A Case for Building Inclusive Research Communities as an Integral Part of Science and Engineering Graduate Education

Susannah V. Hobbs, Amanda M. Holland-Minkley, Lynette I. Millett
(svh4@cornell.edu, amh16@cornell.edu, lim2@cornell.edu)
College of Engineering
Cornell University
Ithaca, NY 14853

Abstract

In this paper we address the issue of research communities in science and engineering and their effects on graduate students and women in particular. We present our observations of graduate student experiences in one particular research community. These observations are considered in the context of research done by national science institutes and feminist theorists about the under-representation of women in scientific research communities. We offer suggestions as to how community-building activities can enhance science and the scientific experience for all involved.

Keywords: research communities, gender, graduate students, women in science, women in engineering

1. Introduction

In recent years, challenges of life for graduate students in science and engineering have been discussed at length in the literature and have been recognized by universities and various science and technology agencies such as the NSF. It has been hypothesized that for women many of these challenges are exacerbated, and that new challenges arise as well. One of the difficulties faced by both women and men graduate students is coming to grips with the narrow focus and one-dimensional existence often expected of young scientists in academia. In observing the activities of women graduate students in engineering at our university, we have noticed that women are more likely than their male counterparts to be involved in university and department-related community-building activities outside of the expected narrow scientific focus. Often, however, such university and department related activities are viewed as extracurricular rather than integral parts of professional development. In this paper, we argue that such activities are, in fact, valuable for scientists and we provide some suggestions for how best to leverage such activities for the good of the science, the university, and of course, the student. We also suggest that recognition of and support for the community-building activities of women and men within academia would be a step towards meeting some of the challenges faced by new scientists.

One observation we have made is that, although the activities undertaken by involved graduate students are varied, a broad theme throughout seems to be the need for a measure of control over and access to information about decision making processes. The types of information sought by graduate students range from administrative details to the university's long-range research goals. We hypothesize that this reflects a breakdown in information distribution methods. Our conjecture for why more women than men are interested in such things is that women are still not completely integrated into the research community

[NSF98a]. We suggest that involvement in a broad range of research and community related activities is in fact beneficial to the individual and the scientific community as a whole. It seems clear that management and "people skills" are essential in academia as well as in industry. Encouraging graduate student participation in activities that enhance these skills will not only serve students well throughout their careers, but can also decrease the marginalization of women in science and engineering. We believe raising awareness about such issues, while obviously not a complete solution, is an important step that needs to be made by the scientific community.

As an example of the type of community-building activity to which we are referring, a college-wide graduate student organization was recently formed in Cornell University's College of Engineering. One of the purposes of this organization is to foster interdepartmental communication, collaboration, and a larger sense of community. No specialized recruiting for this organization took place, but over half of the active participants and both the president and vice president are women. This is striking in a college where the vast majority of graduate students are men. There are several other examples of women taking a disproportionate role (with respect to demographics) that we will address in the paper. The literature on gender issues in science and engineering from the community itself as well as work in feminist theory suggests that these trends are not anomalous.

We structure our argument by first summarizing the place of community building in various discussions of science and engineering and then relating these discussions to our experiences. We begin by presenting some background on gender issues, giving pointers to theoretical work in these areas and to what scientists themselves have had to say about gender issues. We then show that studies by various science and engineering organizations have often uncovered the efficacy of community integration for encouraging girls and women to enter science and engineering. In this context, we present our own experiences of women graduate student participation in community-building activities. We conclude the paper with some suggestions for bringing about more inclusive and effective research communities.

2. Background and Setting

There is a large amount of literature available on the topic of women in science and engineering. Feminist theorists, and others, have been examining the issue of the under-representation of women in various arenas for some time now. We should note that there have been some success stories, at least in some fields. For example, in 1950, 11% of the M.D.s granted were to women; in 1995 this proportion had risen to 38%. In 1960, 2% of law graduates were women; in 1995, 42% [NCE97]. Although there are still difficulties, these fields have done much better than the most of the sciences and engineering in recruiting and retaining women.

Field	Percent Women 1970	1995
Law	5.3	42.5
Medicine	8.4	39.1
Computer Science (all degrees)	11.9	28.0
Engineering (all degrees)	0.8	15.6

Table 1: Percentage of women in various professional fields in 1970 versus 1995 [NCE97]

As shown in Table 1, in 1970, of the total number of degrees in computer and information sciences (including data processing and similar fields), approximately 12% were to women. In 1995 this had risen to just 28%. The field of law, on the other hand, started with a smaller percentage of women and yet has increased to more than 40%. While the percentage of women in engineering has increased by a large multiple since 1970 (starting from almost zero, this was to be expected), the field reached 13% in the mid-80's, and since then has hovered around 15%, in contrast to both medicine and law.

