Aaltojärvi et al., 2008). By contrast, a study of British and Australian evolutionary biologists and ecologists found that women and men did not differ with regard to median citations per paper nor in the proportion of publications with the greatest impact (Symonds et al., 2006).

Publication and citation rates are influenced by structural and institutional factors, including rank, university type (e.g., prestigious versus not prestigious), discipline, and collaborations. Among these factors, rank is one of the most important with regard to publication output. Full professors tend to be more productive than associate professors who, in turn, usually publish more than assistant professors (Noordenbos, 1992; Tien and Blackburn, 1996; Byrnes and McNamara, 2001; Long, 2001; Nakhaie, 2002; Sax et al., 2002; Malouff et al., 2010; McNally, 2010). Higher rank creates networks and resources, all of which favor scientific productivity, thus generating a cumulative positive effect (Lee and Bozeman, 2005). For example, full professors are more likely to be awarded external research funding than assistant professors (Cornoldi et al., 1994). Rank likely impacts citation rates in similar ways as do publication rates because of what rank brings in terms of resources, visibility, and status (Jiménez-Rodrigo et al., 2008). For example, in a study of publication and citation patterns in Nordic countries' sociology departments, full professors were cited significantly more than other faculty members (Aaltojärvi et al., 2008). Similarly, in Australia, citation rates of psychology faculty were highest for full professors (McNally, 2010). Having only recently joined the academic world in significant numbers, women are overrepresented in the lower faculty ranks—a situation that likely depresses their publication and citation rates.

Apart from rank, type of university is relevant to productivity rate and impact (Nakhaie, 2002; Prpić, 2002; Fox, 2005; Joy, 2006; Malouff et al., 2010). Research-oriented institutions prioritize research productivity, and thus generate more and more impactful scholarship than teaching-oriented institutions (Nakhaie, 2002; Joy, 2006). Another university characteristic important in publication and citation rates is institutional prestige. More prestigious universities require less teaching and provide more time and resources for research than less prestigious universities (Noordebos, 1992). Prestigious universities also contribute a positive halo effect facilitating the acceptance rate of manuscripts in major journals (Crane, 1967; Garfunkel et al., 1994), as well as in citations of books (Nock, 1992) and papers (Brym and Fox, 1989). Another institutional feature relevant to publication and citation rates is university size. On the one hand, large universities house larger departments, and in large departments it is easier to establish research groups and networks that enhance publication productivity and visibility. Research facilities are also usually better in larger departments. On the other hand, larger organizations tend to have practices and rules that may hamper initiative and innovation, and thus possibly publication productivity. In some cases (for example, in a study of four Norway universities; Kyvik, 1995), no relationship was found between department size and scientific publishing. Given that women are more likely than men to work in smaller, less prestigious, teaching institutions and to be underrepresented at prestigious research universities (Joy, 2006), differences in publication and citation patterns between women and men could reflect differences in their university affiliation type.

Discipline is another factor influencing productivity (Nakhaie, 2002). Publication rates are generally higher in the natural and physical sciences than in the social sciences and in the humanities. This may be due, in part, to discipline differences in length of publications and in the frequency of co-authorship (Stack, 2004). To the extent that women are more likely to be in the social sciences and the humanities, women's overall lower productivity is in part a discipline effect. Some evidence indicates that women's publication rates may be higher in disciplines like the social sciences, in which they are better represented—one explanation being that when they are less of a minority, women have more access to resources, such as graduate students, that facilitate publishing. This explanation has been supported, for example, for the social sciences in Norway and in the United States (Lie, 1990; Stack, 2004), but not for astronomy in Brazil, a male-dominated field where women's productivity was found to be higher than women's percentage presence as researchers (Leta and Lewison, 2003). Scholars' productivity also varies by subfields. For example, within psychology, cognitive, developmental, and social psychologists publish more than clinical, counseling, school, and educational psychologists (Brems et al., 1996; Byrnes and McNamara, 2001; Byrnes, 2007). While we do not know whether women and men in the same subfield differ with regard to publication output, we do know that men and women tend to specialize in different subfields. For example, in the United States, women are more numerous in developmental, health, and clinical psychology, while men are a majority in general, experimental, physiological, and organizational psychology (Kite et al., 2001).

Finally, opportunities for collaboration are a factor in publication and citation rates. Collaborations increase publication output (although not when productivity credit is reduced in proportion to the number of authors) (Lee and Bozeman, 2005). Collaborations also increase publication impact, especially in the case of international collaborations (Glänzel et al., 1999; Glänzel and Schubert, 2001; Leta and Lewison, 2003), but with variability by field (Glänzel, 2002). Studies of women's and men's scientific collaborations suggest some general patterns. Across a diversity of fields, women report having fewer collaborators than do men (Corley, 2005; Lee and Bozeman, 2005), at the same time, across fields, women are equally as likely as men to co-author a publication (Long, 1992; Corley, 2005). An exception is Indian female psychologists who had fewer co-authors than male psychologists (Goel, 2002).

