

Advancing Women In Leadership

Context Factors Related to Women Attrition From a Graduate Science Program: A Case Study

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These advisors had little awareness of the high student attrition rate in their department (especially female), or of the reasons that led many to leave before completing their degree.

Introduction

Seeing that the average brain-weight of women is about five ounces less than that of men, on merely anatomical grounds we should be prepared to expect a marked inferiority of intellectual power in the former. (Romanes, 1887, p. 383)

Arguments such as this one, seeking to bar women's access to higher education, were still common in the popular science press by the end of the 19th century. Yet, in this unwelcoming climate, many women made important contributions to science (Rossiter, 1974). Some of them, Jane Colden (1724-1766), Maria Mitchell (1818-1889), and Mary Somerville (1780-1872), were mostly self-taught or learned science while helping their scientist fathers (Rossiter, 1974). However, many at the time dismissed these early women scientists as aberrations as illustrated by an article in an 1887 issue of The Popular Science Monthly:

The savante - the woman of science - like the female athlete, is simply an anomaly, an exceptional being, holding a position more or less intermediate between the two sexes. In the one case the brain, as in the other the muscular system has undergone an abnormal development. (p. 205)

Although women have since secured access to all scientific fields, their representation in many areas continues to lag behind their male counterparts. In 2000, American universities awarded to women only 15.8% of the PhDs. in engineering, 24.2% in the physical sciences, and 46.9% in the life sciences (National Opinion Research Center, 2001). Women's representation was even lower in some sub-

disciplines in the aforementioned areas. For example, within physical sciences women earned only 14.7% of the Ph.D.s. in physics and astronomy and 16.5% of the Ph.D.s. in computer science (National Opinion Research Center, 2001).

The Ph.D. thesis in science is primarily an apprenticeship in research (Conefrey, 2000; Holloway, 1993; Widnall, 1988). During this period, students spend large periods of time in a laboratory setting sharing space and equipment with colleagues and research advisor. According to Conefrey (2000), “participating in a laboratory is crucial to succeeding in science because it socializes novice scientists into what is valued by their laboratory and by the larger community of scientists to which they aspire to belong” (p. 253). Thus, graduate students’ experiences “are strongly influenced by their department’s cultures” (National Science Foundation (NSF), 1998, p. 4). Every Ph.D. granting department in a university can set its own policies for recruitment, admission, and curriculum requirements (Hirt & Muffo, 1998; Office of Scientific and Engineering Personnel (OSEP), 1996). Quantitative studies on graduate student attrition indicate that the department is the best unit of analysis when predicting graduate student completion rates (Berg & Ferber, 1983; Ott & Markewich, 1985, as cited in Girves & Wemmerus, 1988).

According to Hirt and Muffo (1998), “departments are guided not by institutional standards but by the norms of the discipline, which in turn influence the climate for graduate students” (p. 18). Although women have become increasingly visible in scientific areas, Eisenhart (1994) contends that the norms of science continue to be “prototypically male” (p. 193). These norms are expressed in the pedagogical practices, which best meet male students’ needs (Lipson & Tobias, 1991; Seymour & Hewitt, 1994); in the communication styles, as those practiced in the science lab (Conefrey, 2000); and in the overall construction of scientific knowledge (Eisenhart, 1994; Harding, 1991; Keller, 1985; Sonnert, 1995; 1996; Subramaniam & Wyer, 1998). All these features of the culture of science interact resulting in a climate that has been “chilly” for women scientists and students (Dresselhaus, Franz, & Clark, 1995; Hall & Sandler, 1982; Meinholt & Murray, 1999; Sandler, 1986; Sonnert, 1995, 1996).

Much of the research on the gender gap in science and engineering has focused on the reasons for females’ lack of interest and achievement in science. Although investigators (Hall & Sandler, 1982; Meinholt & Murray, 1999; Sandler, 1986; Sandler, Silverberg, & Hall, 1996) have uncovered some context factors that contribute to female attrition from undergraduate science programs, few studies have examined, in a comprehensive manner, female attrition in science at the graduate level. Golde (1998) contends that, “to understand doctoral-student attrition, we must critically examine the role of discipline and program in shaping student experiences” (p. 55). The authors of a recent National Science Foundation report on graduate student attrition voice this concern and call for more qualitative or contextual studies at the department and program level.

