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ABSTRACT

Investigated were those long-term processes which contribute to high rates of attrition for women out of mathematics. It is based on the contention that university students drop out of mathematics as a consequence of prior socialization, educational career contingencies, and goal commitment and career aspirations, with the mix of these factors different for men and women. A life history approach was used, tracing any pattern of participation throughout a person's life which could be regarded as an aspect of the decision processes. Related literature is reviewed and the theoretical framework is described in chapter 2. Chapter 3 describes the procedures used to gather and organize information. Chapter 4 presents sample background characteristics, while chapter 5 lists the major findings. Neither ability nor sex alone can account for the attrition process; rather, it is caught up in a complex pattern of interactive effects. These are presented in some detail (including 11 statistical tables) and conclusions are drawn in the final chapter. There is a 25-item bibliography and sample interview questions are included in an appendix. (MNS)

Program On Women

ATTRITION FROM MATHEMATICS AS A SOCIAL PROCESS

Final Report to the National Institute of Education

"Attrition Processes out of Mathematics
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TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION

Very few women in the United States who pursue careers outside the home do so in the field of mathematics. A host of cultural, social, interpersonal and, as some have tried to argue, biological factors have deflected them away from such careers. These factors have existed for years, and regardless of the rhetoric of hope expressed during recent times, they continue to have their effects. The proportion of Ph.D.'s in mathematics who are women has remained at 10% or less for most of this century.

The large scale research projects conducted during the past two decades on sex differences in mathematics have established that junior high and high school are critical turning points. Females shy away from the masculine domain of mathematics presumably because it conflicts with their emergent identities of being feminine and because they relate less well than males to logic and deductive thinking. While the flavor of some of these notions are passe', they have received empirical support in studies that underscore the importance of social processes, including the role of significant others, support systems, career goals, and self-evaluation in sex differentiation in mathematics.

Our research during the past two years follows our previous study (Maines, et. al, 1981) to help uncover those long-term processes which contribute to high rates of attrition for women out of mathematics. The theoretical position in which the present study was grounded contends that university students drop out of math as a consequence of prior socialization, educational career contingencies, and goal commitment and career aspirations. We propose, however, that the mix of these factors are different for men and women, with men focusing more heavily on career opportunities and decisions and women focusing more on the interpersonal realm of their experience. The specific purpose of our study, then, was to determine the social processes of attrition, and consequently we conceived of the actual decision to not take any more math only as the culmination of a long-term process.

On the basis of this conceptualization, our research utilized the life history approach. Accordingly, we became interested not only in the decision processes of attrition but in any pattern of participation throughout a person's life, such as family and peer involvement, which could be regarded as an aspect of those decision processes. Like our previous study, this research became one addressing those processes that did or did not feed into patterns of sex differentiation.

Chapter II of this report describes the theoretical framework we used, the research questions, and the related literature. Chapter III describes the methodological procedures used to gather and organize information. Chapter 4 presents sample background characteristics, while Chapter 5 presents our major findings. Chapter 6 summarizes the study and presents its major conclusions.

CHAPTER II

LITERATURE REVIEW, THEORETICAL ISSUES, AND ANALYTICAL PURPOSES

Recent findings of sex discrimination and other social processes that create or perpetuate patterns of sex differentiation throughout academic institutions have increased the concern for the place of women in higher education (Astin, 1969; Rossi and Calderwood, 1973; Feldman, 1974). A number of studies have focused on educational barriers, ranging from admission and finance policies to sex role constraints (Roby, 1973; Furniss and Graham, 1974; McGuignan, 1976). Others have focused on the problems women face who have sought to enter disciplines traditionally populated by men. These investigations have included studies of medicine (Bowers, 1966), anthropology (Fischer and Golde, 1968), and science and engineering (Mattfeld and Van Aken, 1965).