In conclusion, theory and past research point to a range of institutional and cultural factors, including department size, university type, collaborations, and discipline, as relevant to publication and citation rates. The general consensus is that evaluations of women's and men's productivity and impact require consideration of institutional and cultural factors. A limitation of the literature so far is that studies of gender, publications, and citations have tended to focus on Anglophone countries with similar cultural and academic structures. Given the importance of cultural and institutional factors in scholarly productivity and impact, it is important to expand this kind of research to novel cultural and academic contexts.

1.2 The Current Study

The present study examined publication and citation rates for women and men in Italian academic psychology. We chose psychology because it is a discipline that for decades has had a female majority among its doctorates. For example, in 2004, 85% of Italian

University psychology degrees went to women (Italian Institute of Statistics, 2004). We selected Italy as a case-study country because among European countries it ranks highly with regard to female representation among university faculty, with women constituting 16% of full professors, 31% of associate professors, and 44% of assistant professors in 2004 (European Commission, 2006).

Building on theory and previous findings (e.g., Cole, 1979; Black and Holden, 1998; Goel, 2002; Kite et al., 2001; Nakhaie, 2002; Xi and Shauman, 2003; Corley, 2005), the current study aimed to answer the following two questions: (1) Is the scientific productivity of Italian female psychology academics different from that of their male peers with regard to measures such as number of publications, kind of publications (e.g., journal articles versus books), co-authorship (e.g., sole-authored versus co-authored publications), as well as citations? (2) Are faculty rank, specialization subfield, and university size associated with publication and citation rates?

2. METHOD

2.1 Participants

This study focused on the record of the 250 (49%) women and the 261 (51%) men who, in 2004, were university professors in Italy's 11 psychology departments. There were 171 assistant professors, 160 associate professors, and 180 full professors. Women represented 67% of assistant professors, 49% of associate professors, and 37% of full professors. In other words, there were twice as many women at the assistant professor level, and twice as many men at the full professor level, with these differences being statistically significant ($\chi^2 = 31.28$, $p = 0.001$).

Information regarding age was available for 421 of the 511 professors. Faculty ranged in age from 29 to 77 years (assistant professors, $M_{age} = 44.4$ years, age range: 30–65 years; associate professors, $M_{age} = 50$ years, age range: 29–72 years; full professors, $M_{age} = 57.3$ years, age range: 35–77 years). Women were on average significantly younger than men (women's $M_{age} = 48.67$ and men's $M_{age} = 52.06$, $F(1, 419) = 12.31$, $p = 0.001$), but when rank was considered, women and men were similar with regard to age. Women were more numerous than men in developmental and social psychology, while men were more numerous in psychobiology and research methodology ($\chi^2 = 36.50$, $p = 0.001$; see Table 1).

3. PROCEDURE

Psychology university professors were identified based on their being listed in the Italian Ministry of Education, University and Research [Ministero dell'Istruzione, dell'Universita' e della Ricerca (MIUR)] website (www.miur.it). The MIUR website indicated their full name, rank, and department affiliation. We obtained the age for 421 out of the 511 professors via the curriculum vitae posted on their University's website or via e-mail communication with the professors.

To measure scientific publication productivity, we used the GS database. We chose the GS database because it covers a broad range of psychology publications, including

TABLE 1: Distribution of female and male faculty by rank and department size

		Professor rank			
Department size	**Sex of faculty**	**Assistant (N = 171)**	**Associate (N = 160)**	**Full (N = 180)**	**Total (N = 511)**
Small	Female	13	10	13	36
	Male	6	21	17	44
Medium	Female	37	30	16	83
	Male	23	19	32	73
Large	Female	65	41	35	141
	Male	31	37	65	133
Total	Female	115	81	64	260
	Male	60	77	114	250

N = number of faculty members.

those in psychobiology topics. GS also has good coverage of publications in Italian. We examined faculty publications dated between 1998 and 2004 and recorded individual faculty's total number of publications. We also kept track of: (1) publication type (journal article, book, or book chapter; (2) publication authorship (sole author or co-author); and (3) publication nationality (domestic/Italian versus international). Following the lead of other scholars (Bellas and Toutkoushian, 1999; Xie and Shauman, 2003; Leahey, 2007), articles and books were weighted equally in calculations of number of publications.

