

7 The paradox of critical mass for women in science

At each transitional point the number of women decreases at a significantly higher rate than men. Thus, while women made up 37% of the students taking physics in U.S. high schools in 1988, only 22% of those taking the calculus-based introductory physics course in college were women (AIP, 1988, 1991). Women's presence is reduced to 15% of those receiving the bachelor's degree in physics and then to 10% of the share of Ph.D.s. The decline continues in the shift from education to academic employment, with women constituting 7% of assistant professors of physics and only about 3% of full professors.

What are the effects of such small numbers on the women who persist in scientific careers? A key finding in our interviews was that as the number of women faculty members in a department increased, they divided into distinct subgroups that could be at odds with each other. Senior female scientists typically shared the values and workstyles of older men; their narrow focus failed to meet the needs of most younger women. In contrast, some younger women (and a few men) struggled to create an alternative scientific role, balancing work and non-work issues. The scientific role thus divides along generational and gender fault lines. These developments have significant unintended consequences for the socialization of female scientists – for example, the availability of relevant role models. As long as the relatively few women in academic science were willing to accept the strictures of a workplace organized on the assumption of a social and emotional support structure provided to the male scientist by an unpaid full-time housewife or done without, issues of women in science were not attended to. A modest increase in the numbers of

women in science, without a change in the structure of the scientific workplace, creates a paradox of critical mass.

Affirmative action is expected to clear up blockages in the pipeline but many of these barriers persist. Affirmative action rests, in part, on the premise that a sufficient number of persons from a previously excluded social category is required – a critical mass – in order to foster the inclusion of others from that background. From the 1970s, efforts to increase the number of women in academic science departments have largely resided in affirmative action programs, requiring full consideration of female and minority candidates. However, in the 1980s lack of vigorous enforcement reduced the spirit of the law into a bureaucratic requirement that became a routine part of the paperwork of the academic hiring process, often with little or no effect on recruitment (Nuevo Kerr, 1993.)

A minority group (especially one that has traditionally been discriminated against) is easily marginalized when only a small presence in a larger population; its continued presence and survival is in constant jeopardy, requiring outside intervention and assistance to prevent extinction. As the group's presence and level of participation grows, at a particular point the perspective of members of the minority group and the character of relations between minority and majority changes qualitatively. In theory, the minority is increasingly able to organize itself and insure its survival from within and effects a transition to an accepted presence, without external assistance, in a self-sustaining process. The discrete point at which the presence of a sufficient number brings about qualitative improvement in conditions and accelerates the dynamics of change is known as 'critical mass'.

The magical statistic for a critical mass has sometimes been defined as a 'strong minority' of at least 15%. This implies that there are a sufficient number to have an impact on the majority. But as we shall see in this chapter, it matters what the 15% represents: if it represents women of several nationalities who self-isolate within their own communities, leaving two American women in two unrelated

age in the structure of the scientific mass.

to clear up blockages in the pipeline. Affirmative action rests, in part, on the number of persons from a previous period – a critical mass – in order to foster change in background. From the 1970s, efforts in academic science departments and affirmative action programs, requiring the presence of minority candidates. However, in the past, it reduced the spirit of the law into a mere name a routine part of the paperwork, often with little or no effect.

one that has traditionally been marginalized when only a small number of women are present. The continued presence and survival of a group outside intervention and assistance depends on the presence and level of participation and respect of members of the majority. In the presence of a critical mass, the relationship between minority and majority changes. As the minority is increasing, the majority's survival from within and effectiveness, without external assistance, reaches a discrete point at which the presence of a critical mass leads to qualitative improvement. The dynamics of change is known as 'critical mass'.

A critical mass has sometimes been defined as 15%. This implies that there are 15% of women in the majority who act on the majority. But as we shall see, the 15% represents: if it represents the 15% who self-isolate within their own departments, African women in two unrelated

laboratories unknown to each other, it is a false number. It is also a false number if the departmental culture is so toxic that the freedom to associate with other women is subtly restricted. It is also a false number if the 15% is so dispersed within multiple laboratories that it is not known that there are other women with whom to interact. The outcome in all these scenarios is the perpetuation of isolation. So the precise number is less important than the nature of the response that the new minority receives from the majority – in this case, female scientists from their male counterparts.