In the study reported here, qualitative and quantitative data were used to examine the extent to which the social climate in a chemistry department, as shaped by the students’ relationship with colleagues and research advisor, contributed to the differential attrition rate of female and male students in the doctoral program.

Method

A case study approach was used in the design of this study. According to Merriam (1988), “A case study is an examination of a specific phenomenon such as a program, an event, a person, a process, an institution, or a social group” (p. 9). The “case” consisted of a graduate science department (chemistry) at a large research university.

Setting

The study took place in a chemistry department at a large research university in the Midwest. The department offered only Ph.D.s in all the major areas of chemistry, from biochemistry to physical chemistry. However, students who decided to leave before completing their Ph.D. were given a Master's Degree if their work was deemed of adequate quality. The student's research advisor controlled this decision, solely. The doctoral program was primarily based on research. Incoming graduate students were funded for a period of five years in the form of research fellowships and/or teaching. Students usually taught the first year and received research assistantships after joining a research lab. At the time of the study, the department had 34 faculty members, all male, 74% of them at the rank of full professor. Of the 186 graduate students 30% were female.

Sample

Results were based on survey responses from 84 graduate students (31 females and 53 males) and semi-structured interviews with 16 students (8 females and 8 males). Five of the students interviewed (4 females and 1 male) had left the program before completing their degree. The selection of students for the interviews was done to insure a "representative sample" in regards to gender, self-confidence level, and intention to leave the program (LeCompte & Preissle, 1993). Six faculty members were also interviewed.

Data Collection

Data were collected through a 5-point Likert-type scale survey questionnaire, interviews with students and faculty, and department records. Students' perspectives on their work environment, as shaped by their colleagues and research advisor, were based on 27 items on the survey and semi-structured interviews. Thirteen of the items on the survey were used to assess students' perceptions of their relationship with their colleagues (female and male). Sample items included, "In my lab there is a lot of collaboration between my female and male colleagues" and "I feel welcome to ask for help from my female/male colleagues" (see [Table 4](#)). Item 8 in [Table 4](#) examined students' overall satisfaction with their working conditions. Eleven additional items were used to examine students' perception of their relationship with their advisor. Items included, "My advisor is often available for advice and/or support" and "My advisor has equal expectations for her/his female and male students." Another item "The level of mentoring in my department is very high," was used to assess students' perception of the level of mentoring in their department (see [Table 5](#)). Two other items, one examining students' intention to leave the program, and another students' perception of their ability to handle the work required for their degree were also part of the survey (see [Table 3](#)). Responses to the items on the survey were rated on a 1 (Strongly Disagree) to 5 (Strongly Agree) scale, with a midpoint defined as "Undecided." Each survey item included space for student comments. The alpha reliability coefficient for the 27 items on the survey was .84.

Demographic items in the survey included students' major, ethnicity, gender, and marital status. Students were also asked to report the average number of hours (per week) that they spent conducting research in the lab, and to rate their self-confidence level at two points in their program -- when entering graduate school and at the time of the study. The scale ranged from 1 (Very Low) to 5 (Very High), with a midpoint defined as "Moderate." Department records were used to determine faculty and student composition of the department, student undergraduate and graduate GPA, and the student attrition rate (female and male) over a nine-year period.

The semi-structured interviews were conducted after the surveys had been returned and were used to explore, more in-depth, some of the issues uncovered in the survey, including possible reasons for student attrition. Interviews with faculty focused on questions aimed at assessing their awareness of the student attrition rate (female and male), and their perspectives on possible reasons that might cause students to leave the program. The interviews were audiotaped and took between 30 and 60 minutes each.