Department size was based on the number of full-time faculty members, excluding single-year, adjunct professors. When applied to faculty data for 2004, this criterion generated the following breakdown for the 11 Italian university psychology departments: three large departments (Padova, Roma, and Torino), with a total of 275 faculty (54% of 511); four medium departments (Milano Bicocca, Firenze, Bologna, and Milano SacroCuore), with 155 faculty (30% of 511); and four small departments (Napoli, Chieti, Trieste, Milano S. Raffaele), with 81 faculty (16% of 511).

To measure impact, we used three citation indices. The first one is the *h*-index, defined as "the number of papers co-authored by the researcher with at least *h* citations each" (Hirsch, 2007, p. 19193). According to its developer, the *h*-index is more than a simple count of citations because it allows one to distinguish scholars whose publications are influential from those whose publications are not (Hirsch, 2005). Thus, if a scholar published 10 papers with a least one citation each, this scholar's *h*-index is 10. This index is closely correlated with total publication outputs. In this study, the *h*-index was calculated via the "Publish or Perish" software by Harzing (2007). To control for the effects of co-authorship, we also used the *hi*-index (Batista et al., 2006), which divides the standard *h*-index by the average number of authors. Our third citation index, the age-weighted citation rate (AWCR), is an index in which the number of citations is divided by the age of the paper (Jin et al., 2007).

4. RESULTS

4.1 Women's and Men's Publication Output

4.1.1 Publication Output in Clusters

We first examined publication output in clusters. Forty-nine (9.6%; 29 women and 20 men) of the 511 professors did not publish during the seven-year study period. Nearly half (48.9%) had between 1 and 10 publications, 180 (35.2%) had between 11 to 35, and 32 (6.3%) had more than 35 publications. The median number of publications was 8. Seventeen percent of professors accounted for about half of all the publications. Women's representation among the publishing faculty decreased as the number of publications increased: 50% of women had seven publications whereas 50% of men had 11 publications. Moreover, women were most numerous (30%) in the range of 1–11 publications, with only 25% of women having 13 publications, and even fewer women (10%) having 23 publications. In contrast, men clustered in the center of the publication distribution (40% of men had 15 publications), as well as in the positive extreme of the distribution, with 20% having 22 publications, and 10% with more than 32 publications (see Fig. 1).

4.1.2 Publication Output by Type of Publication

Next, we examined the role of rank in women's and men's publication output. Because rank was correlated with faculty age ($r = 0.63$, $p = 0.001$), we created a new variable by grouping three levels of faculty age (ages 29–44, 45–60, and 61–77). A 2 x 3 (sex of faculty by rank) factorial analysis of covariance (ANCOVA) was performed on total publications, with age levels entered as a covariate. Age as a covariate was found to explain only 6% of the total variance, indicating that the variability in rates of publications was not associated with age but was due to the main effect of rank, $F(2, 510) = 15.42$, $p = 0.001$, $\eta^2 = 0.058$. Bonferroni's post-hoc pair-wise comparisons clarified this effect. The publication output of full professors exceeded that of associate professors, and was almost double that of assistant professors. A main effect of the sex of faculty emerged [$F(2, 510) = 8.80$, $p = 0.003$, $\eta^2 = 0.017$], with women having a lower mean of publications than men (see Table 2). The sex of the faculty effect was small, however, accounting for 1.7% of the variance. No significant interaction effect of the sex of the faculty by rank was found. In a one-way ANOVA that did not control for rank, the sex of the faculty effect was greater ($\eta^2 = 0.035$), with the mean number of publications for female faculty being 9.6 publications, and the mean number of publications for male faculty being 15.5, $F(2, 510) = 88.30$, $p = 0.001$.

A series of two-way ANOVA's for each type of publication revealed a significant main effect of the sex of the faculty only in the case of articles published in international journals, with men having a higher mean rate than women, $F(1, 510) = 10.66$, $p = 0.001$, $\eta^2 = 0.021$. By contrast, for each type of publication, a main effect of rank was detected; that is, across publication types, full professors had the highest publication mean, as compared with both associate and assistant professors [articles in Italian journals, $F(2, 510) = 8.74$, $p = 0.001$, $\eta^2 = 0.033$; articles in international jour-