Critical mass, the presence of a significant minority whose precise number varies by context, has contradictory effects. Indeed, as underlying conditions improve, the situation of the minority group may appear worse as formerly repressed grievances come out into the open. For example, sociologist Paula Rayman and co-workers (1996) have reported that as a 'critical mass' of women appears in medical school, the rate of sexual harassment cases increases. One explanation is that the rise of empowerment is at work, with women feeling safe enough to file complaints, as well as there being more women available to be subject to harassment!

When women are a token minority they may well fear the adverse consequences of raising controversial issues and complaints. As their numbers increase and they become better organized, women are more likely to avail themselves of redress procedures. At one university that we studied, the affirmative action officer reported an active caseload in the humanities and social sciences but virtually none in the sciences and engineering. She attributed this difference to the 'universalistic' character of science.

However, in our interviews we found women in science and engineering departments with similar complaints. With token numbers and an unorganized presence, these women expected highly undesirable consequences, placing their degrees at risk, if they brought an action. In contrast to the humanities and social sciences, science and engineering departments lacked an organized political support structure at the time of the study, leading women to repress their

grievances and giving their departments a false appearance of gender equity.

In one instance, a woman graduate student at this university contemplated making a complaint against a male faculty member who was discussing pornographic images on a computer screen with his male graduate student. The incident took place in her presence in an office that she shared with the graduate student. She drew back from making an official complaint, fearful of endangering her degree. However, the matter became so widely known within the department that the chair sent out a strongly worded message condemning the practice as unacceptable and warning against its repetition. The chair's response to this incident, which received some publicity on the departmental and nationwide e-mail networks for women in computer science, was an isolated event; the department remained basically unchanged in its treatment of female graduate students.

Change without struggle is less likely than conflict with determined resistance. Under certain conditions, an organizational transformation culminates in minority group members achieving and retaining positions of real power and authority that were previously beyond their grasp. Paradoxically, ostracism of women often accompanies the breaching of gender uniformity, the first stage in the breakdown of resistance to women's participation in science. The initial reaction of men to the appearance of women in a scientific field, research unit or academic department has typically been to ignore them.

When they must be taken seriously because of demonstrated accomplishment, there is often a negative reaction couched as a criticism of a woman's personality or appearance. The fear of ostracism often leads some women in science who have 'made it' to deny the existence of the gender-related obstacles in their path. Calling attention to difficulties that they have managed to overcome could lead to counter-charges that they received special privileges and thereby devalue their achievements. Younger women are often concerned that participating in activities for women in their

department will set them apart; they perceive that men will look askance at this affiliation and are sometimes unwilling to participate as a result.

This finding implies that the minority must attain power to overcome resistance, as opposed to findings that a modest increase in numbers, by itself, results in improved conditions. The support of persons in structural positions of power, or attainment of such positions by members of the minority group, is the key to change. In this view, despite accretion of numbers, it is strategic power that really counts. Despite their apparent success within the existing system, women faculty members struggle with feelings of inadequacy regardless of their status.

As one female faculty member summed up the condition of women in science, 'I guess it's our socialization. I have a lack of self-confidence myself. I guess I've gotten more confident as I get older and take on more jobs like editor in chief of a journal and so on. I still notice feelings of lack of confidence and maybe I'm not good enough to do this. I see it in lots and lots of my colleagues. I see it at the faculty level and especially in young graduate students.' This phenomenon explains why many women, especially junior faculty members, do not feel that they can afford, either socially or professionally, to be activists or advocates for young women students within their departments.

ALTERNATIVE THEORETICAL PERSPECTIVES

Two theoretical frameworks have been offered by sociologists to explain the effects of tokenism: the 'group interaction' perspective and the 'demographic group power' perspective. The group interaction literature indicates that women suffer in work groups where they are present in small numbers. Kanter (1977) argued that minority group members or 'tokens' are less likely to be accepted by members of the majority, a process that she called 'boundary heightening'. In addition, tokens face increased visibility and pressure to perform that negatively affects working conditions and reduces performance. Social contact

with majority members is lessened and when such contact occurs it is often based on stereotypes. Significant differences appear as the ratio of minority to majority members improves.

Spangler, Gordon and Popkin (1978) found that women students in a law program composed of 20% women earned lower grades, tended to select 'ghettos' law specialties and participated less in class than women in a law school with 30% women students. Alexander and Thoits (1985), Gutek (1985) and Konrad (1986) found similar effects on grade point averages, relations between male and female co-workers, and self-evaluation of work. The group interaction perspective suggests that as the proportion of minority members in a group increases, achievement levels improve but not necessarily in a continuous fashion.