Clearly, something different is happening in the field of engineering than happened in medicine and in law that is discouraging women from entering and completing degrees in this traditionally male-dominated discipline. Moreover, while there has been an overall increase in the percentage of women earning degrees, recent statistics suggest that in some areas, such as computing and information sciences, this may in fact be reaching a plateau, or even reversing [Camp97]. The National Science Foundation has put out a proposal regarding male/female demographics in science. Its goal is to achieve parity by the year 2020, "50/50 by 2020" [NSF96], but given the statistics described above, achieving this goal is highly unlikely. The shrinking or only slightly expanding pipeline[1] that is evidenced by the Department of Education's statistics does not bode well for women in science, engineering, and technology.

The concern about women's role in science and engineering has not been purely about percentages, though. Among feminist theorists outside of the sciences, there are critiques of the scientific process itself (Harding, Keller, etc.) and its adaptability, or lack thereof, to practitioners from diverse communities with diverse approaches [Harding86, Harding98, Keller93]. These critiques offer a partial explanation for the small numbers of women in these fields. While outside critiques of "the scientific method" are not very satisfying, particularly to practicing scientists and engineers, and while there is plenty of criticism of these analyses ([Sokal96] for one famous example) certainly the observation that different people approach problems differently deserves to be carefully considered. Moreover, the idea that some problems and/or methods of solving problems are deemed more worthy than others due to social, political, and/or funding constraints is, in our view, an accurate observation. This stratification of problems has to happen at some point, of course, in order to decide which, among many, to work on. One of Harding's primary criticisms, however, is that we do not often enough examine what is influencing the choice of which problems to consider [Harding86]. Science and scientific approaches tend to be rather monolithic wherein any deviation from accepted practice is treated skeptically at best. This attitude clearly impinges on creativity, which most researchers agree is an

essential element in the practice of science. Scientists such as Goodall and McClintock are examples that a nontraditional approach can still produce rigorous work with meaningful results [Goodall91, Keller93]. Examining the notion that there are only a few "correct" approaches to a problem may well provide insight into the low levels of interest in younger women and girls as well as the shrinking pipeline.

Along with feminist theorists, women scientists themselves have addressed some of these issues. Conley details her experience as a senior professor of neurosurgery at Stanford and, after a long career in academic medicine fraught with gender-related difficulties, observes of academia: "It is a system white males were born into and which they thought would always be there for them. Unfortunately for all of us, it is a system predicated not only on the basis of capability but also on the basis of skin color and gender" [Conley98]. From another perspective, the recently formed Institute for Women in Technology [IWT] notes:

> It is no accident that as women entered medicine in large numbers, medicine began to question the application to women of research results from studies using only male subjects. Nor is it an accident that serious development of non-stereotypical computer tools and games appealing to girls is being initiated by women who listen to girls. Just as every invention reflects the values, perspectives, background and needs of the inventor, the variety and impact of new technologies will depend on the degree to which women are involved and the degree to which women's needs are taken into account. Involving women actively in technology policy, design, development and deployment will create a better world for everyone. Both studies and evaluations of the real world indicate that *when resources are given to women they are likely to be used for the betterment of the entire community*. (emphasis added)

Finally, in an implicit acknowledgement of the fact that who is approaching the problem also impacts the solutions found, William A. Wulf, president of the National Academy of Engineering, claims that it is essential that women and under-represented minorities be fully integrated into the engineering disciplines. He writes, "Every time we approach an engineering problem with a pale, male design team, we may not find the best solution. We may not understand the design options or know how to evaluate the constraints; we may not even understand the full dimension of the problem" [Wulf98].

On a broader scale, there has been work in understanding the psychological and sociological processes that lead to a devaluation of women's work. Virginia Valian has done an extensive study of the literature and discusses at length, among other things, the effect of unconscious gender schemas on how individuals are evaluated [Valian98]. She cites numerous studies in which women were rated lower than men with identical qualifications. In order to overcome these ingrained schemas, she suggests the first step is to become aware of them, and then to educate, reduce reliance on these schemas, and spend more time on evaluation than we currently do. She also suggests that those who are disenfranchised should learn to build power within organizations. One of her comments is that "Men and women can take actions that will increase their power. … Men are more likely than women to learn about such methods informally from mentors and colleagues, but women can seek out such information." In sections 3 and 4 we provide

examples of where this type of information-seeking and power-building has been done and how the wider community has been improved because of it.

