12 The Graduate Experience of Women in STEM and How It Could Be Improved

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The changing position of women earning doctorates in science and engineering is described by the title of the National Research Council’s 2001 report, *From Scarcity to Visibility* (Long 2001). It reflects the impact of thirty years of study, programs, and initiatives as women have grown from 8 percent of all Ph.D. recipients in science, technology, engineering, and mathematics (STEM) in 1966 to 39 percent in 2002 (NSF 2003, 38; Hoffer et al. 2003, 13). Yet women earning STEM Ph.D.s today are still largely white, as the growth in female Ph.D. attainment has not been paralleled by similar attainment among U.S. minorities, even though more earn Ph.D.s than thirty years ago. Among the growing but still low number of individuals from underrepresented groups earning STEM Ph.D.s, women remain virtually invisible. Indeed, of the 14,313 Ph.D.s awarded to United States citizens in 2002 in STEM fields, only 353 went to African American women, 103 to Chicanas, and 32 to Native American women (Hill 2003). Clearly barriers remain in STEM doctoral education for women of all ethnicities (Hollenshead et al. 1996).

This chapter examines the graduate school experience of an ethnically diverse and highly successful group of sixty-three women who earned their Ph.D.s in science and engineering fields from several University of California (UC) campuses between 1980 and 1990. They were admitted to some of the departments ranked most highly by the National Research Council (NRC), and despite the difficulties they may have had, succeeded in finishing their doctoral programs. These women of all ethnicities also overcame other obstacles in the form of sexism and racism. They all are bright and good at science, with a strong will to succeed, to obtain the skills necessary to move ahead, and to structure a professional life compatible with personal and community values. If individuals of this caliber had difficulties in getting through their graduate programs, we can be sure that others found these difficulties insurmountable and left the program. The problems the study participants had with their training should, therefore, be taken all the more seriously as they are the survivors.

There are two parts to this chapter. The first presents some of the findings
of the qualitative study described below, which focused on the types of difficulty the diverse women participants experienced as they progressed through the graduate program, the role of their advisers, and the benefits, obstacles, and omissions they perceived in their training. The second part goes beyond the study to make a series of systemic recommendations about how these documented issues could be addressed to make graduate education more responsive to the needs of women and other underrepresented groups. It situates the study’s findings in the wider literature on graduate education, and it uses the recommendations of the study participants as well as the many programs and practices I personally know to be successful, along with those documented in the literature, such as the programs described in Preparing Future Faculty in the Sciences and Mathematics (Pruitt-Logan, Gaff, and Jentoft 2002).

Description of the Study

The data analyzed here come from a four-year qualitative project entitled “A Longitudinal Study of Minority Ph.D.s from 1980 to 1990: Progress and Outcomes in Science and Engineering at the University of California during Graduate School and Professional Life.” Included in the study were African Americans, Chicanos, and Native Americans, because these groups are critically underrepresented in higher education. They were augmented by Asian Americans and Hispanics with a matched white group. The match was made by selecting a white graduate student from the same lab or who had studied with the same adviser as any minority student in the study and who received her or his Ph.D. around the same time. Data were collected through telephone interviews generally lasting two hours using a standard questionnaire. Questions covered respondents’ entire lives, from their family background and early schooling through graduate school and professional life. A total of 158 interviews were completed.

Of the 13,700 students who earned a STEM Ph.D. in the UC system between 1980 and 1990, 206 were members of underrepresented minorities (URM) (African American, Chicano/Chicana, Native American). The total number of women among the 206 is not known. On the Berkeley campus, the source of the majority of respondents, there were a total of 87 URM Ph.D.s in STEM, of whom twenty-three (26 percent) were women. The very small number of women Ph.D. recipients overall (even white women were only 22.6 percent of all whites) led to the inclusion of as many other women of color as could be located, so that Hispanic and Filipino women were also interviewed. Women were therefore overrepresented in the study as a whole. On the other hand, they were definitely underrepresented in their doctoral programs without respect to ethnicity, and were thus in a minority position, with all that this entails.

