Academic Climate, Intervention and Institutional Change: Women in Science, Mathematics and Engineering

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Two recent studies at the University of Michigan, conducted by the Center for the Education of Women and its Women in Science program, explored the experiences of undergraduate and graduate students. We were particularly interested in the academic climate as well as devising strategies that the University, as an institution, could utilize to better support and nurture its women students.

The Project on the Graduate Experience surveyed graduate students about a wide range of questions. Students of color, women in the physical sciences and engineering and student parents were oversampled. In brief, this is what we found:

In many ways men and women describe the university in similar terms. Nevertheless,

Women perceive the University as a more alienating environment than do men.

Women are less likely to find the University an accepting environment.

Students in the physical sciences and engineering perceive the environment to be more demanding than do their peers in other divisions.

The survey also revealed differences among fields:

Students in the biomedical and health sciences find the environment more exciting and personal than their peers.

Students in the biomedical and health sciences and the social sciences find the environment more accepting than do their peers in the physical sciences, engineering, the humanities and education.

An open-ended question asked students "What aspects of your experiences at UM have been the most disturbing, disappointing or problematic?" It is not surprising that, overall, the most frequent response to this question concerned financial support. Nearly 23% of both men and women mentioned financial concerns as the most problematic part of their experience.

However, more women -- 26% -- but fewer men -- 16% -- cite lack of adequate mentoring and advising as the most problematic part of their experience. This difference is significant and consistent whether we look at all students in the sample, only Ph.D. students, or Engineering students.

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Another question asked "What aspects of your experience at UM do you value the most?" The most frequent response to this question for men and women alike was "The high quality of my program." The next most common response was that students valued the "sense of community in the respondent's department" followed by the response that what they valued the most was "helpful professors and advisors." Women were more likely than were the men to mention the latter two factors, demonstrating their value for a positive sense of community and support.

The survey also revealed some interesting gender differences among Engineering students. Students were asked to rate their level of agreement with the following statement: "The competitive atmosphere at UM contributes to feelings of alienation and isolation." While 24.4% of the men strongly disagreed with the statement, only 8.2% of the women did so. When asked, "Have you ever been treated in such a way that you felt ridiculed or humiliated?" 25% of the women but only 15% of the men replied affirmatively. Students were also asked if they participated in small study groups to prepare for tests or class assignments. Women reported higher levels of participation in these groups than did the men. Somewhat surprisingly, almost twice as many men (46%) said they "almost never" did so, compared to only 25% of the women. Asked if they had been encouraged to participate in small study groups, 43.5% of the men but only 27.8% of the women said they had "almost never" been encouraged to do so.

While there were some differences in career goals of Engineering students generally the survey revealed few differences between male and female Ph.D. students. In general, women were somewhat less likely to respond that they expected to pursue corporate management or industrial research and somewhat more likely to say they wish to pursue work in a public agency or in the government. The majority of male and female Ph.D. students cited university teaching and industrial research as the areas they wished to pursue.

The second study, Women in Mathematics and Physics: Inhibitors and Enhancers, was conducted with the Departments of Physics and Mathematics and funded in part by the Alfred P. Sloan Foundation. This study examined the literature to assess what is known and what strategies have worked in attracting women to these fields.* In an attempt to increase our understanding of the experiences of women and men in mathematics and science programs at a major research university we also conducted three studies of students at the University of Michigan.

The first of the three studies surveyed students enrolled in first semester Honors mathematics courses during the Fall Terms of 1987 or 1988. Students in these classes represent some of the best prepared incoming students and are a pool of potential mathematics/science concentrators.

The study documents an exceedingly high "dropout" rate in terms of continuing Honors mathematics enrollments. Only 15% of both the male and female students enrolled in the program completed the Honors mathematics sequence. There is a striking difference between the male and female students who dropped out. The majority of the women (58%) dropped out of the Honors mathematics sequence and elected no further mathematics courses; whereas the majority of men (54%) dropped out of Honors mathematics but continued in non-Honors mathematics. Gender differences in experience and choice revealed by the study appear to be based on differences in perception, not in ability.