One of the disciplines especially difficult for women to enter and continue through to completion of the advanced degree is mathematics. For over half a century, the proportion of women receiving doctorates in mathematics has remained constant at about six percent (Rossi and Calderwood, 1973: 257), although in recent years it has been increasing slightly. Research has shown that the sources of the differences contributing to such a low proportion are predominantly, if now exclusively, social in nature. The studies by Ernest (1976) conclude that there is nothing intrinsic in the subject that makes it more appealing to one sex or another. Yet there are sex-linked differentials that begin to appear as early as junior high school. A substantial body of findings (reviewed by Fox, Fennema, and Sherman in Women in Mathematics: Research perspectives for change, 1977) show that performance and participation differentials are systematically linked to sex role socialization regarding femininity, career, family and achievement. The interpenetration of family, education, and peer influences in the process leads to a pervasive and circular process that encompasses most of the educational life span (Fox, 1976). Females avoid mathematics in high school and thus are less prepared for mathematics in college, and therefore are selected out of occupational areas that involve mathematics. Also, they are less likely to envision mathematics as relevant for their lives. The increased attrition rate of females out of mathematics at the secondary school level and the future consequences of that attrition are quite well documented.

Research on patterns and processes of participation of women in mathematics at the university level is much more scarce than that at the secondary school level. Case material, such as Pour-El's (1974) vivid account of her experiences as a graduate student and faculty member, however, suggest that sex-related problems continue, even for those females who are talented and trained in mathematics. A few studies specify some of those problems. Patterson and Sells (1973: 86) show that the attrition rate of female graduate students, controlling for ability, is almost twice that of male graduate students and that being married accounts for some of that differential. Role conflict between domestic and professional obligations appears to be the relevant process underlying this factor. Other factors involve reports that women are more likely to experience emotional strain as well as pressure from their spouse and, in addition, to feel that the professors in their department do not take them as seriously as students (Creager, 1971; Maines et. al., 1981). They appear less likely, as well, to engage in forms of anticipatory socialization and informal peer networks that are critical in graduate school training (Feldman, 1973). What scanty literature there is, in other words, suggests strongly that men feel and experience much less life conflict and are the most adjusted of all. The existing literature relevant to issues of patterns of participation of women in mathematics at the university level thus provides a few clues regarding key variables, but little information regarding the social processes in which the educational careers of female students are embedded and which influence the trajectories exists.

Our research during the past two years has been devoted to uncovering those processes. The theoretical position we took borrowed from Rosenbaum's (1978) tournament model of mobility through a school system, which stresses the probabilstic rather than deterministic consequence of educational achievement and persistence. While there are many reasons and combinations of reasons for attrition out of mathematics, we propose three fundamental dimensions which, in their interaction, are capable of characterizing the dynamics of attrition in relation to simultaneous role transitions. These dimensions are: (a) prior family and educational socialization, (b) educational and social contingencies, and (c) goal commitment and occupational aspirations.

Prior family and educational socialization in part has the effect of preselecting students who drop out at specific points (Astin, 1964; Sewell and Shah, 1967). Some students, for example, enter college with a prior decision to major in mathematics, while otners have no intention of taking any mathematics at all. Others may be undecided at entry and still others may wish to major in a math-related field which requires substantial study in mathematics but not a major.

This pre-selection process interacts with educational and social contingencies which together begin to alter the probabilities of attrition at any given point. Interaction with faculty (Wilson, et. al, 1974), the lack of "person-role" fit (Rootman, 1972), and social integration via friendship (Pervin, et. al., 1966) have been shown to affect attrition significantly. Generically, the quality of interpersonal relations and the distribution of structural conditions (Spencer, 1976; Duncan et. al., 1968) constitutes much of the interaction with the pre-selection process which then affects the attrition probabilities.

The third dimension, goal commitment and occupational aspirations, however, is needed to round out the theoretical explanation of attrition processes. This dimension has been shown to be a major influence on success routes through college (Nelson, 1972; Spaeth, 1970). It represents the process which produces consistency of action and choice, or, when combined with the pre`'ously discussed dimensions, can contribute to attrition as we`l. Structural contingencies can alter aspirations and weaken goal commitment, leading students to review and redefine their educational and occupational plans. Thus, these three dimensions direct our attention to past and present influences and how they are defined by and alter plans during young adulthood.