The Experience of Graduate School

This analysis focuses on the graduate experience of the 63 women in the study: 10 African Americans, 8 Asian Americans, 6 Chicanas, 9 Hispanics, 2 Na-
tive Americans, and 28 whites. As a group, these women did not differ significantly from male students completing STEM doctorates—entering graduate school in their early twenties, having earned a B.S. with good to excellent grades in the same field as their Ph.D. or a closely related one, and going through the program in a timely manner. It would be a grave mistake, however, to view them in only this way.

There were substantial differences among the women in family background and ethnic identity, differences which affected their experiences in graduate school. Chicanas and African American women came from relatively poor and uneducated families, while white and Asian American women came from relatively prosperous families with college degrees. Hispanic women were mostly foreign-born and came from well-educated families. The two Native American women in the study fit no pattern, as one had a father with a Ph.D. and the other had parents with only a high school education. They, along with the Chicanas and African American women, not only identified with their ethnic and cultural heritage, but were identified by it on occasion in unprofessional and unconstructive ways.

The majority of the women had been recognized as bright and capable at an early age, often by a grade school teacher. They also enjoyed very strong support systems provided by their families, including parents with virtually no education who sustained them through school. As undergraduates, the majority attended major research universities such as MIT and Cal Tech or good state comprehensives; a few attended leading liberal arts colleges. A small group attended historically Black colleges and universities (HBCUs), which made their transition to a majority institution more stressful. Their grade point averages were almost uniformly high, ranging from 3.0 to a perfect 4.0, with a heavy concentration above 3.5.

Before turning to the answers to specific questions from the study, a few general observations about graduate school are in order. How graduate school is experienced, the kind of mentoring one receives, the degree of induction into the discipline or profession, the extent to which one builds a personal network—all play a role in whether one remains in the program or leaves (Golde 1998, 55–59; Nettles 1990, 497). These factors also play a role in the choice of post-doctoral programs and subsequent career decisions. Succeeding at UC Berkeley and in other programs requires a student to develop relationships with various faculty advisers, establish personal support systems, and cultivate a general “toughness.”

One question asked students what they wished they had known when they started their program. The number of different areas of vulnerability the study participants articulated is revealing.

One major theme in answers to this question was how much simply being a woman “affected absolutely everything.” A woman coming from an undergraduate institution, where women were 50 percent of the students, wished she had known “how to interact with her fellow students better.” She was the only female in her adviser’s group, and the only female teaching assistant. As a result,
she was “always on the outside in my colleagues’ group.” Another wished she had known “that women would interact differently from men in math. I should have formed a woman’s group to study so there would be a safe environment.”

Other comments in answer to this question covered almost the entire process of graduate training, from someone who wished she had known “more about what is an appropriate course of study,” to another who wished she had known more about career options. Needing to be mentored and to ask for help, but not knowing how to do so, or that it was permissible to do so, was a recurring theme. Women also wished they had known about the importance of academic politics and competition as well as the need to be aggressive in asking questions and making sure their own work was recognized.

Specific lack of skills or knowledge was articulated more clearly in answer to the question “What training would you like to have received?” Thirteen women mentioned grant writing here, in addition to those who mentioned this as something they wished they had known. Nine mentioned techniques and specific training in field-related areas, while an additional seven in public health mentioned areas specific to their field. One woman mentioned the need for interdisciplinary research. The lack of guidance and the need for a mentor was mentioned by six. Career skills of various kinds were mentioned by twenty-four.

Twenty-five questions asked about advisers; twenty-one offered a choice of ranked answers, and four were open-ended. The responses to one question, “How would you rate your overall relationship with your adviser?” were used as a general measure of that relationship. This was only a rough measure, however, because the rankings of answers to more specific questions often were at odds with the general assessment. Low rankings on questions such as whether the adviser provided “teaching opportunities,” “opportunities to present,” “information on grant writing,” “information on preparing articles for publication,” “the ethics of science,” or “information about lab management” were common in conjunction with a high overall ranking. Some individuals refused to answer such questions because it never occurred to them that their advisers should have taught them some of these things. Women in particular tended to blame themselves for not having received specific information and training from advisers.

