A Feminist Cognitive Anthropology: The Case of Women and Mathematics

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ABSTRACT *This article is an exploration of the insights a marriage between feminist and cognitive anthropology offers for understanding the scientific gender gap. Using comparative ethnographic and questionnaire data from India, I argue that Indian cultural models of family, gender, and schooling interact with macrostructural features of Indian society (educational, socioeconomic, and occupational) to frame academic decisions, producing a gender-stratified scientific community. I then evaluate the applicability of Western theories to India. I suggest American individualistic models that emphasize internal, female mathematic deficiencies and gender-identity conflicts embody American cultural models of gender and schooling not shared by Indian informants. Indian patrifocal family institutions also do not imply essentialist gender concepts. Finally, I argue American theories of gendered science embody long-standing American cultural models that warrant critical scrutiny.* [gender and science, India, education, patrifocal family, cultural models]

INTRODUCTION

Psychological anthropology, under the leadership of Margaret Mead, provided the first systematic challenge to prevailing American theories of gender. Over 50 years later, although feminist scholarship has flourished within both psychology and anthropology, a feminist psychological

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anthropology is still in its infancy. Within cognitive anthropology, gender has been largely invisible as a focus of inquiry or theorizing, even though cognitive anthropologists have generated research data that lends itself to, indeed cries out for, feminist analysis.[1]

Recent advances in cognitive anthropology such as the work of Holland and Eisenhart (1990) and Strauss and Quinn (1997) suggest that a marriage between feminist and cognitive anthropology is potentially fruitful. Cultural Models theory, in particular, has profound implications for understanding gender systems and the subtle complex and varied processes through which individuals learn and enact gender. Strauss and Quinn's plea that we focus more on how individuals internalize culture, how culture impacts human motivation (see also, D'Andrade and Strauss 1992), and on the role of cultural models in everyday human reasoning is particularly relevant to understanding gendered educational choices and achievements.

One major topic in the American gender-education field is the persistent underrepresentation of women in mathematics, science, and engineering.[2] The following article is an exploration of the insights feminist cognitive anthropology can bring to this issue. I draw on a body of comparative ethnographic, questionnaire, and statistical data from field research I carried out in India (1988–91, 1996). It includes intensive interviews with expert consultants and college students as well as a larger database of questionnaires and short narratives from precollege students in four Indian cities.

I first introduce the issue of gendered science in the United States, briefly describing the problem and theoretical approaches of American scholars. I then take a comparative look at the scientific gender gap in India and describe my own research efforts and key findings. I argue that Indian cultural models of family, gender, and schooling interact with macrostructural features of Indian society (educational, socioeconomic, and occupational) to frame the academic decision process, producing a gender- (and class-) stratified scientific community. But I also note the complex interplay of circumstances that lead an increasing number of girls to pursue science and engineering.[3] I then critically evaluate the applicability of Western theories to the Indian case. I suggest American individualistic models that focus on internal, female deficits, particularly in mathematics, and on gender-identity conflicts, embody essentialist cultural models of gender and schooling that are not shared by my Indian informants. Finally, I question whether American "expert" theories are even applicable to the American data or whether they are premised on "taken-for-granted" long-standing American cultural models that warrant critical scrutiny. Patrifocal family institutions, such as those in India, do not necessarily imply essentialist gender concepts. And societies with fewer social structural barriers, like the United States, may embrace cultural models of gender and gendered science that rest on deep-seated gender identities, dispositions, and abilities.

THE SCIENTIFIC GENDER GAP IN THE UNITED STATES

A continuing issue in the United States is women's underrepresentation in mathematics, science and engineering, hereafter SMET (cf. Adelman 1998). Acronyms have shifted over time. The current version, SMET, includes technology as well as science, math, and engineering. Despite dramatic increases since the 1960s, women in the late 1990s constituted a relatively small proportion of those earning degrees or employed in SMET fields (National Science Foundation [NSF] 2000).[4] Women since 1982 have received over half of all bachelor degrees. Yet, although their total percentage in SMET has also risen (to 47.1 percent in 1996), these figures include psychology, the social sciences, and biology, areas in which women are equal or predominate. Graduate degrees exhibit comparable trends.

The picture is less rosy in the physical sciences and engineering. Women in 1986 received only 12.3 percent of bachelor degrees in natural science and engineering, falling to 9.1 percent in 1991 (Vetter 1995:3) but rising to over 20 percent in the mid-nineties (NSF 2000). Recent increases in the proportion of female graduate students primarily reflect declines in male students entering these fields.

Despite public outcry for more high-technology workers, the gender gap is greatest in computer science and engineering and increases from undergraduate to graduate school. After dramatic growth in the 1970s and 1980s, both the numbers and percentages of women receiving bachelor and master degrees in computer science have steadily declined. Women dropped from a peak of 37 percent of bachelor degrees in 1984 to 28 percent in 1996. In engineering, women in 1971 received less than one percent of bachelor degrees, and efforts in the 1980s to increase female representation produced significant gains. Yet this figure remained under 16 percent until 1994, rising slightly to 17.9 percent in 1996, a period in which male enrollments declined (NSF 2000; Vetter 1995). Higher female attrition rates continue among engineering students, unrelated to academic performance, and despite higher overall female college persistence rates (Adelman 1998). The numerical significance of the engineering gender gap is enormous. Almost 13 percent of all male college students in 1991 earned engineering degrees compared to less than two percent of females (calculated from NSF 2000:215–219).

AMERICAN RESEARCH APPROACHES

Research aimed at understanding this persistent problem has focused primarily on identifying barriers, especially internal, personal barriers, to female participation in science and engineering. Early theoretical explorations in the United States identified mathematics as "the crucial filter" (cf. Stage et al. 1985). Controversy centered over whether women were inherently less mathematically capable. Brain lateralization research was used to bolster the biological argument and searches for biologically or hormonally based superior male mathematical ability persist today (cf. Benbow and Stanley 1980; Bielinski and Davison 1998). Despite sobering critiques by scholars (cf. Bleier 1988; Fausto-Sterling 1992), this approach receives serious and prominent treatment in the scientific and popular press and, thus, by the public (Brannon 2002).

Most researchers, especially feminist educational psychologists and mathematics educators, have explored environmental explanations for the hypothesized mathematics barriers women experience (Fennema and Leder 1990; Hyde and Jaffee 1998). Scholars often view the scientific gender gap as the outcome of socialization processes that psychologically condition girls' academic choices, steering them away from mathematically oriented fields. Academic decisions are made by individuals and guided by individual interests, preferences, abilities, and personal characteristics. Society-level processes underlying individual preferences are rarely delineated or investigated using ethnographic or cognitive anthropological methods.[5] These studies focus on barriers to (vs. motivators for) girls' achievement in mathematics. Significantly, hypothesized deficits and barriers reside in individuals; girls lack "what it takes" psychologically even if the deficits are societally induced.

In the late 1970s, educational researchers began exploring specific sources of girls' differential achievement and participation in mathematics. Particular attention was paid to the impact of socialization-related psychological attitudes, especially gender-identity issues. The stereotyping of mathematics as a "masculine domain" was viewed as having powerful inhibiting effects on females. Doing well in mathematics could impact one's sense of "femininity," creating a problem of "non-congruence" in gender identity for mathematically successful girls and generating anxiety and a "fear of success" (cf. Sherman 1982).

The Fennema–Sherman Mathematics Attitudes scales represent the earliest and most significant systematic effort to assess these factors and their impact on girls' mathematics course taking and achievement (Fennema and Sherman 1976). Using a battery of tests, Elizabeth Fennema and Julia Sherman showed that if one controlled for differential math taking, girls' math achievement equaled that of boys'. They argued that attitudes toward mathematics, especially gender-identity conflicts, were the primary barriers to women's math achievement, keeping them from enrolling in higher-level mathematics courses.