Data Analyses

Independent sample t tests were used to identify significant gender differences in student responses to the survey items, students' undergraduate and graduate GPA, the weekly number of hours spent in the lab conducting research, and self-confidence level when entering graduate school and at the time of the study. A chi-square test was used to determine significant gender differences in the student attrition rate. Statistical significance was set at an alpha level of .05.

The transcripts of the faculty and student interviews and of student comments to the items on the survey were analyzed using the techniques of naturalistic inquiry (Lincoln & Guba, 1985; Miles & Huberman, 1994). After the interview tapes were transcribed verbatim and students' comments to the survey questions copied, a text-based coding was used (Miles & Huberman, 1994). As each transcript was read several times, one- or two-word codes were attached to each segment of the data. Similar codes were grouped together and organized into broader themes.

Results

As results in [Table 1](#) indicate, both female and male students entered graduate school with similar undergraduate grade point average and self-confidence. However, even though no gender differences were found in student graduate point average and number of hours spent doing research in the lab, the female students reported a significantly lower self-confidence level at the time of the study $t(83) = -2.63$, $p = .01$.

The drop in female students' self-confidence was also reflected in their consideration to leave the program (Item 1 in [Table 3](#)) and attrition rate ([Table 2](#)). The student attrition rate was determined by counting any student who had left without a degree or with a degree different from the one originally sought. Students who had been accepted to the Ph.D. program but later changed to a Master's Degree were included in the computation of the attrition rate. This method was consistent with the literature (NSF, 1998; OSEP, 1996). The attrition rate for female students, for each entering cohort over a nine-year period, averaged 45%, while the attrition rate for males, for the same time period, averaged 30%. These differences were statistically significant, $X^2(1, N = 433) = 8.90$, $p = .003$ (see [Table 2](#)). Yet, no gender differences were found in students' response to one of the survey items examining their perception of their ability to handle the work required for their degree (Item 2 in [Table 3](#)). Thus, female students' drop in self-confidence ([Table 1](#)), their high attrition rate ([Table 2](#)), or their consideration to leave the program (Item 1 in [Table 3](#)) could not be related to their low academic performance (given their high graduate GPA), or perception of their inability to handle the work required for their degree.

Student Relationship with Colleagues

Because of the large number of hours spent in the research lab, the social climate for the students in this study was shaped, mainly, by their relationship with colleagues and advisor. Research indicates that colleagues and advisor are key agents in the socialization of new graduate students into a discipline (Baird, 1992; Girves & Wemmerus, 1988; Lovitts, 1996). According to Girves and Wemmerus (1988), "The frequency and quality of student/faculty interactions appear to be important predictors of retention for men, whereas both student/faculty and peer interactions are important predictors of retention for women" (p. 164).

Analysis of the data uncovered significant gender differences in students' perception of their relationship with colleagues. As results in [Table 4](#) show, the female students were less likely to agree that their comments were taken seriously by their male or female colleagues (statements 3a and 3b); that their male colleagues asked for their opinion or help (statement 4a); that they felt welcome to ask for help from their

male colleagues (statement 5b); that they often discussed science with their male colleagues (statement 6b); and that they often socialized with their male colleagues (statement 7b). The female students were also less likely to agree that they were happy with their working conditions (Item 8 in [Table 4](#)).

Lack of Collegiality

The lack of collegiality identified in the survey was also reflected in student comments during the interviews. According to a female student, in her department “each group does their own thing. There are no interdepartmental collaborations at all.” Another female student described the environment in her laboratory as “A very independent sort of, ‘you do your own thing.’” When asked if she interacted with other female students, she replied: “Not really. The other girls that entered, particularly in my area, are at the other end of the hall.”

The lack of collegiality in most laboratories and in the department as a whole, contributed to a sense of isolation particularly among female students. The absence of female faculty members and limited number of female students in most laboratories added to female students’ sense of isolation, especially in laboratories where female attrition was high. A female student described the lack of female faculty as having “no one to look up to.” Another female student commented on the impact that the high attrition of female students had on her: “All around me women are leaving with their Master’s Degree. And they are all my friends, and I see what they’re going through, and it’s very discouraging.”