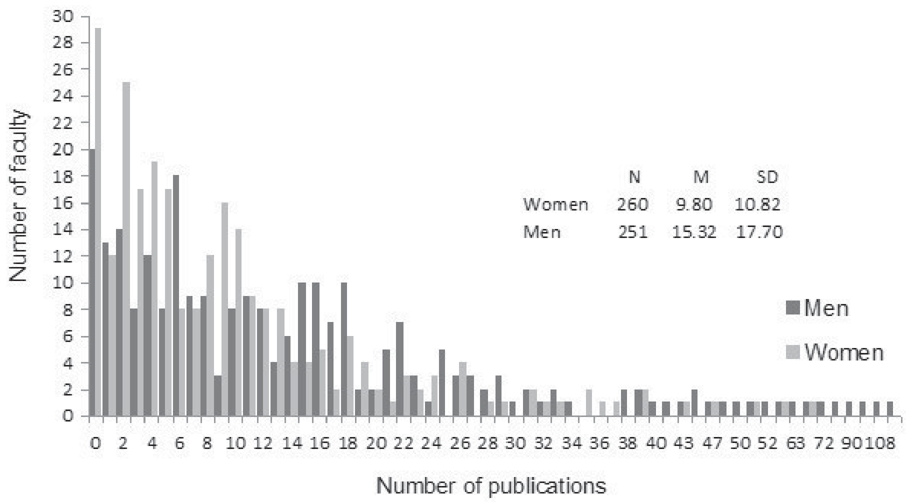

FIG. 1: Frequency distribution of total publications by women and men

nals, $F(2, 510) = 5.13$, $p = 0.006$, $\eta^2 = 0.020$; books with national publishers, $F(2, 510) = 14.57$, $p = 0.001$, $\eta^2 = 0.055$; and books with international publishers, $F(2, 510) = 10.54$, $p = 0.001$, $\eta^2 = 0.040$ (see Table 2). No significant interactions were found for publication type.

4.1.3 Publication Output by Subfield

A 2 x 8 (sex of faculty by subfield) factorial ANOVA on total publications yielded a significant main effect of the sex of the faculty, $F(1, 502) = 10.39$, $p = 0.001$, $\eta^2 = 0.021$, indicating that men had a higher average number of publications than women (see Table 3). A significant main effect of subfield also emerged, $F(7, 502) = 5.48$, $p = 0.001$, $\eta^2 = 0.073$. Bonferroni's post-hoc comparisons revealed that psychobiologists published at higher rates than faculty in other subfields.

Additional analyses were conducted for the subfields of developmental and social psychology, where women represented a majority of the faculty, as well as for subfields of psychobiology and methodology, where men were the majority. In subfields where women were a majority, women and men had a similar average number of publications. In one male-dominated subfield, methodology, men and women also had a similar average number of publications, whereas in the other male-dominated subfield, psychobiology, men had significantly more publications on average than women, $F(1, 75) = 4.72$, $p = 0.033$, $\eta^2 = 0.060$.

4.1.4 Publication Output by Authorship

To examine women's and men's patterns of authorship, we distinguished sole-authored versus multi-authored publications. For multi-authored publications we separated those

TABLE 2: Women's and men's publication types by academic rank

	Professor rank					
	Assistant		Associate		Full	
Publications	**Female (N = 115) M (SD)**	**Male (N = 60) M (SD)**	**Female (N = 81) M (SD)**	**Male (N = 77) M (SD)**	**Female (N = 64) M (SD)**	**Male (N = 114) M (SD)**
Articles						
Italian	2.48 (3.58)	2.25 (3.65)	2.47 (4.21)	2.99 (4.63)	4.72 (6.62)	4.13 (5.37)
English	3.43 (4.85)	8.13 (18.16)	4.69 (6.95)	7.97 (11.62)	8.33 (12.41)	11.23 (15.94)
Books						
Italian	1.07 (1.89)	1.13 (1.88)	1.20 (2.00)	1.58 (2.81)	2.59 (3.30)	2.89 (4.28)
English	0.11 (0.77)	0.13 (0.60)	0.22 (0.52)	0.27 (0.70)	0.53 (1.19)	0.70 (1.55)
Total	7.10 (7.59)	11.65 (18.88)	8.58 (8.96)	12.82 (12.64)	16.17 (14.77)	18.95 (19.36)

N = number of faculty members; M = mean; SD = standard deviation.

with foreign collaborators from those with Italian collaborators. We first evaluated whether co-authorship varied according to the sex of faculty and the rank. As to the overall number of co-authored publications, a 2 x 3 (sex of faculty by rank) factorial ANOVA yielded a significant main effect of the sex of faculty, $F(1, 510) = 5.31$, $p = 0.02$, $\eta^2 = 0.010$, indicating that men had a significantly higher average number of co-authored publications than did women. In addition, a significant main effect of rank emerged, $F(1, 510) = 5.48$, $p = 0.001$, $\eta^2 = 0.044$. Bonferroni's post-hoc analyses indicated that full professors had a higher average number of co-authored publications than both associate and assistant professors (see Table 4).

We also evaluated whether there was variation in publication productivity associated with national versus international collaborations. The findings for publications with international co-authors were similar to the findings for publications with co-authors in general. Men had a significantly higher mean number of publications with international co-authors than women [$F(1, 510) = 11.97$, $p = 0.001$, $\eta^2 = 0.023$], and full professors had a higher average number of publications with international co-authors than faculty in the lower ranks [$F(2, 510) = 4.88$, $p = 0.008$, $\eta^2 = 0.019$] (see Table 4).