The two researchers developed scales measuring distinct student attitudinal components believed to impact mathematics achievement. The theoretically most significant and discussed scales are Mathematics Anxiety, Attitude Toward Success in Mathematics, Confidence in Learning Mathematics, and Mathematics as a Male Domain. Individual scale items (e.g. "Girls who enjoy studying math are a bit peculiar," "I don't like people to think I am smart in math") are designed to tap female role incongruence and gender-identity issues such as the "fear of success" and anxiety about doing well in math. Additional scales assess student perceptions of the usefulness of mathematics and of mother, father, and teacher's attitudes toward their mathematics performance and ability. A final scale measures effectance motivation, defined as "intrinsic satisfaction from problem solving, distinct from confidence." Questionnaires containing randomly distributed scale items were administered to 9th–12th grade students at four American suburban, Midwestern high schools. Results showed a positive correlation between favorable attitudes toward math (measured by the scales) and girls' enrollment in additional math courses in the 11th grade, controlling for "cognitive" factors (Fennema and Sherman 1977, 1978).

The rationale underlying the Fennema–Sherman Mathematics Attitudes scales embodies the Western psychological, internal self-selection approach to the scientific gender gap previously noted. It also reflects a cultural logic derived from American cultural models of gender (cf. Mukhopadhyay 1980). According to Fennema, "Mathematics is perceived to be inappropriate for girls. It seems logical to believe that when young girls feel mathematics is inappropriate, they will feel anxious about succeeding in it and have more negative attitudes because they must, at least partially, deny their femininity in order to achieve in mathematics." (1984:152) Embedded in this logic is an essentialist concept of femininity (and, implicitly, masculinity) as a deeply rooted, fundamental "core" identity and personality (Brannon 2002). It also entails a concept of gender as linked to intrinsic competencies and activity preferences (including intellectual ability). Without such assumptions, why should competence in a gender-atypical activity produce anxiety or require young women to "deny their femininity"?

Subsequent interviews with senior girls by Sherman (1982) explored gender-conflict identity, especially the "fear of success." Sherman found that girls who had taken a fourth year of math had greater psychological ambivalence and anxiety about "being smart" than other females. This extended beyond mathematics to all "intellectual areas regarded as male domains" (1982:441). Sherman described external and internal pressure for high-achieving girls to "play dumb" around male peers (1982:440). She concluded, "These data confirmed the presence of sex-role conflict and math avoidance as factors in girls' educational and career development" (1982:443).

CROSS-CULTURAL APPLICABILITY OF AMERICAN THEORIES

Virtually all research on gendered science by American researchers has been carried out in the United States, primarily using survey-type research methodologies and the theoretical approaches described above. There is a trickle of non-Western research on gendered science and mathematics including India (cf. Subrahmanyan 1998; Vasantha 1996). But the Fennema–Sherman Mathematics Attitudes scales have not, to my knowledge, been tested in non-European countries. Nor have they been tested even with significant numbers of non-Euro-Americans in the United States (Brannon 2002).

Anthropologists, since the time of Margaret Mead, have used cross-cultural fieldwork to advance anthropological theory and keep psychology "honest" by assessing the extendibility of Western psychological theories beyond the United States. Accordingly, I undertook an anthropological study of the scientific gender gap in India, exploring how the cultural and social context in which science is learned and practiced contributes to the gendering of science. One goal of this research was to assess the applicability of the math attitudinal scales, and the basic theoretical paradigm they reflect, to other cultural contexts, particularly non-Western, non-Judeo-Christian settings.

THE SCIENTIFIC GENDER GAP IN INDIA

All India statistics on female representation in science and engineering, on the surface, seem similar to those in the United States. Despite significant educational advances since Indian independence (see Mukhopadhyay and Seymour 1994), women are less likely to pursue science degrees than their male counterparts (Mukhopadhyay 1994). In 1986, Indian women were barely 30 percent of students enrolled in bachelor of science programs although constituting 38 percent of students pursuing "arts" degrees (social sciences and humanities) and 44 percent of those seeking a bachelor of education (Government of India 1987a, 1987b). By 1995, despite anecdotal reports of dramatic SMET increases, these figures had not altered substantially. Women still constituted about one-third of science students (33.3 percent), whereas they were relatively overrepresented in arts (40.0 percent) and education (43.2 percent; Government of India 1995:17–19).

As in the United States, the Indian science gender gap is most dramatic in engineering and technology. In 1985–86, women were just six percent of those enrolled in bachelor's degree engineering courses and less than ten percent of students at the polytechnic institutes. By 1994–95, even with enormous enrollment gains, women still constituted less than 15 percent of engineering and polytechnic students (Government of India 1995). This gender gap is greatest at the most prestigious engineering and science institutions, such as the Indian Institute of Technology (IIT; Mukhopadhyay 1994; Parikh and Sukhatme 1992).[6]

FIELD RESEARCH IN INDIA AND COGNITIVE ANTHROPOLOGICAL APPROACHES

In 1988, I initiated field research in India to identify and more fully understand the processes that underlie and generate these educational statistics. My overall research and analytical approach has come primarily from cognitive anthropology, especially Cultural Models theory and Ethnographic Decision Modeling.

Cultural models are deeply embedded and internalized complex cognitive structures (cognitive schemas) "that have come to be shared among people who have had similar socially mediated experiences" (Strauss and Quinn 1997:48). Among other things, cultural models provide interpretive and information-processing aids for creating meaning, organizing experience, thinking, feeling, and acting (D'Andrade and Strauss 1992; Holland and Quinn 1987). Recent work recognizes the durability, stability, and shared aspects of culture and the powerful, directive force culture has on individual thought, emotions, motivations, and action. Yet cultural models do not determine thought, behavior, or motivations; rather, they are mental "mediating devices" (Strauss and Quinn 1997). Cultural Models theory allows for culturally patterned behavior and intracultural variability, for varying degrees of sharing of cultural models and for multiple, inconsistent cultural models.

Recent work by educational anthropologists in the United States suggests cultural models play a profound role in school-related experiences and achievement (cf. Stone and McKee 2000), and that ethnic groups vary in their cultural models of schooling (cf. Gibson and Ogbu 1991). Holland and Eisenhart's work, perhaps the most systematic anthropological investigation of American women's academic career choices, exemplifies the value of the cultural models approach (1990). Utilizing creative ethnographic and verbal eliciting strategies, they discover how a pervasive peer group "culture of romance" subtly steers American women toward traditional careers and away from math and science. Their peer group focus and cultural models of romance and school going, however, reflect an American cultural context and American cultural themes and institutions.[7]

Cultural models, as internalized understandings and shared cognition, are deeply implicated in and revealed through language. Recent work identifies cultural models through extensive analysis of ordinary discourse, particularly recurring metaphors, key words, and patterns of reasoning. This strategy replaces an earlier concentration on systematic, detailed, formal analyses of native systems of classification.[8]

Another strategy for tapping cultural models is to elicit and analyze informant narratives of decision processes. Adapted from Ethnographic Decision Modeling approaches in cognitive anthropology (cf. Gladwin 1989), it assumes individuals employ internalized, individualized versions of cultural models in making decisions. I employed this strategy when studying American cultural models of gendered household activities (Mukhopadhyay 1980).

Ethnographic Decision Modeling originally developed in conjunction with anthropological attempts to understand the cultural knowledge and cognitive processes underlying human behavior (cf. Gladwin and Murtaugh 1980; Quinn 1976). Since the 1980s, cognitive anthropologists have been pursuing a wider range of goals, representational devices, and testing strategies (cf. Garro 2000; Weller and Romney 1988).

Modified Ethnographic Decision Modeling remains a useful way to identify cultural models implicated in relatively conscious, frequently discussed, and significant decisions. Academic decisions in India meet these criteria. Schooling is a constant and highly significant subject of discussion, information sharing, and strategizing, especially among urban, education-oriented middle-class families. It is a prominent topic in the public media, and newspapers regularly supply information on, and results of, school examinations and competitive academic events.

APPLICATION TO THE INDIA RESEARCH

My research in India integrated cultural models and Ethnographic Decision Modeling approaches. I approach the scientific gender gap as the outcome of cumulative academic decisions made about individuals (by themselves and by families). I view academic decisions as framed and guided (at varying levels of consciousness) by cultural models that produce culturally patterned and predictable, although not uniform, outcomes. Diverse outcomes partially reflect the application of cultural models to variable circumstances and situations. But decision makers utilize, interpret, and apply cultural models selectively and creatively, in the context of their own circumstances and goals.