*The full report of this study can be obtained from the Center for the Education of Women, 330 E. Liberty, Ann Arbor MI 48104-2289; cost $12.00.
The second study used survey methods to examine the experiences of students who graduated with majors in mathematics and physics in 1990. While this study revealed few gender differences, the differences which did emerge were consistent with those identified in the first study as well as in the research literature. Even among those who completed these majors, women were less likely to find encouragement in their departments, less likely to say professors took a special interest in them, and had slightly lower self-confidence than the men.

The third study involved two focus groups of women graduate students in mathematics and physics. Several themes emerged from the analysis that were again consistent with the literature and the two other surveys. Among them, encouragement from faculty and parents played a key role in the women's undergraduate experiences and their decisions to persist in their studies.

Recommendations for Research:

In order to significantly increase the number of women in science, engineering and mathematics, research universities must play larger roles. This will require concerted effort on the part of faculty and university administrators coupled with government, foundation, and corporate support for innovative intervention and research. Outlined below are recommendations for research which is needed to enhance the knowledge base and improve the effectiveness of intervention programs.

Types of Research:

Carefully designed research is needed to increase our knowledge of the causes of student attrition and to develop effective means of increasing women students' success and persistence. Particular needs include:

1. *Longitudinal studies* which follow students throughout the college years and beyond, and which, in part, emphasize the effects of pipeline and special intervention programs.

2. *National studies* which include a large sample of women, including women of color, women who come from varying socioeconomic backgrounds, and women who attend different types of educational institutions.

3. *Observational studies* which analyze all components of the environment.

4. *Exit interview studies* of women undergraduates who pursued majors in mathematics and physics but who chose not to continue on to graduate school, of women graduate students who discontinued their studies before completing the doctorate, and of faculty women who left the academy.

Topics for Further Research:

1. *Studies of the academic environment* within the sciences, mathematics and engineering.

2. *Studies of instructional methods and course content* to determine if they have different effects on men and women and their decisions to pursue science and/or mathematics.

3. *Studies on the selection of subspecialties* within a concentration to determine whether gender differences exist and, if so, why.
4. *Studies of financial support patterns* for men and women within the physical sciences and mathematics at both the undergraduate and graduate level.

**Strategies for Institutional Change**

Although there is a national need for carefully designed research to steer the course of future programs, we cannot afford to wait for research results before beginning to implement institutional change.Outlined below are steps departments and colleges can take to produce positive institutional change.

1. Systematically assess the present situation, collecting and analyzing comparative data on numbers and rank of women faculty, numbers of women students at each level, levels of available funding for women faculty and students, women’s grade point averages and retention.

2. Systematically engage in departmental self-study to determine: which strategies succeed and which fail; which teachers are most successful in working with women students and why they are successful; what are faculty attitudes; why do women leave the program; what elements of the department climate are most supportive and which are not supportive.

3. Analyze the structure and content of advising to broaden the role of the advisor to that of advocate; train advisors to emphasize expectations of competence.

4. Actively recruit women faculty, graduate students, and majors.

5. Formalize regular means of providing feedback and encouragement to students (e.g. faculty-student conferences, written progress updates).

6. Ensure small class sizes so that instructors are able to give students appropriate levels of attention.

7. Use more experienced faculty to teach introductory courses; use outstanding faculty as master teachers. Restructure the faculty reward system to provide better incentives for teaching undergraduates.

8. Revise the curriculum to emphasize problem solving, model building and the discovery method.

9. Establish more collaborative classroom environments and grading practices; provide students with opportunities for team study.

10. Establish regular mechanisms to sensitize faculty to issues of gender and pedagogy and the means of eliminating gender bias in the classroom.

11. Create a safe environment.

Ultimately, increasing the numbers of women scientists and mathematicians depends upon the actions of academic departments and colleges. Each college and university can begin programs to strengthen the interaction and communication between students and faculty; programs which increase the numbers of women students and faculty; programs which provide an academic atmosphere in which women are expected to succeed and in which sufficient numbers of successful women are visible at all levels; and to revise the curriculum so that all students are engaged in thoughtful intellectual work.