Bridging subfield and co-authorship, we explored types of co-authorship by women and men in each of the eight subfields. Table 5 shows the distribution of women and men by subfield, classified into three groupings of co-authorship (all co-authored publications as well as international/non-Italian and national/Italian co-authored publications). Psychobiologists engaged in the highest rates of collaboration, exceeding all other subfields psychologists in overall [$F(7, 501) = 10.18$, $p = 0.001$, $\eta^2 = 0.126$], international [$F(7, 501) = 11.76$, $p = 0.001$, $\eta^2 = 0.148$], and nationally co-authored publications [$F(7, 501) = 5.84$, $p = 0.001$, $\eta^2 = 0.078$], whereas educational psychologists engaged in the lowest amount of co-authored publications.

TABLE 3: Women's and men's publications by subfields

	Faculty		Total publications	
Subfield	**Sex**	**Number**	**Mean**	**Standard deviation**
Experimental	Female	45	8.04	9.21
	Male	45	16.24	20.51
	Total	90	12.14	16.34
Psychobiology	Female	28	15.75	11.97
	Male	48	24.56	19.39
	Total	76	21.32	17.48
Methodology	Female	15	8.33	8.65
	Male	25	14.36	20.29
	Total	40	12.10	16.99
Developmental	Female	48	12.73	12.54
	Male	14	12.14	10.93
	Total	62	12.60	12.11
Social	Female	37	10.43	9.12
	Male	18	14.94	10.07
	Total	55	11.91	9.59
Organizational	Female	11	9.73	11.27
	Male	17	11.12	7.60
	Total	28	10.57	9.04
Clinical	Female	51	7.08	8.10
	Male	57	13.58	18.56
	Total	108	10.51	14.88
Educational	Female	22	3.73	4.45
	Male	21	5.48	7.10
	Total	43	4.58	5.89
Total	Female	257	9.63	10.23
	Male	245	15.45	17.80
	Total	502	12.47	14.71

4.1.5 Publication Output by Department Size

A significant main effect of department size was found [$F(2, 509) = 3.80$, $p = 0.023$, $\eta^2 = 0.015$], with professors in small departments having higher publication productivity ($M = 15.36$, SD = 17.92) than professors in either medium ($M = 13.87$, SD = 17.43) or large departments (M = 10.89, SD = 11.86).

A multiple regression (method ENTER) on overall publication productivity showed that the sex of faculty was a significant predictor of publication rates, accounting for 14% of the variance ($\beta = 0.141$, $t = 3.18$, $p = 0.002$), after controlling for academic rank, which explained 21% of the variance ($\beta = 0.207$, $t = 4.76$, $p = 0.001$), with subfields explaining 17% of the variance ($\beta = 0.175$, $t = 4.14$, $p = 0.001$), and department size accounting for 9% of the variance [($\beta = 0.089$, $t = 2.11$, $p = 0.035$), $F(4, 500) = 17.54$, $p = 0.001$, $R^2 = 0.12$, adjusted $R^2 = 0.11$].

TABLE 4: Women's and men's authorship by academic rank

	Faculty		Type of publication			
Rank	**Sex**	**Number**	**Co-authored *M* (SD)**	**Italian co-authored *M* (SD)**	**International co-authored *M* (SD)**	**Single author *M* (SD)**
Assistant	Female	115	6.02 (6.79)	5.28 (6.13)	0.74 (1.78)	1.08 (1.80)
	Male	60	9.25 (16.03)	6.97 (12.11)	2.28 (4.61)	2.40 (4.22)
	Total	175	7.13 (10.94)	5.86 (8.66)	1.27 (3.14)	1.53 (2.92)
Associate	Female	81	6.64 (6.90)	5.78 (6.18)	0.86 (2.05)	1.94 (3.61)
	Male	77	10.38 (12.34)	8.38 (10.55)	2.00 (3.12)	2.44 (3.79)
	Total	158	8.46 (10.07)	7.04 (8.67)	1.42 (2.68)	2.18 (3.69)
Full	Female	64	13.41 (13.72)	11.22 (11.15)	2.19 (4.09)	2.77 (3.26)
	Male	114	14.41 (17.07)	11.50 (13.87)	2.91 (4.95)	4.54 (5.68)
	Total	178	14.05 (15.91)	11.40 (12.93)	2.65 (4.66)	3.90 (5.01)
Total	Female	260	8.03 (9.50)	6.90 (8.05)	1.13 (2.67)	1.76 (2.91)
	Male	251	11.94 (15.62)	9.46 (12.62)	2.48 (4.38)	3.38 (4.92)
	Total	511	9.95 (13.01)	8.15 (10.61)	1.80 (3.67)	2.56 (4.10)

M = mean; SD = standard deviation.