I applied this combined approach in the ethnographic phase of this project. I first visited major science and educational research institutions and interviewed over 60 "expert consultants"—individuals whose position and experience gave them an understanding of women's participation in science and engineering. Interviews also provided an all-India overview of the complex Indian educational system, the academic routes (and obstacles) to science and engineering degrees, and access to statistical data and research by Indian scholars.

A second ethnographic component involved two months on-campus residence at a major engineering institution, IIT, Madras (Chennai), with briefer stays at Indian Institute of Science (IIS), Bangalore, and Cochin University of Science and Technology (CUSAT), Kerala state. Participant-observation and focus group and individual interviews with both genders provided information on IITs, academic alternatives, science-related career opportunities, and campus gender issues. I collected 20 in-depth, individual academic career histories, primarily from women IIT students. I also elicited more impersonal explanatory accounts of academic choices and the scientific gender gap from college students, faculty, staff, and other off-campus individuals to whom I had access. I spoke with families (adults and children) well-known to me as well as to strangers such as fellow passengers on busses and trains.

Throughout, I employed modified ethnosemantic and more naturalistic interviewing techniques to identify key academic decision points prior and subsequent to IIT admission and alternative choices and considerations at each decision point (e.g. science vs. arts). I probed the broader circumstances surrounding each decision and recurring terms, categories, phrases, and presuppositions in verbal responses. These discussions provided entry into cultural models of family, marriage, gender, schooling, science, careers, and success. Interviews (in English, audiotape-recorded when feasible) yielded rich verbal data and insights into women's subjective experiences, complex family and gender issues in academic choices, relationships between individual student and family goals, and factors producing variability in girls' (and boys') academic paths.

From this combination of individualized, personal narratives and impersonal, explanatory accounts, I constructed a theory of the scientific gender gap (Mukhopadhyay 1994) and then tested it on an expanded, diverse sample of Indian precollege students. I created a culturally meaningful questionnaire, the Student Academic Decision Questionnaire (hereafter, SAQ), which elicited student information on science related academic choices, hypothesized constraints and decision criteria. It also contained questions on academic performance, family socioeconomic characteristics, students' family responsibilities, and sources of academic assistance; on culturally significant variables such as religious orthodoxy and attitudes toward coeducation, marriage, dowry, and careers; and on other hypothesized influences on science-related academic choices in India and in American theories.

The SAQ also contained a narrative response segment that elicited student "folk explanations" for a set of gendered activities (e.g. hunting, engineering, auto-rickshaw driver). Students also provided images of three types of scientists.

In addition to the SAQ, four survey-type, Western-derived math and science attitude questionnaires were adapted to the Indian scene. One was the Fennema–Sherman Mathematics Attitudes questionnaire described earlier. Questionnaires were administered to 6th-, 9th-, and 11th-grade students at 12 linguistically, regionally, and socioeconomically diverse urban schools in four major Indian cities (Madras-Chennai, Delhi, Bangalore, and Hyderabad).[9] The resulting database contains nearly 5,000 questionnaires from over 1,600 students.

A third phase of the project, supported by the NSF, used the precollege data to evaluate and refine the ethnographic theory of the scientific gender gap. I constructed and tested a simplified formal decision model of science related academic choices using 9th- and 11th-grade student SAQ data. I employed both conventional Ethnographic Decision Modeling testing procedures and statistical tests. I expanded the initial model to include conditions that lead some women to enter science and tested it using multivariate, logistic regression modeling. Finally, I explored contrasts in Indian and Euro-American cultural models of science, mathematics, gender, and causality using the SAQ student narrative vignettes and the four Western-based math and science attitude questionnaires. For detailed results of this testing phase, see Mukhopadhyay (2001).

FINDINGS FROM INDIA: PATRIFOCAL FAMILY AND GENDERED SCIENCE

The theory of the Indian gender gap in science and engineering that emerges from my research contrasts strikingly with American theories described earlier. Briefly, I found three major factors underlie overall Indian gender disparities in educational enrollments as well as the gender gap in science at secondary and college levels. First, educational decisions are treated as family, rather than individual student decisions, involving investment of collective family resources, and guided by collective family concerns and long-term goals. Second, gendered family obligations produce gendered educational expectations and goals for sons versus daughters, leading to educational investments that advantage sons over daughters. Third, family concerns about girls' marriageability, social reputation, and family honor make the education of daughters socially problematic.

These three factors reflect a long-standing and widespread Indian cultural model of family that Susan Seymour and I have termed "patrifocal family structure and ideology" (Mukhopadhyay and Seymour 1994). Among its characteristics are: the merging of individual goals and collective family welfare; structural features (patrilineality and patrilocality) that reinforce the centrality of sons versus daughters; gendered family responsibilities; regulation of female sexuality (to maintain the purity of the patriline) through arranged marriages and restricted male–female interactions; and female standards that emphasize "homely" traits (e.g., obedience and self-sacrifice) conducive to family harmony.

Although other cultural models of family exist in India (cf. Kolenda 1987; Pai 2002), this is a prominent one to which most Indians have been exposed, whether through popular culture, including Hindu epics and mythology, written literature, or personal experience. As such, it provides a significant culturally rooted, conceptual and cognitive framework for thinking about and making educational decisions

Education, especially since independence, is linked to family status (Mukhopadhyay and Seymour 1994). Postindependence India emphasized education, science, and technology. This fueled the enormous expansion of the Indian educational system and the rise in literacy rates, school attendance, and college enrollments. It also produced an academic hierarchy of subjects, with tremendous competition for "seats" in high-ranked fields (applied sciences-engineering) at high-ranked educational institutions. Such degrees provide access to jobs "with scope"—that is, with financial and career advancement potential.

Within the context of the patrifocal family model, educational decisions, whether for sons or daughters, are framed by their projected impact on the collective family welfare. They involve significant family resources, status, and marriage considerations. Families have traditionally viewed boys' education differently than girls'. Because sons have the primary obligation to care for natal families, investments in a son's education benefit the family directly. Daughters are expected to marry, "leave" the family, and acquire obligations toward their husbands' family. Thus, a daughter's education eventually benefits her in-laws, rather than her natal family.

Furthermore, girls' education can endanger the family reputation and her marriageability. Schooling requires going "outside the family" into the male world of public spaces. It can "spoil a girl's character," cultivating traits such as independence that could undermine patrifocality.

In the context of patrifocality and given the limited economic resources of most Indian families, it is generally more "worthwhile" to devote resources to the education of sons than to daughters. Many poor children never attend school or drop out after elementary school. Only a fraction of students obtain college degrees. But these trends are more pronounced for girls (Mukhopadhyay and Seymour 1994). Thus, although daughters receive some education, sons receive more and, when economically feasible, take the subjects prerequisite to entering higher-ranked fields and colleges.

PATRIFOCALITY AND SCIENCE DEGREES

Pursuing science exacerbates these issues by increasing the size of the family investment. Obtaining a science degree, especially an engineering or medical degree at a reputable institution, is more competitive and, hence, more difficult than a nonscience degree (e.g., arts or commerce). Because science seats are limited, entry into science requires academic success early on, so one can take the science streams and subject prerequisites for college science.

Education is "costly," especially at "good" schools—those that best prepare students for exams leading to the limited science seats at "high-ranked" colleges. My relatively well-off expert consultants bemoaned the growth of expensive, highly competitive, academically oriented schools in major urban centers, some requiring entrance exams for first graders! Nevertheless, they felt compelled to give their children every advantage in the race for academic success. Many IIT women engineering students had attended private, academically rigorous, English-language secondary schools. Virtually all came from highly educated, science-oriented urban families.

Pursuing science also exacerbates the social dangers of girls' education and poses exceptional threats to women's marriageability. My informants cited the male-dominated social context of science and engineering as a major constraint on women's participation. In the past, science was unavailable at all-girls schools and even today, especially in rural areas, often requires attending coeducational institutions (cf. Vasantha 1996). Yet same-sex girls' schools are still preferred by many families. Girls wishing to pursue science at higher secondary levels (11th and 12th grades) often face the dilemma of either going "outside" to a girls' school in some other locale or attending a local coeducational school filled with "rough" and "rowdy" boys.