In each of these examples, there is an implicit (sometimes explicit) notion of the need for a better sense of community and for more inclusive techniques – at both the macro-level and at the micro-level. Of course, it is not only women who are hurt by an inflexible approach to scholarship; men who might rather take an untraditional approach or non-standard career path are also disadvantaged. We should note that none of what we are suggesting is about granting "special privileges" or what some have deemed "hand-holding" or "nurturing." Instead, we believe that what is needed is explicit recognition and support for the idea that diverse perspectives in science and engineering can only enhance the disciplines and that for these perspectives to be realized, diversity among the community of scientists is required.

3. Current Work in Science and Engineering Organizations

The issue of the under-representation of women across levels of science and engineering education and employment, particularly in contrast to non-science and engineering disciplines, has been of high concern over the past several years. The science and engineering community itself has been investigating the situation, partially through a series of congressionally mandated reports on the status of women, minorities, and persons with disabilities in science and engineering. These reports, gathering statistics from a wide range of studies, have consistently documented the proportionally low numbers of women in science and engineering, though improvements have been occurring [NSF98a]. As shown in Table 2, women are under-represented in science and engineering, with a particularly large imbalance in engineering fields.[2] Women who go into science and engineering are less likely to go into engineering fields than men are: of women who received doctoral degrees in science and engineering, 11.3% of those were in engineering and 5.1% were in computer science, whereas 34% of men in science and engineering received doctorates in engineering and 9.6% received doctorates in computer science. Women were also a smaller proportion of engineering graduate students than were men: 18.2% of all graduate students in engineering and 24.6% of all graduate students in computer science were women. These problems persist after women obtain their degrees.

	Percent Women		
Field	**Bachelors**	**Masters**	**Doctorate**
Science and Engineering	46.5	38.0	31.2
Engineering	17.3	16.0	11.6
Mathematics and Computer Science	35.1	30.0	20.6 (computer science only)

Table 2: Percentage of degrees in science and engineering fields awarded to women in 1995 [NSF98a][3]

Many programs have been started to respond to these findings and encourage women to enter and stay in the fields of science and engineering. Several of these projects focus on providing a community for science

and engineering professionals, and for women in these fields in particular. For example, the Women in Science and Engineering (WISE) Initiative [NSF97a] has been working to get undergraduate and graduate women involved in professional societies and cyber-mentoring. Additionally, NSF has set up special funding sources, such as the Program for Gender Equity in Science, Mathematics, Engineering and Technology, which supports projects that are designed to increase participation and retention rates of women in science and engineering programs and careers. A common problem with programs such as these that focus on building a community of scientists and engineers is getting individuals to devote the time necessary. A key to avoiding this pitfall is stressing to faculty members how important this type of community service is, suggesting that faculty should even be evaluated on this service in order to emphasize its importance [NSF97a].

Through observation and talking to the women and girls involved in these programs, it has been noticed that part of encouraging women to participate in science and engineering is building a community and ensuring that the women or girls are part of it. At the high-school level, Sandy Madison, director of a program which helps train high-school computer teachers and provides mentoring to high-school girls, observes that “Girls don't see themselves as belonging in the culture of computer science” [NSF97b]. She also suggests that mentoring and instruction can be viewed as building a community.

In the follow-up of a Baylor College of Medicine mentoring program for undergraduate women, the feedback about the types of mentors that women wanted indicated that while accessibility was important, the mentors were valued as information providers and facilitators more than as nurturers:

> We found that they wanted the person they dealt with to be knowledgeable. They wanted that individual to be approachable. But they really didn't care if that person was kind. That was a little bit of a surprise to us. They wanted people to tell them the truth, to prod them on and move them ahead. They wanted somebody who knew the system and could relate what the next step up was. [NSF97a]

Another study that explored the effects of the culture of science and engineering on the sense of achievement and overall satisfaction of women undergraduates had similar findings [Seymour97]. According to this study, women are socialized to measure their achievement by the feedback and attention that they get from others. In contrast, most men don't require the same amount of interaction to feel confident about their abilities. Women dislike large classes because they are impersonal and prevent close contact with the professor, whereas men dislike large classes because they think that it is harder to get good grades in them and that less qualified faculty are selected to teach them. Women are more likely to expect individual relationships with their instructors when they enter college; these faculty relationships are, in fact, crucial to many women's confidence about their abilities and directly affect the likelihood that the women remain in science and engineering fields.