Competition

Data from the interviews suggested that the social climate in the chemistry department was best characterized as competitive. A female student described the environment in her department as “very competitive.” Another one pointed out that “competitiveness comes where you do what it takes to get ahead without regard for other people.” Some of the male students also commented on the competitive environment of their department and laboratories. One of them described the environment in his department as a “cut-throat atmosphere.” According to another male student the environment in his lab was “a highly competitive environment where you are constantly asked to prove yourself.” Still another one pointed out that the high work demands created an environment that was “incredibly uptight and competitive.”

Student Relationship with Advisor

As results in [Table 5](#) indicate, the female students also had a more negative perception of their relationship with their advisor than did their male counterparts. The female students were less likely to agree that they had learned a lot from their advisor (statement 4); that their advisor had the same expectations for them as for their male colleagues (statement 5b); that their advisor asked for the opinion of his female students even when male students were present (statement 6a); and that their advisor knew how to deal well with his female students (statement 7b). The female students were also much less likely to agree that the level of mentoring in their department was very high (statement 8).

Analysis of the interview data suggested that the advisor played a major role in the sort of social climate that existed in the research lab. Furthermore, because of the large number of hours that students spent conducting research in the lab and the lack of collegiality that existed in the department, the environment that existed in the lab was the main lens through which students evaluated their experiences in graduate school.

Mentoring

Research on mentoring indicates that students who have a mentoring relationship with their advisors feel

professionally affirmed and are more productive after graduation (Heinrich, 1991; Subotnik & Arnold, 1995). Successful scientists, especially women, consistently report on the important role that their advisors play in their careers (Davis, 1999; Jacks, Chubin, Porter & Connolly, 1983; Sonnert & Holton, 1996).

As illustrated by female students' response to statement 8 in [Table 5](#), most of them did not feel the level of mentoring in their department was very high. Conversations with students during the interviews also indicated that few of the advisors used a mentoring approach in their relationship with their students. Indeed, students referred to their advisor as my/our "boss." This perception was due to the organization of the research lab, which resembled to a great extent a small research enterprise. Incoming graduate students became part of a research team when they joined a lab. The research projects were financed by grants secured by the advisor. The advisor provided financial support to the students who in turn performed the work necessary to the success of the project. According to a male student,

It's sort of a bargain, and the bargain is that you go in, they give you a project to do because, of course, they need to get this research done for their own purposes. You fulfill your part of the bargain by doing this research for three or four years and you get a Ph.D. The advisor will then get a number of papers from that to then be able to secure more grant money to continue another research project.

Indeed, students reported working between 40-65 hours per week doing research in the lab and advisors expected, and many demanded, this level of commitment as illustrated in the comments from a male student:

I feel that periodically I'm expected to prove to my advisor that I'm doing research. And in that sense then, it's much like an employee-boss relationship where you have to prove to your boss that you're worthwhile or else, you know, maybe you won't be around much longer.

Some laboratories resembled small enterprises with as many as 25 students and a few post-doctoral fellows. In these labs most of the advisor's effort was spent securing funds and in finding efficient ways of running the operation. This in turn created a social climate in the research lab and department characterized by a narrow focus, competition, and focus on fast results. According to a female student, her advisor "has used the term 'survival of the fittest,' and that's how he believes his lab should be run. That's how he believes the department should be run, 'survival of the fittest.'" Another female student described her advisor as running "his research groups so that we compete against each other. I'm competitive and I can compete against other people, but it's not really the type of atmosphere that I'm interested in."

The attitude of some advisors toward their female students also contributed to their sense of isolation as illustrated in the following quote from a female student who had left the program,

I felt that I was judged before I even had a chance to show what kind of scientist I was. For some reason I was judged negatively from the beginning. I don't understand why. I worked on a project by myself and I worked so hard to try to learn and understand everything. Why does my advisor have favorites? I would force my advisor to say hello to me in the hall, and he would barely do that. But right after that he would stop and talk to someone else, a guy, about drinking or skiing.