By virtue of its longitudinal implications, this conceptual framework improves on most studies of attrition (see Tinto, 1975: 90). In particular, it specifically requires a focus on the dynamics of attrition rather than simply on antecedent variables. Its processual qualities fully take into account the forces of structural constraints and the emergent decision-making processes engaged in by students as they must deal with a variety of social and educational conditions. It also insists that we intensively examine how various factors combine. Clusters of factors, (eg. those relating to family, self-concept, educational plans, occupational decision making) combine in different ways at different points along the educational career. Attrition very early in the college career is most likely to be the result of factors clustering around prior family and educational socialization processes. Attrition later on at the undergraduate level undoubtedly represents a very complex mix of all three dimensions, and it is plausible that educational and social contingencies play a very large part in ordering that mix. Thus, the meaning of attrition is very different depending on when it occurs in the educational career. Further, the difference between male and female attrition may well be greater in the early years than later on.

This conceptual framework is intended to specify the structural and processual elements of attrition by identifying the major dimensions of the attrition process and then conceptually specifying their inter-relationships. It points to the attrition process itself, the differences in that process for students at varying stages of the educational career, and the differences it may hold for males and females as the critical areas of study. It argues that the attrition process must be view as a series of longitudinal and interactive relationships between the individual and the academic and the social systems of a college during which the student's experiences in those systems continually modify educational and career goal commitments in ways which lead to attrition at different points along the educational career. It is that process that we attempted to study, using both males and females to provide us with information.

CHAPTER III

RESEARCH METHODS AND PROCEDURES

This chapter will describe the procedures we used for drawing a sample of respondents, how we collected our data, and the procedures we used for organizing those data into forms suitable for analysis.

SAMPLING

Our sample was drawn from the undergraduate population of Northwestern University. Permission was obtained to generate a matched sample of equal numbers of males and females from the student files in the Registrar's office. Our research problem required that we sample respondents with comparable educational backgrounds who (1) took no math at Northwestern (set 1), (2) took only enough math to satisfying the University math and science requirements (set 2), and (3) majored in math but changed to another major (set 3). We regarded these three sampling frames as representing three different points of attrition from math.

Within each of these categories, we sampled equal numbers of men and women. Within sets one and two, we sampled high and low SAT math scores. All of set three's, the former math majors, were high SAT math scorers. The SAT-M scores ranged from 310 to 780, with a mean score of 616 and a median of 647. The high scores ranged from 530 to 780 (mean 670), and lows ranged from 310 to 560 (mean 540). The reason a few in the high group had lower SAT-M scores than some in the low group is because we used a percentage as a cut-off, not raw numbers. For example, for each calendar year, those in the top 15% of all SAT-M scores were coded as highs. The raw numbers which fell in this 15% fluctuated from year to year. We use the term "low" cautiously, since at Northwestern, the lows exceed the national average by over 50 points. Thus, they should be regarded only as low at N.U. These procedures produced the sample depicted in Table 1.

Our sample ranged in age from 18 to 37, with a mean age of twenty-one. Forty men and forty women were sampled. Of this total, 28 had social science majors, 30 were in humanities, 6 in journalism, 6 in science, 7 in music, 2 in engineering and 1 in physical education. More women than men were in science (25% vs 3%), and more men than women were in social science (85% vs 60%). In terms of academic year, 53 of our eighty respondents were seniors, 19 were juniors, 7 were sophomores, and one was a first year student. The sex and high/low groupings included 30 high females, 18 low females, 30 high males, and 10 low males.

DATA COLLECTION

Our research problem focused on attrition from math

Table 1

SAMPLING DESIGN

		MALES	FEMALES
SET ONE	High	9	10
	Low	5	5
		14	15
SET TWO	High	11	10
	Low	5	5
		15	15
SET THREE	High	10	10
		10	10
	TOTAL	40	40

N of males = 40
N of females = 40

TOTAL N = 80

as a long-term social process; thus the interview guide was constructed to provide a life history for each respondent. Questions were designed to reflect the life course experience relevant for each set, and were clustered around the following dimensions: high school and family background, social history of experiences with mathematics, college experiences, and work and family aspirations. (See Appendix A for a sample interview schedule).

Data were gathered through in-depth, semi-structured interviews. All interviews were taped and followed the interview guide. In addition, follow-up on the respondents ideas and experiences was provided through systematic probing, thus producing elaborations on original responses. While the interview guide produced comparability among respondents, it was also flexible and allowed for respondents to expound on their answers.