Even in urban areas where girls' schools with science streams are plentiful and girls can live at home, incursions into predominantly male public spaces remain socially problematic. Informants cited persistent family concerns about the dangers of a daughter traveling across town, especially alone and at odd hours (e.g., after dark). Girls living in what they considered the relatively safe South, described risks: the “comments,” the “pinching and that sort of thing, quite common in busses, in streets, and in market places when it’s crowded” and which “of course, prohibits us from going into crowded places.” The associated dangers and risks were not primarily physical. They were social and reputational. On crowded busses, for example, informants were mainly afraid of “creating a scene” should they resist an attempted pinch, especially because some passengers might say it was the girl who “tempted that person.” I was told that even if something “serious” happens, “your parents will ask you to keep quiet because it’ll not be good for your future . . . if you’re not married.” Unless a girl’s family can transport her to school, she must either confront the reputational dangers associated with traveling or attend a closer coeducational school. Or, she may go for arts (or commerce) at a nearby all-girls’ school lacking a science stream.

Expert consultants (and students) cited the lack of “suitable housing” for girls (i.e., socially safe hostels) as a major family concern and a constraint on women entering engineering. Residence in a student hostel may be mandatory, the only choice being whether on a coeducational or all-female campus. Although one can study pure science at women’s colleges, at the time of my research all engineering institutions were coeducational.

At CUSAT, a graduate institution, the girls’ hostel was strategically located next to the administration building, at the opposite end of the campus from the boys’ hostels. Girls were expected to be in the hostel by 7 p.m. unless they needed to be in the laboratory, for which they could stay out “ ‘till ten.” Barring a special program or campuswide movie, after 7 p.m. the campus (including the student cafe) was a virtually all-male world.

At IIT Madras, the girls’ hostel was close to the campus library, far from the boys’ hostel, and distinctly separated from the main road by a long, tree-shaded path. IIT hostel girls would “wander about” in the evening, going to labs, library, and even the campus canteen. Girls described the campus as quite safe. Indeed, it included an entire residential community (staff, faculty, and students) complete with post office, bank, and walled, guarded campus entrances. Nevertheless, even women graduate students said they experienced social discomfort when going alone to the student canteen.

Girls were a distinct minority on campus and were aware of social dangers such as rumors of social impropriety. One informant, the only female in her mechanical engineering class, spent weeks without verbal interaction with other classmates. She (and her classmates, apparently) felt it was inappropriate to initiate casual conversation with the other gender. Ironically, the practice of sharing notes and textbooks sometimes required girls to visit the boys' hostel. Some upper-class women students declined opportunities to go on industrial tours because of the inappropriateness of traveling in virtually all-male company and because there were no "suitable accommodations" (i.e., socially appropriate for an unmarried girl).

For families, the social dangers, and financial costs, of a girl's engineering education are minimized by sending her to a local college, even if she is eligible for a more distant, higher-ranked institution. This was a recurring theme in my expert consultant interviews and in girls' academic life histories. Among my 13 key IIT Madras hostel-dwelling women informants, several were from Madras, others had relatives there, and all but one came from Tamil Nadu or a neighboring state. Virtually all CUSAT hostel students I spoke with were from Kerala, usually nearby cities.

Science and engineering exacerbates the threat that education will "spoil a girl's character." Verbal assertiveness, independent thinking, and leadership were encouraged in CUSAT's graduate management studies program. Some girls from all-women's colleges seemed shocked at the behavior expected of them. "It's totally different in a girls' college. . . . But here, everybody's so aggressive. And unless you are ready to fight it out, nobody's going to stand back and let you go and give you a chance." Women engineering students recounted, sometimes with laughter, their embarrassment at the atypical female behavior required for *practicals* (hands-on workshops), such as donning overalls and learning to do *smithy* (blacksmith) work. Some IIT girls mentioned initial discomfort at participating in sports and other extracurricular activities that required exerting authority over male peers. Yet my informants had adjusted and often welcomed these educational side effects. From the perspective of many families, however, cultivating such traits could pose a marriage risk.

Science and engineering education, according to informants, potentially threatens girls' future marriages in yet another way. "Too much education," especially in high-prestige fields, can make it difficult to find a husband. A boy, I was repeatedly told, should have an equal or higher educational rank than a girl. Rank is not just based on degrees but on subjects. Because science ranks above arts, bachelor of arts degrees present relatively little risk for girls. Science degrees, especially highly ranked applied-science degrees, are more problematic. But an advanced arts or pure science degree can be balanced by a lower degree in an applied-science field. The arranged marriage of one female Ph.D. chemistry candidate at CUSAT was considered appropriate because her spouse-to-be was a higher-ranked M. Tech (master's degree in technology and engineering). To conform to patrifocal models, girls with engineering degrees must find grooms with even higher academic rank, narrowing the pool and increasing any dowry demands.

Patrifocal family cultural models, then, have a more negative educational impact on daughters than on sons, especially when large investment of family resources are required and when social dangers are high, as in engineering and science. Economic considerations affect all children but within the same family, limit girls more than boys. As for marriage impacts, boys' academic success and science and engineering degrees facilitate a "good marriage." For girls, the benefits must be weighed against potential increased risks.

ADVANTAGES OF GIRLS PURSUING SCIENCE

There are also countervailing pressures for daughters' education, generally, and science education, specifically, particularly among families who can afford college education for both sons and daughters. Families increasingly see education as enhancing a girl's marriage prospects, even cultivating attributes consistent with the patrifocal cultural family model (Chanana 1994). Better-educated husbands often prefer more highly educated wives. As more boys acquire education in science and engineering, so can girls without threatening a system of educational hypergamy.

Informants consistently described "earning potential" as a plus in the marriage market, given the rising cost of living and the desire of some husbands for "economic independence." With more jobs at women's colleges and in other "respectable" settings (government offices), an earning daughter-in-law can be an asset. Several informants pursuing engineering-computer science degrees planned to set up small electronics firms with their (future, not yet selected) spouses.

Education can also benefit a girl's natal family. One IIT informant's father initially resisted paying for her graduate education even though she was a "brilliant" student. He was eventually persuaded she could secure a better job and improve her marriage chances with an advanced math degree. Moreover, she would receive a stipend as a graduate student. He even insisted she attend IIT, rather than a local state university, because the IIT graduate stipend was larger and could be used to finance her younger brother's engineering education. A daughter's earnings can also be insurance should she not marry and insulation against pressures to marry. Virtually all my informants anticipated some form of arranged marriage, albeit with their consent and sometimes their help in finding a potential mate (e.g., a classmate!) They seemed convinced their earnings would offset, or at least be a negotiating factor, in dowry demands. At the same time, they felt their degrees would prevent them from being a financial "burden" on their natal families, should they not marry. They did not always feel personally compelled to marry, although not marrying could look bad (socially) and hurt the marriage prospects of younger siblings.

Among highly educated elites, potential social risks of girls' science education may be balanced by the prestige accorded the girl and her family. Educational achievement is highly respected in its own right. I was constantly impressed by the emphasis on academic accomplishment, for boys as well as girls. A brilliant daughter was a source of pride, even when families expressed the concerns described earlier. Relatively conservative family members also apparently appreciated the level of academic accomplishment represented by admission to IIT. And once at IIT, families seemed more willing to allow girls to pursue related, relatively unconventional and socially problematic opportunity paths, such as traveling or living alone in India or even abroad.

For some families, especially relatively nonorthodox, education-oriented urban families, such as those whose daughters I encountered at IIT, CUSAT, and IIS, the benefits of girls' science degrees can outweigh the potential social costs. This is discernible in recent educational statistics (Vasantha 1996), in ethnographic accounts (cf. Seymour 1999), and in my own data.

SAQ EVIDENCE FOR THE ETHNOGRAPHIC THEORY

Given the conditions I have described, a scientific gender gap is predictable.[10] This can be seen in the preferences and future expectations of my precollege-student SAQ sample. A majority of 9th-grade girls (and boys) planned to select the science stream at the higher secondary level, if they had the requisite marks. Yet girls were less likely than boys to choose college science, especially applied-science degrees, and within the applied sciences, were less apt to select engineering than medicine. A similar pattern occurs in the 11th-grade science stream students. Virtually all plan to pursue college science but boys are far more likely to pursue applied (vs. pure) science and engineering (vs. medicine).