A male student who had also left described another such advisor:

I knew at least another professor who was terrible. He created a terrible environment for both

men and women students in the lab, but particularly for women, though he did not do it in an obvious manner. No woman had ever gotten a Ph.D. under him. He had a huge ego, although he had a good scientific mind. A friend of mine decided to leave before finishing. She hated him. I wasn't his student, but he even had a negative impact on me.

Another male student replied when asked why so many female students left the program:

There were probably thirteen graduate students in my subdiscipline when I came, half of them were female. I think two of them got Master's degrees and most left before or after their candidacy exams. All the female graduate students left before getting their Ph.D. I think it has to do with the fact that several of those students went to work in very large male dominated groups. I'm left with the conclusion that somehow the environment isn't friendly to women.

These results suggested that in some labs the advisor's excessive expectations created a competitive climate that led to student sense of isolation. Among the female students, this feeling of isolation was compounded by their small numbers in most laboratories, their advisor's lack of support, and the absence of female faculty in the department.

Faculty Members' Perspectives

When asked about the student attrition rate in their department, most of the faculty members interviewed provided much smaller figures than those computed in [Table 2](#). According to one of them, the student attrition rate was "about one third." Another faculty member responded that, "about 10% leave the first year and 20% leave with a Master's degree. Everyone else gets the Ph.D." In addition, most faculty members believed the attrition rate in their department was similar for female and male students. When asked whether the attrition rate for female was higher than that of male students one of the faculty members replied: "I certainly don't think so. The department has had an increasing number of females and we have certainly a good record of placing them well." Two other faculty members actually believed that student attrition rate was greater for male than female students. According to one of them:

A few years ago it was much higher for females. I was involved in gathering that information and was appalled by it. The reasons were always good, they decided to get married or other things, but I believe a graduate student recently looked into this and the attrition rate was lower for females than for males.

Another faculty member was of the same opinion. In fact, he was concerned about male students' seemingly alienation from science:

My concern is the traditional male that we used to have in science who used to think this was going to be a great career. He loved doing science, thought he would make good money, have a family and a house, etc., etc. That guy seems confused. He is not totally committed to this. It used to be that women would come into chemistry, find a guy, get married, and would quit. Now the women are staying and the male students seem to be drifting off.

In addition to lack of awareness about the higher attrition rate of female students, these two quotes also reflect a common belief among the faculty in the department that women left because of a significant other. Indeed, when asked why female students left, most of the faculty members provided similar reasons. According to one of them "Some students who leave are women. They choose to get married and leave graduate school." Another faculty member replied:

Women more than men want the balance of work and family. In most cases women realize

that they don't want to give up what they will have to give up for a job in chemistry. So half-way through they say, "the heck with it, I don't want it." Far too many women left with a Master's degree for that reason.

Two of the faculty members, however, did not believe marriage was the main reason for female attrition. According to them, students (female and male) left because "they are not up to it." Not being "up to it" signified that students either did not have the intellectual capability "they are essentially not smart enough," or did not possess the necessary motivation for the long hours of research essential to success in science:

They find how many hours a week they have to work in the lab; how many hours a day; that they have to do 2 or 3 things simultaneously, and while it is really nice around here because they have lots of friends to talk to, they aren't accomplishing anything themselves. They're just slowing down people around them.

The faculty members' lack of awareness of the student attrition rate, and their use of individual student characteristics as justifications for those who left, support Lovitts' (1996) contention that, "universities believe that the problem lies not with the graduate school and the dynamics of graduate education but with the students themselves" (p.1).

Discussion and Conclusion

According to Lovitts' (1996), "[graduate student] attrition has less to do with what the student brings to the university than with what happens to the student after s/he has been admitted" (p. 3). The results of this study support Lovitts' contention and illustrate the importance that context factors play in female student attrition from graduate science programs. In the department described here, female students' relationship with colleagues and advisor were the main context factors that contributed to student attrition. Furthermore, as the head of the lab, the advisor played the most important role in the development of the social climate that existed in the research lab. Unfortunately, many of the advisors in this study contributed to a climate characterized by competition and lack of collaboration.