Since study participants were women who got through the doctoral program, it is not surprising that on a 1 to 5 scale, with 1 the highest ranking, 72 percent of advisers received overall evaluation scores of 1 or 2. Typical comments for those giving high rankings included this from a Hispanic woman: “He was always a good role model, very supportive and gave me freedom.” From a Chicana: “Gave me training that allowed me to succeed and be professional.” And from a white woman: “Our relationship was phenomenal, he is very knowledgeable and willing to share his knowledge.” An African American woman who ranked her adviser as a 3 still remarked, “I gained a lot of independence, self-reliance. This has been helpful in terms of initiating new activities and programs in my environment and to develop confidence in my ability.” But even those who did rank advisers as a 1 or 2 made comments suggesting ambivalence,
such as “He was great, but he wasn’t there much, it was a problem for a couple of years . . . he didn’t micro manage which I adored.”

Thesis advisers were usually perceived as benign to actively supportive, their faults those of omission rather than commission. But these omissions were often very significant for the women concerned. Lack of direction, particularly in the first year, led to floundering in the program and lost time, and to initial poor choices of lab or adviser; later lack of advice led to failed experiments, unpublished results, and poor choice of employment or postdoctoral positions. Only one adviser out of this group was ranked 1 in all categories by all advisees.

Even women who rated an adviser overall as 1 almost never gave rankings of 1s in all of the more specific categories. Nearly a third also said that when they entered the program they were naive, did not know what to expect, and did not expect very much. Scores for specific faculty advisers’ behaviors varied widely with no apparent pattern, but on this set of questions there were some notable low scores. These, plus the comments about what students would have liked to get from their advisers but did not, provide a clear picture of the elements left out of the students’ training, especially such things as grant writing, article preparation, lab management, and the workings of the academic profession.¹

## Issues of Racism and Sexism

Problems with racism and sexism tended to originate with male student colleagues. One African American woman always felt under surveillance by fellow graduate students and stated, “Berkeley was my worst experience of racism ever,” although few other women of color were so emphatic. In response to the question “Have you experienced discriminatory or racist behavior during graduate school?” 42 of the 63 women stated that they experienced some form of discrimination that was either racist, sexist, or both. Sometimes prejudice was perceived, but its form was hard to describe. While often only single events were mentioned, what was more clearly remembered was the ineffable sense of being different, being excluded in small ways, and sometimes a pervasive sense of discomfort (Ibarra 2001). There were also blatant cases of discrimination: two faculty members were known to always fail women in either the preliminary or the oral examination, and failed the two women who reported this.

Women’s comments suggest that faculty were often unaware that they were treating women or persons of color differently. Yet the women reported such different treatment fairly extensively. Some women reported that an older white male faculty member likened them to a daughter (although one woman was very happy with this). Women also could sense that they were directed toward applied rather than theoretical areas, and when they pursued theory nonetheless, they encountered noncomprehension. Some sensed doubt about their overall ability. Many observed switches in behavior when they, as lone women, joined gatherings of men, whether in the lab or the hallway. No man would be congratulated on passing his qualifying exam by being kissed and having his
ear bitten, as was one respondent. As discussed above, many also said that they did not receive much advice or mentoring, leading to unsuccessful experiments or poor choice of postdoctoral positions.

Women of color in the study reported faculty doubt about their abilities more often than white women, although they usually found more such doubt in their workplaces than in graduate school (see also Turner 2002). They commented on subtle changes in behavior suggesting they did not belong, that they were seen as "a" or still "the" minority, not as a student or a potential colleague. The women of color felt that they were not seen as themselves, as persons, or future scientists, but as "representatives of their race," and were scrutinized and judged on that basis. Degrees of difference were accentuated by language. If white women experienced "a thousand paper cuts" (Mason 2002), persons of color experienced "micro-aggressions" (Solorzano 1998). Is this deliberate? Even many of those affected by such behaviors often did not think so, but attributed the discrimination to "ignorance." Nonetheless, the accumulation of all of these negative experiences can form a substantial barrier to success for women of color in science and engineering graduate programs.