SAQ data, however, reveals the complex interplay between socioeconomic and gender rooted constraints on science pursuits. Science choosers of both sexes are socioeconomic and academic elites. They come from families with educational, income, and occupational levels significantly higher than nonchoosers or the sample as a whole. Academically, they have much higher grades in all subjects and attend higher-ranked (and more expensive) schools then the sample as a whole. In statistical analyses, socioeconomic background and academic achievement are the most consistent predictors of science-related outcomes, for both sexes, and are highly correlated. Class, then, seems to compensate somewhat for gender-related constraints among female science choosers.

However, female science choosers are even more socioeconomically and academically elite then their male counterparts and the gap between female science choosers and nonscience choosers, is greater than among the two male groups. Among 11th-grade arts and commerce students, girls have significantly higher marks on all subjects, including math, than their male counterparts. This is consistent with the higher economic and academic constraints patrifocality imposes on girls.

Additionally, in the SAQ sample, female science choosers (and apparently their families) tend to have future expectations that deviate from conventional patrifocality: They expect to marry late (if they marry), work after marriage, and assume financial obligations for their natal family, before as well as after marriage. They cite job-related considerations for their academic decisions. And, although most still expect their families to arrange their marriages, they anticipate a role and that their consent will be required.

Patrifocality also emerges as a factor in the multivariate analysis of 11th-grade student SAQ data. Science-stream girls from less patrifocally oriented families are more likely to select applied (vs. pure) science, pursue engineering over medicine, and try for admission to IIT than girls from families that adhere more closely to the patrifocal family model. This relationship emerges even when controlling for parent education and student achievement.[11]

SAQ data, then, is consistent with the ethnographically derived theory. Patrifocality acts as an additional gender-related constraint, beyond academics and economics, on women's entry into science and engineering, and, within engineering, on entry into prestigious institutions like IIT.

INDIAN VERSUS AMERICAN EXPLANATORY MODELS OF THE SCIENTIFIC GENDER GAP

This theory of the Indian scientific gender gap differs significantly from American individualistic, internal, self-selection expert theories that attribute the scientific gender gap primarily to biological or psychologically rooted internal, female deficits, especially in mathematics and gender-identity conflicts. The primary barriers for Indian women lie in the family context within which science decisions are made, the social context in which science-related activities occur, the social purposes for which the activities are carried out, and the academic hierarchy of subjects, reflecting India's occupational structure. In the Indian context, science, especially the applied sciences and engineering, is socially, rather than cognitively or psychologically, unsuitable for most females.

Indian explanations for gendered science, whether by expert consultants, Indian students, or ordinary families I spoke with, consistently focus on social causation and social context, rather than locating causality in the internal psychological states, character attributes, or intrinsic biological attributes of individuals.[12] Student academic paths are not individual matters but embedded in a family context, guided by family goals and circumstances. Informants repeatedly cited family-related considerations, finances, gender-differentiated investments, and long-term family financial obligations.

Patrifocal family themes permeate precollege-student SAQ explanations for why males predominate in engineering, as seen in these representative accounts: "In India, boys are given higher education so that they can support their parents. In case boys have to leave home for engineering studies, parents let them do that but not with girls." And "boys (their families) can pay capitation fee (school "donation" to facilitate admission). They'll get it back as dowry. Girls can't. It's a waste of money for girls."

Indian expert and folk explanations also emphasize the social attributes of various activities. A recurring theme is the "tough," "dangerous," "strenuous," "arduous nature of the duties" associated with engineering. On closer examination, each term indexes the social (not physical) difficulties associated with engineering, especially the prototypic civil engineer at "camp." What makes it a tough, heavy, strenuous, and arduous job is the rural or isolated location and the socially improper (sexually unsegregated) living facilities and required behaviors (supervising rowdy male laborers). So social attributes of jobs associated with engineering degrees can eliminate that degree as a viable option. Some employers cite these reasons for not hiring women.

Expert consultants of both genders also attributed the scientific gender gap to the historical "social oppression" of women in Indian society. Men as well as women spoke with apparent empathy and a sense of injustice of the social barriers women had encountered, the unwillingness of schools or employers to admit or hire women scientists and engineers, "male chauvinism," the preferential treatment of sons over daughters, and traditional fears of educated daughters-in-law. Precollege-student SAQ accounts echo these themes: "parents get their daughters married and kill all their ambitions thinking they are the property of their to-be-husbands."[13]

MATHEMATICS AND INTELLECTUAL INFERIORITY

Perhaps most striking in Indian accounts of the scientific gender gap is the virtual absence of American-style arguments about male intellectual superiority and female intellectual deficiencies. According to two prominent Indian women social scientists, Indian men do not believe women lack the ability to enter science and engineering or any Western field, for that matter.

The "math as a masculine domain" notion, so pervasive in American theories, produced surprise, laughter, and bewilderment when I described it to Indian informants. They were unfamiliar with the argument and almost shocked that anyone would suggest women were intrinsically less capable than men at higher mathematics. They found the brain-differentiation theory startling. They were astonished by the idea that mathematics was a purely masculine domain and that female mathematics competency could produce gender-role identity conflicts. They pointed out it was well known that girls perform extremely well in mathematics, are uniformly "toppers" on statewide exams, which "anyone" could see by looking at the newspaper. They told me about famous female mathematicians in Indian history. They cited case after case of "brilliant" girls in mathematics. And IIT informants argued, accurately, that a majority of students in the prestigious masters of science program (mathematics, physics, and chemistry) were women!

My informants did not argue for the intrinsic mathematical superiority of females. Rather, they rejected the concept of inherent gender differences in mathematical ability. Some said the girl toppers simply worked harder than boys because they were not involved in politics or other extracurricular activities. Others attributed girls' lack of mathematics achievement to laziness or a casual attitude toward school caused by lack of family pressure and job orientation. A Bangalore sociology professor argued that science stream required harder work, noting female arts students often come from "conservative families. Their families feel if they get too much education, then they can't get married. . . . It's not that they are *not* bright. They just don't want to work hard. They are not motivated. They don't see any need to work hard."

Informant accounts, like SAQ data, suggest that patrifocality can depress female academic achievement (and in mathematics, specifically) by reducing the motivation to succeed. Similarly, interest in a subject such as mathematics is generally perceived as being fueled by the long-term outcomes associated with that subject. In the words of three sisters, "If we cannot get the jobs, we will have no interest (in the subjects one must study to get such jobs)."[14]

Informants were puzzled by the idea that anyone, boys or girls, would fear academic success, experience anxiety about doing well in mathematics (vs. about failing!) or experience internal gender-identity conflict from academic achievement, especially in mathematics. Why would girls be afraid of success, they queried, given the associated prestige? I did not find any evidence that girls, even in coeducational schools, felt pressure to "play dumb." My expert consultants were surprised this happened in the United States.

Expert consultants noted that it was socially inappropriate for individuals to brag about their own accomplishments, perhaps girls more than boys. And some high-achieving girls reported being teased and called "mugpots" by male peers in coeducational schools. But this seemed to be a social discomfort issue not a gender-identity conflict. Girls, generally, are not supposed to draw unnecessary attention to themselves. Yet others can celebrate their academic success and numerous public vehicles exist for bragging. Exam scores and admissions to top educational institutions are published in the newspaper, are public knowledge, and are widely discussed. Families openly share academic success stories (and are silent, even embarrassed, by mediocrity or failure).

Consultants found many statements in the Fennema–Sherman Mathematics Attitudes test curious or difficult to interpret, such as "I would expect a woman mathematician to be a masculine type of person," "When a woman has to solve a math problem, it is feminine to ask a man for help" or "Women certainly are logical enough to do well in mathematics." Their puzzlement is understandable. There is simply no culturally logical basis for the American-type theory.