Community-building activities may be particularly important for improving the number of women in graduate school. Graduate programs have problems with the low percentage of female students who enroll and remain enrolled, and there is widespread concern about attrition of graduate students of both genders in science and engineering fields [NSF98b]. A variety of findings indicate that community building is crucial to solving the attrition problem, particularly the attrition problem for women and other under-represented groups. In studying methods for encouraging undergraduate women to enter science and engineering, supplying role models and providing peer groups have been identified as key [AS96]. The overall culture of the science and engineering community has been cited as significant in whether undergraduate women remain in science and engineering or switch to other majors [SH94]. The NSF Workshop on Graduate Student Attrition [NSF98b] discussed the relation of these factors to retention of graduate student women. Examining the effect of the type of funding on attrition, it was observed that "By becoming research or teaching assistants, ... students intensify their relationship with the department, which becomes a positive factor in their retention." Another study at this workshop observed that providing opportunities for students to integrate into the department correlated highly with student retention rates. Integration opportunities were measured by looking at occurrences of interactions of students with faculty and other graduate students, both in academic and in social contexts. Faculty who produced proportionally high numbers of Ph.D. degrees tended to participate in these activities.

The Workshop on Graduate Student Attrition also stressed the need for information about expectations and processes to be provided to graduate students:

> Departments assume that graduate students understand a lot more about the structure and process of graduate education than they really do. The consequence may be a gap between departmental or institutional expectations and student expectations. To bridge this gap, faculty and administrators could help students to develop better cognitive maps of the structure and process of the graduate programs they undertake.

Without involvement in a community, women graduate students often will not have access to this type of information.

These studies indicate a desire on the part of women in science and engineering and on the part of all graduate students to have a better understanding of the community in which they are living. Though a solution to the problem of under-representation of women in science and engineering will ultimately have to include encouraging girls and women at all education levels, it is productive to focus some attention at the university level. Though many women stop taking mathematics and science classes in high-school, most women remain open to science and engineering until after they leave high-school [Hanson97]. By making the science and engineering community more accessible at the undergraduate and graduate levels, more of these women may be retained. Community-building activities, particularly those with a potential for networking and information flow, could facilitate this retention.

These questions and observations about the science and engineering community that have been considered in the effort to increase the number of women in these fields are similar to the questions that feminist theory has been asking. A report from one NSF-sponsored discussion of how best to implement suggested programs stated that participants became keenly aware of the fact that time was not available to discuss a central question: "Are the issues really about gender or a larger cultural question about how science has acculturated both female and male practitioners?" [NSF97a]. The above-mentioned programs have to do with encouraging women and helping them to adapt to the science and engineering community. Both these studies and the literature we have presented suggest that we need to make the time to ask the question: is there adapting that the science and engineering community ought to do?

4. Current Work in Engineering Academia

Concern regarding the under-representation of women in the science and engineering community has also spread to academic circles as universities have begun to assess gender balance and associated problems and solutions. Within the past decade a number of institutions have surveyed the climates for faculty and students, particularly in science and engineering. The most recently published of these studies was issued by MIT this year [MIT99].

The study of women faculty at MIT found that women comprised only 8% of tenured faculty in the School of Science as of 1994, and that the number of tenured women faculty had not changed substantially over the previous 10-20 years. Additionally, the study found that gender discrimination existed within the faculty. This discrimination was described as pervasive, but largely unconscious, gender-bias in the treatment of women faculty. The discrimination was described as a general experience of "exclusion and invisibility". This discrimination was mostly perceived by the senior faculty women and these experiences only came to the front and were recognized once the women began meeting to discuss their experiences.

> Women faculty who lived the experience came to see the pattern of difference in how their male and female colleagues were treated and gradually they realized that this was discrimination. But when they spoke up, no one heard them, believing that each problem could be explained alternatively by its 'special circumstances'. Only when the women came together and shared their knowledge, only when the data were looked at through this knowledge and across departments, were the patterns irrefutable.