In summary, students expressed dissatisfaction in a large number of areas, despite the fact that all had completed their degrees. Women in graduate science programs, however, often may not know how their environment could be improved because they tend to arrive with fairly poor undergraduate experiences and low expectations. As one woman remarked, "MIT was heavily male, so it [Berkeley] wasn't hard for me." Difficulties articulated by women in the study covered a broad range of areas, but very frequently women saw themselves as the source of the problem(s) rather than extensively critiquing the system of training.

Although this is only an abbreviated presentation of the findings, it is sufficient to suggest that there are better ways of training diverse women for STEM careers. In addition to the lack of guidance, most women considered aspects of their intellectual development to be missing, along with a long list of professional development activities, from grant writing to publishing. Career advice, particularly advice on postdoctoral positions, was often lacking. In what follows, I discuss how to provide a better graduate experience for women, and all students.

Reconceiving Graduate Education

The areas of omission and hardship articulated by this diverse group of sixty-three women are similar to those examined in recent surveys of graduate students (Golde and Dore 2001; NAGPS 2000), as well as in many years of research on graduate education and in various studies by federal agencies. The particular situation of women in science has also been discussed for many years, although issues faced specifically by women of color rather less so. If the goal is to address these issues in order to make graduate education more effective, and especially to avoid the all too common negative and denigrating experi-
ences in graduate school, then the first step is to work with faculty and staff in STEM to change the culture of departments.

Although there are STEM faculty actively engaged in making graduate education more accommodating to new kinds of students, and focused on preparing students for the complex scientific workplace, their efforts are usually not systemic. On the contrary, they often rest on the initiative of an individual scientist or department chair, and are randomly distributed throughout graduate programs in the United States. Faculty consciousness of their roles vis-à-vis graduate students and the doctoral program in their departments is all too often underdeveloped because they themselves may never have been exposed to alternative models of behavior and organization, or have given the issues much thought. This lack of consciousness can all too often be compounded by a belief that surviving a program without assistance, as the faculty commonly did (or thought they did) themselves, is actually part of the process (Katz and Hartnett 1976; MacLachlan 1996; Golde and Dore 2001). Hence faculty frequently resist changing either their own behavior or the system.

Arguments made to faculty that the low numbers of women and minority group members in so many graduate programs continue the historical legacy of exclusion and segregation largely affect only rhetoric. Faculty members unwilling to reconsider their role as graduate educators will deliver only politically correct bromides on the need for diversity. Many scientists are unconvinced that there is a national workforce crisis in STEM because the current system is not developing and utilizing the talent of U.S. women and minorities. The recent reports reiterating arguments made in the 1950s (Hollis 1950) that graduate training in science is inefficient with respect to time to degree and training for future employment appear to make little impression. Moreover, the fact that STEM graduate education has been critically if not extensively examined for the last thirty years (Katz and Hartnett 1976; Baird 1993; Bowen and Rudenstine 1992) has had little impact, as STEM faculty usually do not read this kind of literature. While the demand for better training for academic employment has generated a few Preparing Future Faculty programs in STEM, these are not at Research I institutions with top-ranked National Research Council (NRC) departments (Pruitt-Logan, Gaff, and Jentoft 2002).

If faculty think of graduate education as a boot camp, they will not be persuaded that this form of training wastes talent and shatters lives. All programs expect some measure of attrition, but there could be another way of doing things, even if attrition in STEM fields is substantially less than in others (Nerad and Miller 1996; Rapoport 1998). Because many do not “survive,” the question also arises whether the traditional model of graduate education is an efficient use of departmental resources, since many are employed to partially educate those who leave.

Graduate education has become more than ever a complex process of socialization (Austin 2002). STEM faculty understand that they must induct graduate students into the practice of science, convey to them the values of research ethics and the nature of scientific inquiry, and teach them research methods. They

The Graduate Experience of Women in STEM  243
understand less clearly the process of socializing students into a particular social and institutional system in which academic science is practiced. There are also cultural ramifications, since students from low educational backgrounds are often assumed to suffer from a lack of “human capital” (Nettles and Millet 1999), and are expected to learn the customs, language, and manners of the academy. This can be a painful and alienating process for the student. Such students tend to have difficulties in becoming socialized into both the graduate and the science system (Zelditch 1997). Faculty’s heightened consciousness of these issues, as well as their acceptance of a broader range of learning styles (reflected in their approach to instructing students whose ethnic culture and social world is unknown to them) would make a substantial difference.