Although this competitive environment might have contributed to male student attrition, it had the most negative impact on the female students, as illustrated by their loss of self-confidence and high attrition rate. Researchers contend that women tend to "shy away from very competitive projects more than their male counterparts" (Sonner & Holton, 1996, p. 68). According to Holloway (1993), "[Women] respond to a challenge better if the process of meeting it is framed as a collaboration rather than a competition" (p. 99).

The lack of collegiality in most labs and in the department as a whole, combined with the lack of support from their advisor, appeared to be contributing to a "null environment" for many female students in this chemistry department. Meinholt and Murray (1999), contend that the blatant sexism that exists in science has been substituted by a "null environment" characterized by the exclusion of women from informal interactions with peers and professors. Yet, according to Girves and Wemmerus (1988), "being treated as a junior colleague by the advisor accounts for much of the variability in degree progress" (p. 185). Similarly, Tinto (1993) contends that graduate student persistence in the last stage of their work is primarily the result of the student relationship with the advisor. This assertion is supported by research on graduate student success (Davis, 1999; Girves & Wemmerus, 1988; Golde, 1996; 1998; Hollenshead, Younce, & Wenzel, 1994; Jacks et al., 1983). Students, particularly females, who receive high levels of support from their advisors, are more likely to succeed in graduate school and persist to complete their degrees (Kluever, 1995; Lenz, 1995).

Davis (1999) points out that advisors in fields with few women need to show genuine interest in their female students' work and make an effort to help them feel welcome. Unfortunately, the data suggest that few of the advisors in this study provided such support to their female students. Indeed, one might argue that access to a Ph.D. in the chemistry department reported here was controlled by the students' advisors, all white males, most of them holding prestigious positions in the department and in the field. These advisors had little awareness of the high student attrition rate in their department (especially female), or of the reasons that led many to leave before completing their degree.

Researchers contend that many of the issues faced by graduate women in science are related to the lack of a "critical mass" of women students and professors (Dresselhaus et al., 1995; Meinholt & Murray, 1999). "Critical mass" is defined as "the discrete point at which the presence of a sufficient number brings about qualitative improvement in conditions and accelerates the dynamics of change" (Etzkowitz, Kemelgor, Neuschatz, Uzzi, & Alonso, 1994, p. 51). Researchers have found a direct relationship between the quality of the climate and the proportion of women faculty and students in a science department (Dresselhaus et al., 1995). Although 30% of the students in the department in this study were women, their subordinate status and isolation they experienced in their lab and department as a whole had little impact on the quality of their working environment. As Etzkowitz and others point out, "A modest increase in the number of women in science, without a change in the structure of the scientific workplace, creates a paradox of critical mass" (Etzkowitz et al., 1994, p. 51).

The lack of female faculty, who could serve as role models and mentors, added to the sense of isolation that many female students in this study experienced. Although research indicates that a mentor or role model does not necessarily need to be of the same race or sex as the protégé, seeing others of the same sex and/or race in positions of power and expertise helps affirm one's career aspirations (Astin & Astin, 1993; Janes, 1997; Kegel-Flom, 1995). The lack of female faculty in the department reported here was also an indication of the climate that existed in the department. As one of the female students pointed out:

I chose this department because it seemed to be the best academically. So I disregarded the fact that it didn't have female faculty. I should have paid attention to it because I really didn't realize what kind of indicator it was.

Women have made considerable strides in their quest for science. However, even though they no longer confront the open barriers faced by their foremothers, their full access to scientific knowledge continues to be challenged by those in power. To the women in this study,

Institutional barriers, sexism, and stereotyping in educational and professional contexts served as gatekeepers to these women as they sought to reach their potential in science and develop identities as fully participating and legitimate members of the science community. (Davis, 1999, p. 141)

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