FENNEMA–SHERMAN MATHEMATICS ATTITUDES QUESTIONNAIRE RESULTS

As expected, Indian results on the Fennema–Sherman Mathematics Attitudes questionnaire are more consistent with Indian than with American cultural models of gender (notions of masculinity and femininity), school-going (i.e., nongendered, the considerations that enter into academic decisions, or goals), and gendered science (why males predominate in science; cf. Tables 1–2). Indian-student math attitudes appear to be highly socially embedded, linked to family attitudes and perceived social consequences. Thus, students who perceive their parents as having positive attitudes (toward students' math performance) score high on success and usefulness of math scales. These relationships are much stronger than

Table 1. Comparison of Means, Standard Deviations for Indian and U.S. Populations; by Gender, Grades 9 & 11[1][2]

		INDIA		U.S.		INDIA		U.S.	
Grade		Female	Male	Female	Male	Female	Male	Female	Male
		CONFIDENCE IN LEARNING MATH				MOTHER			
9	Mean	41.52	45.36	41.66	44.05	43.91	48.10	43.86	45.85
	SD	7.43	7.89	9.99	8.69	8.29	7.10	7.90	6.15
11	Mean	39.93	42.75	42.50	45.58	41.79	45.93	44.77	45.76
	SD	7.74	9.37	9.58	8.54	7.56	8.43	6.94	6.89
		FATHER				SUCCESS IN MATHEMATICS			
9	Mean	45.45	49.73	44.72	46.76	43.36	45.53	47.24	46.74
	SD	8.61	7.69	7.91	6.86	7.72	7.48	6.78	6.02
11	Mean	43.69	47.77	46.50	46.99	41.83	44.63	47.96	47.60
	SD	7.89	8.56	7.95	7.22	7.89	7.41	6.25	6.30
		TEACHER				MATH AS A MALE DOMAIN			
9	Mean	41.03	42.89	41.69	42.57	43.47	41.94	52.94	45.24
	SD	7.22	7.72	7.32	6.68	7.19	7.04	5.98	7.78
11	Mean	40.10	39.83	42.66	43.01	42.20	41.90	54.93	45.78
	SD	7.16	8.81	7.11	7.21	8.20	8.48	4.43	8.15
		USEFULNESS OF MATH				EFFECTANCE MOTIVATION			
9	Mean	42.47	47.15	45.68	46.90	40.52	43.58	38.48	38.78
	SD	7.92	7.89	8.56	7.62	6.85	7.11	9.09	7.75
11	Mean	41.14	45.86	46.77	47.84	39.49	41.50	39.90	41.04
	SD	7.90	9.41	6.49	7.57	7.00	8.38	8.29	8.00

Table 1. (continued)

		INDIA		U.S.		INDIA		U.S.	
Grade		Female	Male	Female	Male	Female	Male	Female	Male
		MATHEMATICS ANXIETY							
9	Mean	39.65	42.39						
	SD	7.26	8.60						
11	Mean	37.64	41.24						
	SD	7.18	8.88						
9–12th comb.	Mean			37.32	40.20				
	SD			14.88	14.04				
Sample n	11th	441	234	169	199				
	9th	179	140	219	194				
	Anxiety Only			187	183				

[1]Source of U.S. data: Fennema-Sherman 1976:15–16. Original tables contain 10th and 12th grade data also. No significance levels were given for the U.S. data. Fennema-Sherman originally created 9 scales but eliminated anxiety because it was so highly correlated with confidence. Other scales were found to be independent. In the Indian data, anxiety-confidence scales are intercorrelated but not appreciably more than other scales.

[2] Higher mean scores reflect more math positive attitudes. On the Masculine Domain scale, higher scores will reflect **less** agreement with the math as masculine domain premise. Each scale consists of 12 statements (6 positive, 6 negative) related to the underlying concept of the scale. There are five possible responses for each item: strongly agree, agree, undecided, disagree, or strongly disagree. Responses are coded from 1 to 5 with higher scores given to responses that the authors feel express more positive attitudes and impacts on math achievement. Thus, a total of 60 points is possible on each scale (12 items, up to 5 points each).

Table 2. Scale Correlations for U.S. data and Indian data, by gender [1]

	Anxiety		Confidence		Mother		Father		Success		Teacher		Male		Useful	
SCALE	Male	Fem	M	Fem	M	Fem	M	Fem	M	Fem	M	Fem	M	Fem	M	Fem
Confidence in Math (C)																
India	.76	.71														
U.S.	nd*	nd														
Mother (M)																
India	.34	.52	.50	.60												
U.S.	nd	nd	.38	.48												
Father (F)																
India	.40	.47	.58	.61	.78	.79										
U.S.	nd	nd	.34	.38	.57	.65										
Math Success(AS)																
India	.33	.45	.53	.55	.60	.71	.64	.75								
U.S.	nd	nd	.37	.23	.42	.33	.35	.33								
Teacher (T)																
India	.55	.59	.61	.63	.49	.61	.50	.59	.50	.58						
U.S.	nd	nd	.61	.64	.45	.52	.37	.46	.39	.32						
Math as Male Domain (MD)																
India	.15	.43	.28	.52	.33	.70	.38	.76	.45	.78	.14	.56				
U.S.	nd	nd	.23	.22	.23	.25	.18	.23	.30	.34	.38	.25				
Usefulness (U)																
India	.46	.54	.67	.66	.64	.73	.67	.70	.62	.63	.54	.59	.38	.64		
U.S.	nd	nd	.46	.44	.53	.58	.51	.58	.40	.36	.50	.44	.27	.25		
Effectance Motivation (E)																
India	.54	.53	.69	.62	.52	.58	.55	.58	.48	.52	.55	.50	.31	.55	.62	.56
U.S.	nd	nd	.66	.61	.37	.46	.33	.37	.40	.34	.53	.50	.23	.17	.50	.55

[1]Sample: India Male n = 374 Female n = 620. U.S. Sample: Males = 644 Females = 589 U.S. Data Source: Fennema-Sherman 1976:18 Significance levels for Indian correlation coefficients: males all <.002, females: all <.0000, one-tailed. No data are available for U.S. *nd = no data given in Fennema-Sherman 1976, 1977.

in the American data. For example, the correlation between father's attitude and student's attitude toward success is .75 for Indian girls, and only .33 for American girls. Instead of the eight independent attitudinal scales in the Fennema–Sherman formulation, the Indian scales are highly intercorrelated (see Table 2), and the factor analysis yields only one prominent underlying factor.

Gender differences in the Indian data are widespread but most dramatic on scales that tap gendered family educational expectations: father and mother's attitudes and the usefulness of math (see Table 1). There are much smaller differences on success, confidence, anxiety, and effectance motivation scales. Surprisingly, there are no statistically significant gender differences on the math as a male domain scale. For girls, math as a male domain is highly correlated with every other scale but, contrary to the Fennema–Sherman theory, the lowest correlation is with anxiety (r = .45).

Given contrasting Indian and Western psychological models of gender, I expected Indian students to have difficulty with the math as male domain questions. Indian responses patterns on individual items, however, indicate students managed to reinterpret most items through an Indian cultural lens. Fennema and Sherman identify three dimensions of their scale. The first is "the relative ability of the sexes to perform in mathematics" (1976:3). Indian students, regardless of gender, overwhelmingly rejected statements that mathematics is intrinsically a male domain, that females are less mathematically capable, or that "mathematics is for men; arithmetic for women." The second dimension, "the appropriateness of this line of study for the two sexes," is interpretable through an Indian framework of social appropriateness (e.g. "studying mathematics is just as appropriate for women as for men.")

The third dimension, "the masculinity/femininity of those who achieve well in mathematics" (Fennema and Sherman 1976:3), is most embedded in American gender ideology. It is these items ("It is feminine to ask a man for help," "Girls who enjoy studying math are a bit peculiar") that display chaotic student response patterns and large numbers of "undecided" responses (coded "3" in the American study). These items depress the overall internal coherence of this scale.

Yet there are enough culturally interpretable (and reinterpretable) items to produce a scale that is relatively reliable and exhibits interscale correlations consistent with Indian cultural models. The math as a male domain scale, in the Indian context, does not assess psychological identity issues. Rather, I believe it mainly taps patrifocal cultural models about the social appropriateness of mathematics study (and associated degrees) for girls, models familiar to both genders. Thus, if a girl's parents feel mathematics is something their daughter should (even must) do well in, she will tend to hold similar attitudes (about usefulness, success, and confidence) and not think of mathematics as a masculine domain. Similarly, the attitudes toward success scale taps variations in the value placed on success, rather than fear of success.