In considering the issues of diverse women in graduate school it is important to bear in mind that the pedagogical efficacy of graduate programs depends heavily on the interest and activity of faculty. Not only can the relationships faculty form with students as thesis directors or principal investigators make or break the student, general faculty engagement with graduate student training in the department can promote more effective socialization. One useful way to develop this awareness is to draw from the various activities developed for faculty training and education by those seventeen campuses which have received NSF ADVANCE Institutional Transformation Grants. The ultimate purpose of the grant program is to increase the number of diverse women on the STEM faculty by transforming departments and entire campuses. Generally the goals of programs funded by ADVANCE grants are the same as those of programs or graduate women generally; they are intended to make departments welcoming to and supportive of women, whether faculty or graduate students. However, in order to specifically address the issues articulated by women in the study reported in this chapter, interventions should focus on making faculty more effective graduate educators. The role of faculty in making graduate education successful for more students than it currently is should also be discussed, and language and behaviors that can exclude women and students of color from the mainstream of graduate education should be explained and demonstrated. Specific training in effective mentoring should be included—knowledge useful for working with undergraduates and junior faculty as well. This training would also encourage faculty to organize and participate in the various activities described below. Ideally such training would be mandatory for all faculty at all levels, whether new hires or long-tenured professors. While there are always faculty who support such work in any department, resistance can be expected from many more. For that reason such training has to be part of broader considerations about how a department wants to function, and must be based on strong leadership from the chair and the dean and supported by the top administration.

Direct external pressure on grant recipients by the large federal funding agencies, such as the National Science Foundation (NSF), the National Institutes of Health (NIH), and the Department of Energy (DOE), is highly desirable for fostering systemic change. Small steps have been taken in this direction by the
structure of some grant programs, such as the NSF ADVANCE program and the Alliance for Graduate Education and the Professoriate, which provide the resources to increase the number of graduate students of color earning STEM Ph.D.s and going into the professoriate. Mandatory education components in large institutional grants are also helpful. On the whole, however, federal agencies need to be much more active (NSB 2003).

Faculty reconsideration of graduate training—however it is brought about—could lead departments to adapt the recommendations below to suit their individual disciplines and needs. These recommendations build on the graduate student study participants’ comments and draw from models of such successful activities at the department level as can be identified. They are organized sequentially, following the path of the new student through a program, and are intended to provide the missing pieces which are more likely to make more students successful in their STEM graduate programs. Taken together, these programs reorganize the system of graduate education and remove obstacles which can hinder successful completion of a STEM graduate program. Since there are no adequate data on who leaves—and certainly many white men leave—such programs need to be for everyone, with special components for women and students of color. They focus on three main areas: (1) orientation to the department and its people, to the discipline, and to academic expectations; (2) mentoring to provide individual support, encouragement, knowledge, and advice, including advice on how to mentor others and build networks; and (3) socialization to the culture of the academy and the discipline, and advice on the steps beyond, which include training for life after the doctorate (professional development). In practice, these components are not so tidily separated. Moreover, the goals of these activities have been sought for at least thirty years, with only varying degrees of success. That is why the majority of faculty in any given department must be engaged for these activities to be successful.