Alternatively, the demographic group power thesis argues that a subgroup's ability to gain organizational resources is proportional to its size. Thus, some group power theorists argue that the higher the proportion of women, the greater their ability to improve their share in the distribution of resources. However, while the increase in the size of a discriminated-against sub-group may improve members' ability to influence the distribution of rewards in their favor, it also engenders increased resistance from majority members who expect to suffer corresponding losses.

Indeed, South *et al.* (1982) found that among office workers, as the proportion of women increased, their interaction with male co-workers and the support they received for promotion from male co-workers decreased. Thus, the larger the minority the greater the discrimination against it, causing the culture and experience in different departments to seem impervious to incremental change.

IS CRITICAL MASS SUFFICIENT?

Attainment of critical mass only partly resolves the dilemma of women in academic departments and research units. The fallacy of critical mass as a unilateral change strategy is shown by the fact that female faculty and senior research scientists pursue strikingly different

strategies. Despite some progress, organizational structures within units, and the divisions they engender, continue to isolate women.

Furthermore, the dispersal of women students into male-dominated research groups sustains isolation even when there is a potential critical mass in academic departments. Nor does an improvement in the total number of women in a unit necessarily overcome an underlying situation of subfield fragmentation that further increased the isolation of women.

Quite often a department is divided into subdisciplinary groupings that have little to do with each other. For example, one chemistry department in our sample was so fragmented by area that neither a female faculty member respondent nor the students interviewed had an accurate picture of how many women graduate students were in the department. This fragmentation seems to be especially pervasive in chemistry, more so than in other disciplines studied. When the numbers are low to begin with, once in research groups, women students often do not see one another, and occasionally barely know of each other's existence.

In this environment, small numbers have two implications. First, members of any group characterized by small numbers will have a statistically lower chance of being central figures in different networks. Second, although critical mass is a prerequisite for access into powerful social networks it is not enough on its own, because social networks criss-cross sub-specialties in the field, research topics and geography. Nevertheless, we also found that a modest increase in the number of women did bring about some change in departments.

In this respect, critical mass does work smoothly: there is more support and safety in numbers. A female student observed, 'One good thing is that there were female faculty members. It definitely changes the attitude of how male students react to women. They must take them seriously and this is positive.' When senior females were present, overt male behavior toward women improved (for example, public sexual joking and stereotyping declined) in a threshold effect of critical mass.

THE EMERGENCE OF FEMALE-GENDERED SUBFIELDS

Women who are in positions of power can act as mentors to help bring other women into central networks, rather than leaving them in minor subfields where women traditionally congregate. Of course, what is central and what is peripheral changes over time. We are currently in the midst of a transformation in which the male-dominated physical sciences are being displaced from their scientific and economic central position by biological sciences, both molecular and evolutionary. Women have traditionally made up a larger proportion of biologically related fields.

The concentration of women in subfields is not always voluntary; women are also subtly or not so subtly directed to these fields. It is significant that these areas are usually biologically focused. In chemistry at one university, biochemistry had a significant number of women and the area was connected to the bio-science division. In computer science, many women gravitate to artificial intelligence (AI) where cognitive processes and psychological links are prevalent. In electrical engineering, the bio-electrical subfield attracted the most women.

Biology has evolved sufficiently in its gender composition and character into a field where attitudes toward women have changed. Many informants expressed this as a given: when they were told that we were looking at biology, their assumption was that this field was less problem-ridden owing to the numbers of women present. There is a snowball effect: as the numbers increase in the biologically related areas in electrical engineering, chemistry and computer science, they then attract still more women.

The difficulty in relying on creation of a critical mass of women faculty members in a department as a change strategy is that the faculty members may be unable or unwilling to play the designated role. Nevertheless, even though it is not the whole solution, a significant presence of women on the faculty allows students to become acquainted with female role models, even if some are persons they do not wish to emulate. As one faculty woman put it, 'Women are

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attracting women. The broadcasting of women-friendly environments
 through the grapevine [is a step forward]. Women are being empowered
 as women are increasingly a scarce commodity of departments seeking
 female faculty.' Beyond the creation of women's networks is the issue
 of opening up all networks to female participation.