Finally, analysis of 11th-grade math attitude scales by academic stream finds science and commerce (vs. arts) students significantly more math positive on all nine scales, regardless of gender. But there are also statistically significant stream-gender interaction effects for every scale except math as a male domain. Female arts and commerce students have significantly higher scores on five scales: mother's attitudes, father's attitudes, teacher's attitudes, success, and usefulness. But there are weak or no gender differences on confidence, anxiety, and effectance motivation. In essence, girls with equally math positive attitudes are more likely than males to be in lower-ranked nonscience, academic streams (Mukhopadhyay 2001), consistent with patrifocal related constraints on girls' academic pursuits.

CULTURAL MODELS IN AMERICAN EXPERT THEORIES

My research indicates American psychologically oriented theories of the scientific gender gap are not extendible to India. This is partially caused by differences in the Indian and American cultural context. But it may also reflect internal weaknesses stemming from taken-for-granted cultural models and causal explanatory models in these theories.

American theories of the scientific gender gap resemble long-standing Western models of the sexual division of labor (see review in Mukhopadhyay 1980). Such models have conventionally used biological or psychologically rooted gender-specific abilities (strength, manual dexterity, or color-sensitivity) or deeply embedded personality traits (nurturance, aggression, or courage) to explain gendered activities (hunting, typing, interior decorating, nursing, fighting wars, or leading nations). Using gendered brains (or mathematics capability) to explain contemporary high-status, male-dominated activities like engineering is a high-tech version of this same model.

These theories, however, draw on a more fundamental American cultural model of how activities are allocated (Mukhopadhyay 1980), what I call "the best man for the job" model. This is a competency-based model in which personal characteristics of performers are matched to activity requirements. Motivationally, the primary goal of decision makers seems to be to optimize production through efficiently matching workers and activities. Implicit is a merit-based (and, hence, fair) labor allocation system: the "best (most competent) man gets the job." The meritocracy and justice claims are bolstered if performer competencies (whether of an individual or a group) are "natural abilities," rather than acquired traits. This model has been used to justify racial inequality. When applied to gendered activities and occupations, it suggests a rational and just sexual division of labor.

A professional-employee oriented version of this model can be found in American stories of occupational choice (Linde 1993) whereby personal ability and psychological adjustment determine one's professional path. In these accounts, personal preferences and interests flow out of natural abilities, deeply rooted psychological orientations, or character traits. More fundamentally, informants employ a cultural model that matches individual personal attributes with job attributes (finding "the best career for the person").

The generic performer-task, attribute-matching model can accommodate a wide range of attributes, activities, and careers. It can generate theories of gendered science that rest on gender differences in mathematics or in "autonomous learning behaviors" (Fennema and Carpenter 1998), even if the outcome of socialization processes.

Traditional American cultural models of the sexual division of labor, however, also draw on an oppositional, bipolar, essentialist, naturalistic (or nearly equally immutable psychological developmental) cultural model of gender. Gender attributes are mutually exclusive, opposite values on a set of dimensions, especially physical, intellectual, and personality dimensions (cf. Brannon 2002). In this "opposite sex" view of gender, if men are strong, women are weak; men are independent, women are dependent; men are hard, angular, tough, and rough and women are soft, round, and smooth. This oppositional view is revealed in how ordinary Americans talk about gendered domains in book titles (Mars vs. Venus), clothing colors and textures (rough-dark-leather vs. smooth-silky-pale), and even alcoholic drinks (Mukhopadhyay 1980). It is expressed in old stereotypes of male and female homosexuals as reverse-gendered persons, reflecting Freudian-based cultural models of personhood, gender, and sexuality.

American-gender models, perhaps because they are oppositional, tend to be female-deficit models, especially for highly valued traits. Accounts of male competence presume female incompetence. Semantically, this is conveyed by references to females being unable or incapable of doing a particular activity, whether it be hunting, fighting wars, or doing mathematics.

American expert theories of gendered science (and gender-education overall) reflect cultural models of human capacities, psychological development, and academic achievement that may be culturally specific.

Why are only some academic competencies deemed abilities (e.g., math vs. history) and others labeled skills (typing)? In common American parlance, males end up with capacities and abilities whereas females end up with skills or task-appropriate personality traits. And what cultural theories of learning and academic achievement (and "innate" ability) lead American educational researchers to treat "achievement" (e.g., grades) as a "control" rather than a "dependent" variable, relative to socioeconomic factors?

These American cultural models and semantic suppositions do not seem shared by Indian informants. Conceptions of gender in Hinduism, I have argued (Mukhopadhyay 1982), are not fundamentally oppositional or naturalistic and essentialist. Indian SAQ explanatory accounts of gendered activities that assert one gender's competence or greater suitability for an activity lack modifiers implying the incompetence of the other gender. The other gender may have the same potential capacities but "can't do it" because of social contextual factors, such as having to earn a living, being busy with other tasks, or social dangers of the setting in which the activity takes place. References to inherent mechanical or mathematical superiority of males, to psychological deficits or gender-identity conflicts, are virtually absent from Indian student accounts. The occasional exception reflects exposure to Western sources, such as *Science* magazine articles on gender and mathematical "ability."

Perhaps the most striking characteristic of American expert models, especially compared to Indian cultural models, is the relative absence of social context. It is as though individuals select (or are matched with) activities, academic subjects, and occupations in a social void, in a social contextless world of infinite choices, constrained only by one's natural (or in feminist accounts, socially acquired) abilities, predispositions, and personal preferences. Absent are economic or social constraints, social groups within which choices are made, and social purposes for which activities are performed.[15]

One odd feature of American expert models is their almost exclusive focus on ability and interest in explaining educational choices, ignoring the fact that students often take courses because they are prerequisites for pursuing preferred degrees and careers. In short, mathematics is often simply a means to a longer-term goal, a substage in a larger sequence of activities (cf. Burton et al. 1977).

In the United States, as in India, activity sequences occur in social contexts, performed as part of social obligations such as "providing for the family" (Mukhopadhyay 1980). Trying to understand gendered academic decisions, math taking, and math achievement, without this larger activity and social context can lead us astray.

CAN AMERICAN THEORIES EXPLAIN AMERICAN DATA?

I am suggesting American psychological theories of the scientific gender gap may be so mired in taken-for-granted, long-standing American cultural models that they are preventing alternative perspectives from being explored. One example is the "mathematics as crucial filter" theory of the gender gap in the physical sciences and engineering. There are many reasons to believe this theory is inadequate even for the American data.

First, American gender differences in mathematics (test scores, course taking, and math degrees earned) are small and cannot plausibly account for the far-greater gender gap in physical sciences, engineering, and technology. The gender differential in mathematics has been virtually eliminated over the past decade although it persists in engineering and computer science (Vetter 1995).

American data on gender and mathematics, (and other measures of intellect) exhibit two types of gender gaps. Males both outperform and underperform females. Males are overrepresented among the highest and lowest scorers on mathematics achievement and other measures of intellectual ability. Theorizing has focused almost totally on male "superiority" and seems inapplicable to the other side of the performance coin, male "inferiority."

Also questionable is the applicability of American theories to all ethnic groups in the United States. Vetter (1995) finds the gender gap in engineering greater among Euro-Americans than all other major ethnic groups: Asian Americans, Hispanics, Native Americans, and African Americans.

Second, analysis undertaken in this study, comparing American and Indian students attitudes on mathematics, using the Fennema–Sherman Mathematics Attitudes scales, are intriguing (see Tables 1–2). Most striking is how little support the American data provide for the Fennema–Sherman theory. Males and females look remarkably alike, even on the scales designed to measure gender-role incongruency. There are no statistically significant gender differences on anxiety or attitudes toward success. Numerically, girls have slightly more positive attitudes toward success than boys—and both are very positive.

The only significant American gender difference is on the math as a male domain scale. But girls in the American sample overwhelmingly reject negative statements in the scale and display positive attitudes toward math as a subject for girls (see Table 1).[16] It is American boys who are more apt to think of mathematics as a male domain.

This suggests that in the United States, as in India, external and often explicit social influences, rather than internal identity issues, may steer girls away from mathematics and math-oriented fields. In the American context, however, it is male peer pressure combined with the culture of romance that seems to constitute a powerful and recognizable social constraint on female math-related behavior, leading some girls to “act dumb” (cf. Holland and Eisenhart 1990). Perhaps marriageability considerations are academic barriers for American as well as Indian girls!