Recommendations for a Successful Graduate Student Experience

Graduate student orientations should be distributed throughout the first and subsequent years, organized sequentially, with participation considered a part of the formal program. Incoming students in particular are often greatly overwhelmed with information as they try to learn about their new environment. Whether or not students participated in a campus recruitment visit, their initial contact with faculty and staff upon arrival should make them feel welcome. In order to be successful, students need information and guidance. They also need to be actively involved in their own success, and if they arrive without knowing what they want to get out of a doctoral program beyond just the degree, they should be encouraged throughout to think about what they want to learn, why they want to learn it, and in what kind of working environment they want to use their knowledge.
Just prior to term, the first orientation should be a two-day department retreat to meet faculty and staff, examine various labs and other campus facilities, and pair up with an older student for mentoring. In a well-organized presentation, faculty and some advanced students should discuss the structure of the academic program, the nature and timing of “milestones” such as the preliminary or qualifying exam, meeting learning expectations, and what options are available to students (courses in this or other departments, lab rotations, available equipment, and opportunities to use off-site labs). As many of the department’s faculty as possible should be present to introduce themselves and briefly discuss their current research projects, their current students’ work, and the placement of former students. Faculty in interdisciplinary areas who collaborate with others either on or off campus should speak to how to prepare for interdisciplinary work and describe opportunities for such work in other departments and with other faculty. Interspersed throughout the day should be informal opportunities for new students to speak with faculty and the more advanced students present.

Built into the orientation should be breakout sessions so that all incoming graduate women students can meet with more advanced women and establish a formal mentoring relationship. If there is a department-sponsored women’s organization, representatives should be present to describe their activities and invite all of the new women to participate. Women faculty should also be available to meet the new female students and discuss resources available to women on campus, along with the resources of national organizations like the Association for Women in Science (AWIS) and any disciplinary-specific organization, such as the Women Chemists Committee of the American Chemical Society (ACS), which offers a great deal of valuable information for chemists in training. At this meeting, too, it should be emphasized to the students that they need to develop a plan for their own education. Senior women should explain, from their more advanced perspective, how pitfalls can be avoided. A discussion of the real department climate would also be helpful to incoming women, along with suggestions of what to do if they encounter sexist or racist behavior. All of this can be done in a positive way so that students feel informed and prepared, but not frightened or discouraged.

At another time there should be a breakout session for all minority students, men and women, to discuss the same themes as in the women’s and general orientations. Since it is all too likely there will be few or no minority faculty members in the department, this session should be coordinated with other STEM departments so minority students have the opportunity to meet one another and the faculty, minority or not, who are interested in their welfare. Since most leading graduate school faculty are white (Nelson 2004), most minority students in STEM will have to find a white adviser. If there are minority faculty in STEM on campus, they should attend; some might even be invited from neighboring institutions. More advanced minority students from several departments should also be invited and encouraged to become official student mentors for the new students. If there are minority student organizations on campus, their
coordinators should be introduced and describe the goals and activities of the organizations. Advanced students or faculty could also discuss minority organizations such as the Society for Advancement of Chicanos and Native Americans in Science (SACNAS), the National Society of Black Physicists, the National Association of Mathematicians, and Mathematicians of the African Diaspora, and minority sections of larger organizations, such as the Women Chemists Committee of the American Chemical Society and the Minority Scientists Network of the American Association for the Advancement of Science (AAAS). The minority and the women's groups should continue to meet regularly both socially and to discuss graduate issues as they arise.

All of these initial programs need careful planning and should involve as many faculty members as possible. The goals are to communicate (1) valuable information about the department and how to succeed in it; (2) department policy, established by the chair or dean, that hostile, sexist, racist, unethical, or destructively competitive behaviors will not be tolerated (to be effective this policy must be backed up by actual behavior, not just hope); (3) that students are active participants in shaping their own education, and should think about their intellectual objectives and future employment; and (4) that obtaining information, advice, and mentoring from faculty requires action on both sides—faculty have to be accessible but students must ask for what they may need and are not receiving. Examples of such first-year orientation meetings are found in the neurosurgery department at the University of Iowa and in the astronomy department at UC Berkeley.

Meetings of the various groups of graduate students should be repeated during the first and subsequent years so that discussion of the topics moves along as the students do, and the students move in a cohort. The second meeting could discuss examinations, if one is administered in that particular department in the first year. The third could focus on developing a research topic, and so on, with meetings preceding each major event. Social events should also be part of the program so that students at different levels and students and faculty have a chance to get acquainted (Katz and Hartnett 1976; Nettles 1990).