4.2 Women's and Men's Publication Impact

Of the 462 professors who had publications between 1998 and 2004, 17 did not have any citations. For the remaining 445 professors, the *h* values ranged from 0 to 28 ($M = 5.05$, SD = 4.65), the *hi* index ranged from 0 to 9.59 ($M = 1.91$, SD = 1.43), and the AWCR values ranged between 0 and 331.92 ($M = 19.15$, SD = 38.72). A series of 2 x 3 (sex of faculty by rank) factorial ANOVA's for the three indices was performed. As shown in Table 6, the average citation values for female faculty were significantly lower than those of the male faculty, with the exception of the AWCR, where there was only a trend favoring men. Table 6 also shows the main effects of these ANOVA's on the *h*-index [$F(1, 462) = 5.25$, $p = 0.022$, $\eta^2 = 0.011$], the *hi*-index [$F(1, 462) = 10$, $p = 0.002$, $\eta^2 = 0.021$], and the AWCR [$F(1, 462) = 3.98$, $p = 0.059$, $\eta^2 = 0.005$]. Moreover, the main effect of rank indicated that full professors had an *h*-index significantly higher than those of both associate and assistant professors [$F(1, 462) = 12.38$, $p = 0.001$, $\eta^2 = 0.052$]. Similar results were found in the cases of both the *hi*-index [$F(1, 462) = 19.13$, $p = 0.001$, $\eta^2 = 0.077$] and AWCR [$F(2, 462) = 9.80$, $p = 0.001$, $\eta^2 = 0.041$]. No significant interaction of the sex of the faculty by rank was found.

Due to field differences in citation values (likely because of variability in publication and citation practices), the subfield variable was not introduced in analyses of citation indices. We did, however, explore women's and men's *h*-indices for subfields in which

TABLE 5: Women's and men's co-authorship by psychology subfield

Subfield	Sex of faculty	Publication type: Co-authored *M* (SD)	Publication type: Italian co-authors *M* (SD)	Publication type: International co-authors *M* (SD)
Experimental	Female	6.89 (8.67)	6.18 (8.13)	0.71 (1.55)
	Male	12.53 (17.16)	10.27 (14.07)	2.27 (3.93)
	Total	9.71 (13.81)	8.22 (11.61)	1.49 (3.07)
Psychobiology	Female	14.68 (10.90)	11.00 (8.13)	3.68 (5.41)
	Male	22.35 (17.18)	16.15 (14.74)	6.21 (5.85)
	Total	19.53 (15.54)	14.25 (12.73)	5.28 (5.78)
Methodology	Female	7.87 (8.53)	7.33 (7.68)	0.53 (1.55)
	Male	11.20 (18.54)	9.12 (14.30)	2.08 (4.86)
	Total	9.95 (15.50)	8.45 (12.16)	1.50 (3.99)
Developmental	Female	9.63 (9.08)	8.33 (8.13)	1.29 (2.40)
	Male	8.79 (8.88)	6.57 (6.17)	2.21 (3.42)
	Total	9.44 (8.97)	7.94 (7.72)	1.50 (2.66)
Social	Female	8.16 (7.30)	7.22 (6.51)	0.95 (1.87)
	Male	10.33 (6.76)	7.72 (6.58)	2.61 (3.18)
	Total	8.87 (7.14)	7.38 (6.47)	1.49 (2.48)
Organizational	Female	6.64 (8.85)	5.27 (6.74)	1.36 (2.69)
	Male	7.06 (5.62)	6.94 (5.60)	0.12 (0.33)
	Total	6.89 (6.91)	6.29 (6.01)	0.61 (1.77)
Clinical	Female	5.78 (7.60)	5.37 (7.22)	0.41 (1.02)
	Male	9.58 (16.02)	8.23 (13.07)	1.35 (3.31)
	Total	7.79 (12.84)	6.88 (10.76)	0.91 (2.54)
Educational	Female	5.09 (3.41)	1.82 (2.84)	0.27 (0.77)
	Male	2.52 (3.94)	2.00 (2.65)	0.52 (1.75)
	Total	2.30 (3.64)	1.91 (2.72)	0.40 (1.33)
Total	Female	7.85 (8.77)	6.75 (7.50)	1.10 (2.58)
	Male	12.02 (15.69)	9.49 (12.64)	2.53 (4.42)
	Total	9.88 (12.79)	8.09 (10.41)	1.80 (3.67)

M = mean; SD = standard deviation.