One of the two key recommendations made in the MIT report was that better communication needed to be created between the senior women faculty and the heads of departments and administrators of the school. The goal was to ensure both that instances of discrimination would be heard and that these women's perspectives would become integrated into higher levels of academic power.

The College of Engineering within Cornell University, our home institution, is also concerned about the climate for women and minorities in engineering, and conducted a similar assessment during the spring of 1998. The outside consultants hired to facilitate the process interviewed a large number of faculty and students, including all women faculty and most women graduate students. Some of the same issues were raised at Cornell as were discussed in the MIT report. Key findings included feelings of isolation on the part of the women and a lack of community in general. Attempting to improve the situation, the College of Engineering has identified a number of college-wide actions that, along with recommendations from the consultants, are beginning to be implemented.

5. Personal Observations

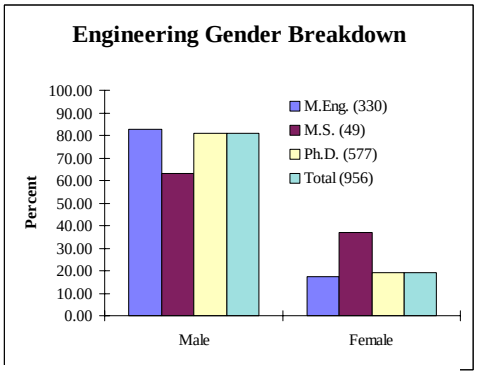

Figure 1

At Cornell University, and likewise at its peer institutions, women are a severely under-represented minority in Engineering.[4] As of Fall 1998, only 19% of all graduate students in the college of Engineering were women, as shown in Figure 1. Of the three different graduate degree programs, the percentage of women was higher for M.S. students, but that degree is only a small fraction of the College of Engineering as a whole, as seen in Figure 2.

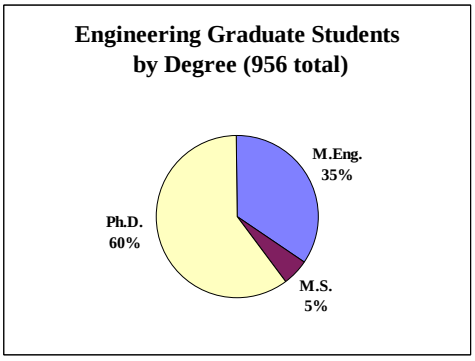

Figure 2

Partially as a result of this under-representation, women graduate students at Cornell often feel isolated and perceive a lack of acceptance into the engineering community. We have however, that despite this isolation (or because of it), women graduate students are more likely than their male colleagues to participate in college-wide activities and organizations outside of their specific research areas. While critical for professional development and community building, these activities are not considered to have direct research value, and are thus often relegated to the status of extracurricular activities by faculty. We believe that women take an active role in these activities, however, because they recognize the value of these activities as tools for community building, integration, and information flow.

One such organization is the Engineering Graduate Student Association (EGSA) at Cornell. The EGSA was formed in response to the findings of the College of Engineering assessment, with its main goals being to enhance the climate for graduate students in the College of Engineering and to encourage interaction

between graduate students and faculty in different departments. The EGSA is working to foster communication, collaboration, and community throughout the College of Engineering. While the EGSA sponsors activities for all faculty, researchers, and graduate students in the College of Engineering without specifically targeting women, the coordinators of the events and the officers of the organization are disproportionately women. For example, EGSA maintains two e-mail lists: one for active participants and one for officers/organizers, both of which have more than double the percentage of women than does the College of Engineering as a whole. As seen in Figure 3, the participant list is nearly 40% graduate women, and the officer/organizer list is more than 50% graduate women, despite the fact that the College of Engineering has only 20% graduate women. It is interesting to note, however, that attendance at the EGSA sponsored events, especially those which are focused on free food, is much more representative of the gender breakdown in the college as a whole, perhaps with an even slightly higher percentage of men.

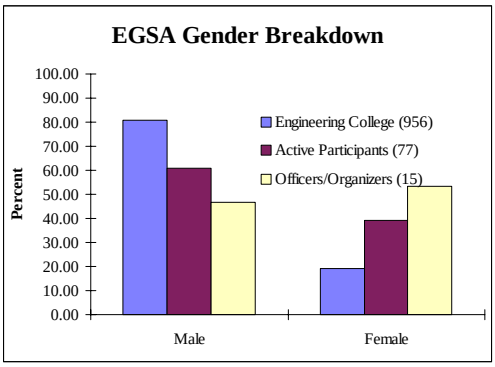

Figure 3

Another organization which represents the entire College of Engineering but is disproportionately women is the Engineering branch of the Council of Representatives (CoR). CoR is comprised of one to two graduate students from each field in the entire university and serves, among other things, as the pool from which the 15-person Graduate and Professional Student Assembly is chosen. As of Fall 1998, 10 Engineering CoR spots were filled, six of them by women. The imbalance of this statistic is particularly striking when compared with the percentage of women in the entire college of engineering, as seen in Figure 4.