A complement to a general orientation is an initial individual advising and evaluation session with an engaged faculty adviser. The incoming student and the adviser should discuss the student’s background, scientific interests, and possible employment goals, and explore how the student may best navigate the program, covering classes, faculty members, and departments. The student thus receives a clear idea of what is expected of her and what she needs to do to progress. Although she will find other academic advisers, her progress should be monitored by this professor, who should remain available as a general program mentor. In the department of biomathematics at UCLA, this program’s success is reflected in the fact that students finish within five years and generally go directly into employment, since a postdoctoral position is considered superfluous (personal communication from Professor Carol Newton).

Mentoring is a significant element in the success of women and persons of color in STEM—not to change the student, but to provide information and

The Graduate Experience of Women in STEM 247
guidance as necessary—and is something which departments should develop (Frierson 1998; COSEPUP 1995). Mentors are usually made, not born, so it would be valuable to have ongoing programs on how to be a mentor for both students and faculty. Each party in the relationship needs to understand its parameters and how to make it successful. Students in turn can mentor undergraduate students as well as younger graduate students. There is a fine line, too, between providing advice and guidance and not allowing the mentee sufficient latitude. While many respondents in the study complained about the laissez-faire approach of some faculty, some used it to develop independently and more or less favored being left alone. It is also debatable whether mentors are or should be role models. Having a white man as a mentor may foster excellence in science, but not provide insight on either dealing with the sexist or racist elements of the environment (Turner and Myers 2000) or balancing child raising with academic life (Zelditch 1997). That is why women and minority group members want more faculty like them, even though matching students and mentors by social identity categories stereotypes such faculty and such individuals may not always be good role models. This is a significant issue, since graduate students often do not find the lives of their advisers worthy of aspiration (MacLachlan 2000). Consequently only a small percentage of Ph.D.s actively seek faculty positions at research universities. Also, students need to be aware of potential “negative” mentoring—another reason for training students in mentoring—as this can undermine both student confidence and career aspirations (Wilson 1997).

First-year students would profit greatly from being exposed to the inner workings of subfields in their disciplines by having faculty offer seminars or talks about their own research areas, the significant problems within them, and how the problems are being addressed. Particularly important for the student is a discussion about what one needs to know to actively participate in the field and how one acquires this knowledge. Often students only discover in their third year or even later that they need to take a vital class or master some research technique. Acquiring such information early makes the path clearer and is likely to shorten the student’s time to degree as a result.

Although many STEM students seek work after the Ph.D. outside of the academy, the usual assumption is that students will follow the path of the adviser and become faculty. The irony of this is that faculty advisers often do not prepare their students for work in the academy, and neither does the department. Being effective in an academic environment requires several distinct skills, few of which are currently deliberately taught in graduate school. The most obvious is teaching. How much is really taught about instruction in teaching assistant orientations or assigned pedagogy courses is an open question, since their content varies greatly, depending on the faculty in charge of such courses. The faculty themselves may or may not have ever received formal teacher training. Since many introductory and even upper-division courses in science and mathematics are taught by graduate students, often bad teaching (and attitudes) drives women and minorities, as well as majority men, out of science.
majors (Seymour and Hewitt 1997). Teaching can be highly discriminatory (Sandler, Silverberg, and Hall 1996) and thus it is critical that graduate students receive solid training to fulfill their student teaching obligations effectively and to maintain an inclusive environment in the classroom—to prepare them to be successful teachers after the Ph.D.

More than just relying on the current, rather haphazard structure, departments should offer seminars in teaching methods in which every student would have to participate. Several examples now exist, which can be accessed through the Preparing Future Faculty program, the Council of Graduate Schools (CGS), or the American Association of Colleges and Universities (AACU). Organization would undoubtedly vary, but students should have at least a semester-long course on teaching taught by a combination of professional pedagogy teachers and department faculty before being placed in the classroom. This implies that all students in a department, whether on an external fellowship or not, would be required to teach as a prerequisite for graduation. The logic behind this is that even if a student does not ultimately go into teaching, she will still be in a professional environment in which she needs to communicate her ideas clearly, listen effectively to what is being communicated to her, be able to work cooperatively with others, and be able to involve and motivate others (Richlin 1993). Effective teaching is based on these skills, and these also are the areas of expertise that industry employers would like to see in Ph.D.s (COSEPUP 1995; Poock 2001). For those who do become faculty, the knowledge of how to teach effectively in their field makes the transition to academic employment much easier.