TABLE 6: Women's and men's citation indices by academic rank

Rank	Sex of Faculty	*h-Index* *M* (SD)	*hi-Index* *M* (SD)	*AWCR* *M* (SD)
Assistant	Female	3.28 (2.38)	1.21 (0.83)	8.12 (14.34)
	Male	4.66 (4.87)	1.77 (1.54)	17.29 (34.48)
Associate	Female	4.15 (3.05)	1.61 (0.97)	11.21 (17.16)
	Male	5.11 (4.11)	1.94 (1.23)	16.04 (21.57)
Full	Female	6.16 (5.48)	2.26 (1.41)	26.28 (49.54)
	Male	6.78 (5.94)	2.60 (1.80)	33.34 (58.65)
Total	Female	4.33 (3.82)	1.62 (1.13)	13.96 (29.76)
	Male	5.77 (5.26)	2.20 (1.62)	24.34 (45.45)

M = mean; SD = standard deviation.

women were more numerous than men and found no statistically significant differences (developmental: $M = 4.21$ and $M = 3.57$; social: $M = 4.14$ and $M = 5.53$, for women and men, respectively). We also found that women's and men's *h*-indices were similar in subfields with more men than women (psychobiology: $M = 8.25$ and $M = 10.65$; methodology: $M = 4.38$ and $M = 4.39$, for women and men, respectively) (see Table 7).

Finally, we examined the relationship between co-authorship and the *h*-index. In this study, the correlation between the *h*-index and co-authored publications showed a greater association with publications with four co-authors ($r = 75$, $p = 0.01$) than with those with one co-author ($r = 47$, $p = 0.01$).

5. DISCUSSION

The present study examined the publication and citation rates of female and male academic psychologists in Italy, a country with a strong female representation in academia, relative to other European countries, and especially in psychology. At the time of the study, women represented 67% of assistant professors, 49% of associate professors, and 37% of full professors in Italy's 11 psychology departments. Female professors were significantly younger than male professors, although when rank was considered, the age difference was no longer statistically significant.

Consistent with previous studies' findings (Noordenbos, 1992; Tien and Blackburn, 1996; Byrnes and McNamara, 2001; Long, 2001; Nakhaie, 2002; Sax et al., 2002; Aaltojärvi et al., 2008; Malouff et al., 2010; McNally, 2010), this study found that rank was the best predictor of publication output and impact, with full professors having the highest publication and citation rates. Specifically, full professors had more publications, especially in international venues. They also had more co-authored publications, including publications with foreign co-authors. Furthermore, the citation values of full professors were higher than the citation values of lower rank professors. These findings confirm the advantage of full professors with regard to productivity and visibility, an advantage

TABLE 7: Women's and men's citation indices by selected psychology subfield

Subfield	Faculty		*h-Index*	*hi-Index*	*AWCR*
	Sex	**Number**	***M* (SD)**	***M* (SD)**	***M* (SD)**
Psychobiology	Female	28	8.25 (5.75)	2.27 (1.44)	42.80 (62.23)
	Male	46	10.65 (6.28)	2.89 (1.71)	59.94 (65.65)
	Total	74	9.74 (6.16)	2.66 (1.63)	53.46 (64.49)
Methodology	Female	13	4.38 (4.31)	1.35 (1.09)	14.81 (24.95)
	Male	23	4.39 (4.20)	1.94 (1.80)	13.62 (26.69)
	Total	36	4.39 (4.18)	1.73 (1.59)	14.05 (25.72)
Developmental	Female	47	4.21 (2.80)	1.70 (1.01)	10.68 (12.74)
	Male	14	3.57 (2.71)	1.60 (1.17)	9.83 (12.42)
	Total	61	4.07 (2.77)	1.68 (1.04)	10.48 (12.57)
Social	Female	35	4.14 (3.03)	1.78 (1.24)	9.20 (12.28)
	Male	17	5.53 (3.00)	2.49 (1.31)	14.94 (13.84)
	Total	52	4.60 (3.06)	2.01 (1.30)	11.08 (12.96)

M=mean and SD=standard deviation.

likely the result of full professors' significant access to resources and networks that matter for publication output and impact.

In this study, rank reduced—but did not quite flatten—women's and men's differences in publication productivity and impact, as was the trend in some previous studies (e.g., Stack, 2004; Joy, 2006). In other words, men had significantly higher publication and citation rates than women even when rank was taken into consideration. For example, men had more publications, more co-authored publications, and more publications involving foreign co-authors. However, women and men published at similar rates in Italian outlets and in subfields where women were the majority. With regard to impact, men had significantly higher impact values across citation indices, except in the AWCR, an index adjusted for the publication's age. However, men's citation advantage was not uniform across subfields, with women and men having similar *h*-index citation rates in social and developmental psychology (where women represented a majority of faculty) as well as in psychobiology and methodology (where women were a minority).