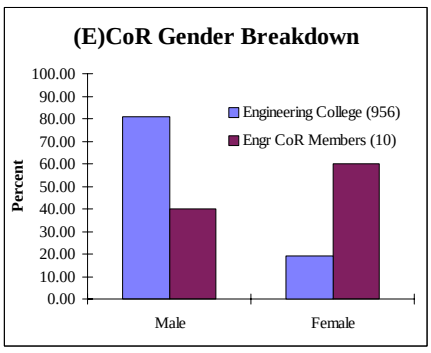

Figure 4

Within departmental activities, the disproportionate representation of women is also evident. The computer science department, for example, maintains a set of volunteer positions, which are held by different graduate students each year. These positions include sorting and delivering graduate student mail, organizing students into offices when they arrive or change offices, coordinating the department picnic and running the department orientation for new graduate students. While students are not required to hold these positions, they are strongly encouraged by the department to fill at least one during their graduate tenure. The percentage of women in 1998 who volunteered was not radically different from the percentage of women in the department, but women are more likely to hold multiple volunteer positions than are men. Over the past

five years, 5 women, but only 13 men, have volunteered more than once; thus, women are 28% of the people volunteering for multiple positions but only 14% of the computer science department.

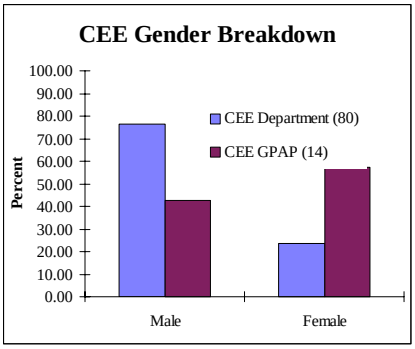

Figure 5

Another example of a departmental organization with a higher percentage of women than its host department is the Civil and Environmental Engineering (CEE) Graduate Peer Advising Program (GPAP). This mentoring program pairs current graduate students with incoming students to help the transition of new students into the department and the Cornell community. This program is unlike the computer science positions discussed previously since it was initiated entirely by students and is completely voluntary and certainly not required by the department. The current students who participate are interested simply in contributing to the community of the department and assisting the incoming students. While just under 25% of the graduate students in CEE are women, nearly 60% of the students who volunteered to be mentors for the GPAP program are, as illustrated in Figure 5.

The above examples cover a large number of the community enhancing activities that exist in the College of Engineering at Cornell. We have found that in all of them, women take a more active role. The nature of these activities tends to be two-fold: they improve the quality of the community in which graduate students live, and they make information about that community available to graduate students. Women seem particularly invested in ensuring that these activities take place.

6. Suggestions & Conclusions

Studies done at both the national scale and at individual universities have observed that one of the keys to encouraging women to participate in science and engineering is to ensure that these women will be part of a community that accepts and encourages them. We have observed in the course of our own graduate studies that women are also more likely to participate in activities that help provide this much-needed community. What has not been determined is in what ways the current community structure is insufficient, and why women are particularly involved in community-building activities.

We have no conclusive answer to these questions, but one central aspect to all of the activities discussed here is that they increase the amount of information that women have about their university, their graduate program, and their research field. Graduate students of both genders desire information about their program and the process of engineering research. For students who are fully integrated into a community, this information is passed on to them through their advisor and/or other graduate students, not only through

explicit instruction but also by being observed in the act of being an engineer. The lack of integration of women into a research community means that women do not get as much of this information as men do.

Furthermore, the very fact of being disconnected from the engineering community makes women graduate students desire the information even more. The workings of the university will seem less organized to those who are not part of the community than to those who have been integrated into its structure. Thus, women are stuck in a vicious circle, where the very factors that prevent them from obtaining information make them desire that very information even more.