One could argue that Holland and Eisenhart’s culture of romance is one aspect of an American model of marriage (Quinn 1992), itself linked to American cultural models of family, gender, and work (Mukhopadhyay 1980). I suggest that patrifocal elements, especially gendered primary responsibilities for family income production and child rearing, persist in American cultural models and are lurking in the background as additional social factors in girls’ math attitudes, motivations, and levels of participation and achievement in mathematics and in mathematics-associated fields.

Academic and career choice models can affect academic motivation and persistence. If academic decisions are primarily guided by finding a good person–academic subject match, poor or mediocre academic performance or lack of interest signifies a poor match, reducing one’s motivation to persist in the field. American boys, socialized into the “provider role,” may emphasize other choice considerations (like access to future job opportunities). This could account for their greater persistence in math, engineering, and science, even when student grades are equal. For girls, poor grades (or boredom) may signal an intrinsically poor “person-activity” match and legitimate grounds for switching fields to find a “better fit.”

Finally, there is the persistent popularity and pervasiveness in American public culture of essentialist biopsychological explanations for everything from race and academic achievement to individual career choice, spousal infidelity, rape, and sexual preference. In gendered subjects like math, the apparent “mismatch” some females experience can evoke and reinforce long-standing cultural models of female mathematical or technological inferiority. Males, on the other hand, would not have this explanatory schema available (except perhaps African Americans or other groups that have been similarly stereotyped).

AREAS FOR FURTHER EXPLORATION BY FEMINIST COGNITIVE ANTHROPOLOGISTS

The preceding material suggests many areas for further exploration. We need to look more closely at the social context of gendered academic decisions and their linkages to cultural models of kinship and marriage.

Family, as a social context of learning and academic goal setting, has been surprisingly ignored, especially in the American research literature.

We need to explore the processes through which individuals internalize and utilize what Strauss and Quinn (1997) call "public culture" as it relates to gender, schooling, academic subjects (mathematics, science, etc.), family, kinship, and marriage. We need to understand more about how and why some messages have more motivational force than others, for some girls more than others, and how they mediate math and science attitudes, achievements, and choices.

We need in-depth, cognitively oriented studies of how individuals, females as well as males, think and feel and make academic and career choices and the impact of relevant social influences (peers, family, and teachers). We need to investigate the phenomenon of playing dumb and its intersection with other dimensions of American gender models (e.g., authority). We need to investigate student concepts of success, intelligence, anxiety, mathematics, technology, and engineering through cognitive, narrative methods, rather than through using forced-choice surveys developed by experts steeped in American theory.

We need to critically evaluate the language and assumptions embedded in American expert theories of gendered science and mathematics, psychological development and personhood, and especially the notion of gender identity. We need to examine the gendered motivational and performance impacts of alternative ethnotheories of academic achievement and of academic and career decisions.

One goal of a feminist cognitive anthropology would be to better understand the process through which minds become gendered. I do not refer simply to the development of American theories of gendered minds (brains, conscience, ways of thinking and feeling, or empathy), although this is also important (cf. Strauss this issue). I refer instead to the actual process through which males and females, exposed to and expected to know about both sets of gender-appropriate cultural models, internalize and learn to experience and act in the world in ways socially appropriate to their own biologic sex. Pursuing such questions will also have bearing on how individuals handle, store, process, and utilize multiple cultural models.

In addition, American cultural models of gender are entering the public culture of non-Western societies. American expert theories, especially in psychology, are inserting themselves into other cultures through academics trained in the United States (see Seymour chapter in this issue), through American textbooks (often outdated and prefeminist) and scientific journals. Popular media disseminates American public culture to an even wider and less-sophisticated audience. The spread of the English language is a cultural influence, as cognitive anthropologists have long known. This is complicating the process through which individuals learn about and construct gender.

CONCLUSION

A major contribution of anthropology has been to expand the boundaries of current theorizing in our own and other academic disciplines through carrying out research in non-Western cultural contexts. A feminist cognitive anthropology can play this role in psychological and educational theorizing about gendered science and mathematics. Introducing cross-cultural data from India challenges the extendibility and universality of American theories and forces us to consider alternative theoretical paradigms that might be applicable in other cultural settings.

Equally important, applying a feminist cognitive anthropological perspective forces us to more critically examine the fundamental assumptions and cultural models embedded in American expert theories. Cultural models, in the heads of experts as well as ordinary folk, act as mediating structures for reasoning about and constructing theories of gender, science, and mathematics. Systematic analysis of American expert theories can reveal long-standing American cultural themes and understandings that have permeated American theorizing about gendered mathematics and science. A feminist cognitive anthropology can, therefore, contribute to the unraveling of deeply embedded, culturally shared, and individually enacted and experienced expert and popular American cultural models that have dominated American discourses about gender for at least the past 150 years.

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NOTES

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1. Ironically, cognitive anthropologists were among the first to theorize about gender (cf. Quinn 1977). See also Seymour's introduction to this special issue.

2. In using *American,* I follow here the rather nationalistic convention of equating it with the United States.

3. Indian convention uses the terms *girls* and *boys* when talking about college students.

4. I have tracked NSF statistics since 1988. For historical data, I rely primarily on NSF's most recent report (NSF 2000) because some figures differ from other NSF or American agency data.

5. Educational researchers are now focusing more on classroom processes and "chilly climates." An exciting body of feminist science research explores the "culture of science" itself. Yet this work also partially embodies American psychologically oriented approaches, emphasizing the "masculine" nature of science and the resulting psychological barriers to female participation.

6. Indian women are only about one-third of all college students versus over a half in the United States. So the Indian college-level SMET gender gap is actually less than in the United States.

7. This applies to Eisenhart's more recent fascinating explorations into American women's involvement in science "at the margins" (Eisenhart and Finkel 1998).

8. See D'Andrade's (1995) useful review of cognitive anthropology. See Kronenfeld (1996, ch. 2), for an anthropological linguist's perspective on Cultural Models theory.

9. Questionnaires were administered to representative class sections at each school. All classes were to complete the SAQ; other questionnaires were prioritized and administered when conditions permitted. SAQs versions were created for 6th-, 9th- and 11th-grade "standard" students, in English, Hindi, and Kannada. Regional differences in results do not appear when similar school types are compared (e.g., Central Government vs. Municipal Schools).

10. Statistical analysis of SAQ data has produced extensive support for the ethnographically derived theory of gendered academic decision processes, particularly of science-related choices. However, given space limitations and the goals of this article, the following sections simply summarize some key findings without supplying detailed statistics and tables. These are available in Mukhopadhyay 2001.

11. Patrifocality was reconceptualized into four, independently varying, composite measures: sexual division of labor (mainly future job expectations), male–female interactions–sexual segregation (attitudes and behavior), family investment in education, and degree of orthodoxy (religious and household arrangements). Each measure was a composite of relevant SAQ questions. They were combined in the logistic regression analysis. But they are not highly correlated and only sexual division of labor and sexual segregation significantly impact science outcomes.

12. This is not quite fair. Indians sometimes cite such traits but without assuming biological-developmental origins (see Mukhopadhyay 2001, ch. 4). Indian cultural models of schooling resemble other "Asian" cultures, de-emphasizing individualism (vs. collectivism) and intrinsic ability (vs. effort). However, I find these dichotomies too simple for the Indian data. For example, posing the alternatives as "effort" versus "intrinsic ability" still focuses on the individual, whereas Indians instead talk about the social basis of educational choices. Academic success (or failure) may also be attributed to one's previous life! Theories for individual achievement (as among siblings in one family) may differ from those applied to groups (e.g., gender). Collectivism and individualism are also not necessarily oppositional; a "merging" (vs. "subordination") of personal with family goals seems to characterize what I found in India.

13. Similar explanatory themes emerge for other male-dominated activities: "Men hunted because women were not allowed to come out of their houses and roam about in forests."

14. Once again, in the Indian context, "effort" (and "interest") have social (and perhaps other) causes and are not sufficient explanations for achievement.

15. I am oversimplifying and overgeneralizing both Indian and American cultural models and academic processes to highlight the thematic contrasts that I found.

16. As noted earlier, higher scores on the male domain scale reflect greater rejection of the scale concept.

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