Career development for graduate students, whether female or minority, requires much more than occasional workshops. To be an effective scientist one needs to learn many different skills. In an ideal world, the principal investigators (PIs) would make sure that, in the years a student works with them, these skills are imparted through both their active teaching and the student’s careful observation. Unfortunately, in the judgment of the study participants, almost every PI fell short in some area, although very rarely in all areas. These shortcomings included all the things related to effective lab management, as well as grant writing, article writing and submission, and even effective training in the field. Advisers also often failed to support students in job hunting, networking, and developing specific job-related skills. Many students requested classes or more organized training in all of the skills they did not obtain. Consequently, in the ongoing orientations, all of these missing pieces should be discussed, with extra sessions taught by department or other experts in grant writing, publishing, and laboratory management. Fischer and Zigmond (1998, 39–40) noted the need for “explicit instruction in survival skills” like these and indicated that the University of Pittsburgh provides a program of instruction as well as training in honorary authorship, avoiding plagiarism, oral presentations, and much more, in eight seven-hour workshops, one each month. In all of this instruction, attention needs to be paid to ways in which women and minority group members can be poorly served and how to overcome these impediments.

At least a year before graduation the department should offer focused job
search workshops which deal with the purpose of postdoctoral positions and how to go about selecting the one most advantageous to career development; how to obtain an academic job, beginning with the kind of position the student might be interested in; how to prepare job search materials and organize the search effectively, so as to get the most help from advisers; how to give a job seminar and prepare a teaching demonstration; how to be effective in an on-campus interview; how to evaluate an institution's suitability; and how to negotiate a job offer. Similar workshops should be offered for other forms of employment.

While the recommendations made in this chapter do not provide a detailed blueprint of what a department ought to do, they do provide a guide. How these recommendations would be actually implemented depends greatly on the configuration of each specific department. The overriding goal of all these activities is to make progress through graduate school intellectually informed and to provide substantial information about skills and future employment. However, the implementation of even some of these activities and programs would serve to make departments more collegial and collaborative for graduate students and faculty (Etzkowitz, Kemelgor, and Uzzi 2000).

The various remedies suggested here will not necessarily fit all fields and departments. The idea is to provide a broad picture of departmental activities that could be adapted for local circumstances, emphasizing critical elements which should always be present. Implicit in this discussion is the need for graduate education to transform itself from within to make it more successful for more graduate students. Departments and their faculty have to be the loci of this change, not external administrative entities such as graduate divisions, although they, and the higher administration, need to strongly encourage such efforts. Federal funding agencies can also help by requiring specific supportive and professional development activities for graduate students as part of the grant activity and requiring their assessment. Likewise, various professional organizations can make valuable contributions (Applegate 2002). These are forms of acknowledgment that the “standard model” of graduate education, still bearing traces of its nineteenth-century Germanic origins as a program of study for a male social elite, must change to accommodate the current, more democratic ideology of access based on merit. Women and minority group members must be full participants in every form of education in the country in order to acquire the tools for full participation in the professions. The current system of graduate education in science and engineering is still far from this goal.

Notes

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1. See similar findings in LaPidus (1998) and Nettles and Millet (1999).
2. See Ivie, Stowe, and Czujko (2001), who report that of the 150 Black academic physicists, two-thirds teach at a historically Black college or university.

References


The Graduate Experience of Women in STEM


Rapoport, Alan I. 1998. Summary of Workshop on Graduate Student Attrition. Arling-
ton, Va.: Division of Science Resources Studies, Directorate for Social, Behavioral, and Economic Sciences, National Science Foundation.

Websites of Organizations Mentioned

American Association for the Advancement of Science, Minority Scientists Network. http://nextwave.sciencemag.org/miscinet/
American Chemical Society, Women Chemists Committee. http://membership.acs.org/w/wcc
Preparing Future Faculty program. http://www.preparing-faculty.org
Re-envisioning the Ph.D. project. http://www.grad.washington.edu/envision/

The Graduate Experience of Women in STEM 253