We believe that the over-representation of women graduate students in community-building activities is a sign that these women are reaching out for opportunities to insert themselves into a community and acquire the information they lack. In conversations with some of these women, we have observed a pattern that they are often interested in knowing more about what is happening in the College of Engineering and their home departments and learning more about the decision-making processes. Their community-building activities give them access to people with this information: either faculty and administrators, or other graduate students who have closer ties to faculty and administrators.

In studying community-building activities, we have noted that they also function as career building opportunities for graduate students. Communication, organizational, and management skills are vital in virtually every post-graduate career. Traditional graduate programs in engineering do not include explicit training in these skills, so graduate students can only become proficient in them through practice. Participating in community-building activities give students an opportunity to practice these skills. The community-building setting allows graduate students to focus on perfecting these skills without simultaneously trying to perfect their research or teaching skills as they must when in an research or teaching assistant situation.

Unfortunately, these community-building activities are often considered optional by the graduate students' advisors, if not purely recreational. Time spent on these activities, particularly during work hours, may be discouraged and some students even feel they have to hide the fact that they participate in these activities. This is a great loss to these students; discussing their community-building activities with faculty and perhaps even getting faculty members involved in them would greatly increase the potential for useful information flow in the course of these activities and would broaden the participation in activities. Rather than discouraging or merely tolerating community-building pursuits, faculty and administrators need to recognize the positive effect of these pursuits on the overall graduate school experience. Due to their greater experience and better sense of the underlying engineering community, faculty could even suggest new activities which could serve the dual purpose of (i) increasing the sense of community that graduate

students feel and (ii) actually involving them in the information-dissemination and decision-making processes that already exist in the university.

Graduate students can take an active role in community building as well. With the support of a faculty member or administrator, graduate students began many of the community-building activities described in this paper. It is important, when taking part in these activities, that some students do not feel excluded or less welcome than others; the activities must be inclusive. Additionally, some students who would appreciate these activities may not be aware they exist, or feel comfortable joining a new activity. Community-building activities must be promoted and graduate students need to encourage their peers to participate.

The need for better information flow should be addressed outside of its role in community-building activities. Faculty and administrators need to be aware of what information is getting to graduate students, and how the dissemination process works, or in some cases does not work. In our experience, administrators at one level often pass information down to a lower level with the intention that it will eventually be dispersed, but if this intention is not passed along with the information, the dissemination may not occur. Graduate students need to make an attempt to create their own methods for information flow, whether it be a weekly study break in a graduate student lounge, a graduate student mailing list, or a more ambitious project such as a graduate student handbook. The university needs to have a commitment to communicating information that affects the life and research of graduate students to those students. Informal pathways, such as word-of-mouth, cannot be relied on and more formal venues need to be created. Fortunately, with the widespread use of e-mail and the web in engineering colleges, this information distribution is quite feasible.

Finally, although we have been explicitly addressing the experiences of women in this paper, we recognize that many of these issues hold for other under-represented groups as well. We would be interested in seeing further examinations of community and community-building activities with respect to these other groups. It would also be useful to examine where there are similarities that allow the same solutions to be applied and where there are differences that would warrant further study.

7. Acknowledgements

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8. Biographies

Susannah V. Hobbs is a Ph.D. candidate in Civil and Environmental Engineering. Her thesis research is on degree of hydration of cement-based materials. Amanda M. Holland-Minkley is a Ph.D. candidate in Computer Science. Her thesis research is on natural language generation from formal mathematics. Lynette I. Millett is a Ph.D. candidate in Computer Science. Her thesis research is on static slicing of concurrent programming languages. Hobbs and Millett co-founded Cornell University's Engineering Graduate Student Association.

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[1] The "shrinking pipeline" is terminology we have borrowed from Camp [Camp97]. It refers, on one level, to the fact that the higher up in the academic hierarchy one looks (high school, undergraduate, graduate student, assistant professor, associate professor, etc.), the lower the percentage of women. Camp's paper suggests that this cannot be completely explained by age.

[2] NSF separates computer science from engineering in its statistics and instead includes it with mathematical sciences. We include findings for both, as computer science is included in Cornell's College of Engineering.

[3] We follow NSF in considering all science and engineering fields as a group. We recognize that some fields of science, notably biology, have done very well with respect to gender demographics, and that other non-engineering fields have statistics similar to engineering's. Our purpose is to demonstrate that engineering has not improved as well as some other fields.

[4] We note again that Cornell's Engineering program includes computer science; subsequent statistics about the College of Engineering refer to all the engineering fields within Cornell, including computer science.