In this study, as in several other studies (e.g., Prpić, 2002; Kyvik, 2003; Fox, 2005; Joy, 2006), a few individuals accounted for most of the publications. At the same time, even the most productive women published less than the most productive men. Furthermore, the proportion of women, relative to the proportion of men, was smaller as the number of publications rose. In this study, the difference between women's and men's productivity was concentrated at the positive extreme of the distribution, rather than both extremes, as was the case, for example, in Fox's study. In other words, in our study, women were less numerous among the super-publishers but were not more represented among the nonpublishers.

Finally, in this study department size was a predictor of productivity. In the case of psychology in Italy, being in a small department was associated with greater publication productivity than being in a medium or in a large department. Our findings add to the diversity of findings regarding the role of department size on productivity (Kyvik, 1995; Dundar and Lewis, 1998). This diversity points to the importance of considering the local dynamics of variables such as department size.

The general trends as well as the unique nuances in our findings reinforce the importance of examining research productivity and visibility in light of institutional and cultural variables. Specifically, in our study, as in previous studies (e.g., Prpić, 2002; Leta and Lewison, 2003; Joy, 2006), whether women or men differ in terms of productivity and visibility, and the direction of the differences, varied depending on context and field.

Our findings should be interpreted in light of the strengths and weaknesses of our method. Among the limitations are our use of an international publication database and of international citation indices to measure productivity and impact by Italian scientists; and our focus on one scientific field, psychology. It is possible that our data sources might have selectively under-recorded women's research productivity and impact because more of women's work appeared in Italian outlets and may, therefore, not have been included in our study's international citation indices. There is also the issue of a possible gender bias in citation rates because of the correlation between citation rates and publication rates (Symonds et al., 2006; Jiménez-Rodrigo et al., 2008). Furthermore, there are questions of generalizability. Future research is necessary to establish whether our findings apply exclusively to psychology or generalize to other disciplines in Italy and beyond. Among the strengths of our study is the use of publicly available databases. This method avoids the self-selection problems associated with survey methods (e.g., Boice et al., 1985) and supports replication. At the same time, in future studies, public database accuracy could be verified and possibly improved via use of other data sources. Another methodological asset of our study is its national sample. This feature brought comprehensiveness to our analyses. By contrast, as noted by Long and Fox (1995), many studies of productivity and impact are based on elite university samples (e.g., McNally, 2010).

We acknowledge that our observations are descriptive and about a limited range of structural variables. Thus, we may only speculate on the range of factors and processes likely responsible for the patterns we recorded. Based on our data, seniority is likely a factor in Italian women's generally lower publication and citation rates. Women have only recently joined the academic world in significant numbers. Thus, they are not only underrepresented in the higher ranks. They are also the more recent members of the higher ranks—a situation that likely depresses their publication and citation rates because of the roles that seniority and established networks play in facilitating publication output and visibility. The fact that women in this study were less likely than men to have international co-authors and to publish in international journals suggests that women may have more difficulties than men in cultivating international connections—perhaps related to their lesser mobility, given typical gendered patterns of family labor. The role of international contacts in productivity was highlighted in a Croatian study showing that the best predictor (explaining 51% of the variance) of women's lower scientific productivity was their lower participation at international scientific conferences abroad (Prpić, 2002). In reviewing our and other studies' findings, one is struck as much by the discrepancies and the surprises as by the commonalities and the confirmed trends. Among the surprises in this study's was the fact that in psychobiology, women represented a minority of faculty and contributed a minority of publications but had similar citation rates. Peculiarities and apparent contradictions within and between studies' results call for more fine-tuned research using a diversity of predictors and measures of productivity and visibility.

In conclusion, rank and seniority appear important in Italian academic psychologists' publication and citation patterns, with smaller but significant sex of faculty effects. The fact that in this study women's citation rates were similar to those of men when age of publication was taken into consideration suggests that seniority may be a critical factor in Italian female academic psychologists' current lower productivity and visibility patterns. Future studies are needed to further explore the expected and unexpected patterns observed in this study, and in other studies. As noted by Prpić (2002), psychological research indicates that the smaller productivity of female scientists is socially driven because there is no indication that women and men differ in intellectual abilities. Therefore, explanations for women's and men's "differences in scientific productivity should be sought in the organization of science where, just as in society in general, hidden or (more rarely) open mechanisms of discrimination may exist" (Prpić, 2002, p. 49).

This study addresses a gap in the empirical literature given the very limited research on Italian female scientists. Together with the contribution of similar research, this study's findings highlight the importance of examining scientific productivity and visibility in context and over time.

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