DATA ORGANIZATION

At the beginning of each interview, a face sheet was filled out which included relevant background and demographic information. The tape recorded interviews were transcribed verbatim by professional transcribers. There was an original and carbon copy made of each interview. After being transcribed, each interview was given a code number and an additional copy was photocopied. The code number represented the respondent's gender, year in school, SAT-Math score, and set number. In addition, each respondent was given a triple digit identification number. For example, ML42-051 represents a male senior with a low SAT-Math score, who took at least one math course in college and whose file number is fifty-one.

The interview pages were numbered consecutively for all 80 interviews, totalling thirty six hundred pages. All interviews were logged into a mast file by code numbers.

The interviews were coded for distributional characteristics of the data and for insights and understandings into the meanings of the responses. To insure maximum coder reliability only the principal investigator and two other persons coded the data. The coders were graduate students in the social sciences with qualitative research experience. They were trained by the principal investigator. They coded a number of interviews together and the principal investigator spot-checked the coding for accuracy. The principal investigator and the coders developed a codebook for undergraduate interviews, graduate interviews, and faculty interviews. These codebooks gave the criteria by which the transcribed interviews could be synopsized for distributional coding, yet maintain the richness and quality found in open-ended interviews. The data were coded onto large accountant sheets according to set, SAT score, and gender. For example, all the high SAT females who took no mathematics were coded on the same sheet. The interview questions were listed along the left side of the coding sheets and the code numbers were listed across the top. Each cell contained a response as well as the page number(s) where that response was found. The page numbers were included so the raw data could be easily retrieved. This phase of coding allowed the research team efficient access to the data, yet was also a shorthand version of the transcripts that provided accurate distributions of responses.

Computer analysis required the generation of inductive categories; that is, categories created to fit the responses. A codebook was developed which allowed for all forms of the interview to be coded, and provided for the coding of detailed questions as well as questions to which more than one answer was given. The final coding schema was exhaustive and thorough for all data collected. Approximately 300 variables were created from the interview schedules.

The data were punched on cards, entered into the computer and saved on an SPSS file. Frequency distributions including mean, median and mode were obtained. Two- and three-way crosstabulation tables were run and analyzed for significance. These tables were analyzed using a chi-square test of significance or fisher's exact test. While a significance level of .05 was considered preferable, because this is exploratory research some findings with *p* values as high as .07 were reported to indicate trends.

CHAPTER IV

SAMPLE BACKGROUND CHARACTERISTICS

This chapter serves the function of presenting basic descriptive findings relevant to the backgrounds of our sample. We consider family, mathematics education, experiences with math, participation in school, and career aspirations.

Family Background

The typical respondent came from a family where the father was in business or a profession (72%) and the mother was a housewife (34%) or schoolteacher (20%). About one-fourth of the mothers were in business or professions.

The fathers of these respondents were more educated than the mothers: the mean educational attainment for fathers was "some graduate work," with 15% of the fathers having achieved a professional degree. Among mothers, the mean attainment was a college degree, with only 4% of them having achieved a professional degree.

However, there is a significant difference in the level of mothers' education between male and female respondents: females reported mothers who were more educated. Men reported their mothers had a college degree (modal category, 41%) while the modal category for women was mothers with a master's degree (modal category, 30%).

The modal family size was three children, and 11% of respondents had families of five children or more. Most of the respondents (69%) were first- or second-borns.

Math Background

Almost 40% of respondents came from families where they reported math was emphasized, and it was emphasized mostly as a job skill (59%). However, females were more likely than males to come from a family where math was emphasized (44% vs 19%), and males were more likely to say math was not emphasized at all (46%) as compared to females (13%, $p=.01$).

During elementary and high school years, the typical respondent's attitude toward math shifted from positive to negative, although males tended to exhibit more negative attitudes overall. While 60% of the respondents could recall a specific math memory before the fourth grade, most reported this memory as neutral. Recalling their elementary school experience, 60% of all respondents said this experience was a positive one, and 77% reported math was "easy and fun." Only 7% of the respondents reported having had difficulty with elementary school math. However, when analyzed by sex of the respondent, it is clear that more men were experiencing a negative elementary school experience

(16% vs 3%, p=.04).

When the respondents entered high school, one-fifth reported their experience in math shifted from positive to negative, slightly over half (51%) now found math "easy and fun," and 26% reported a negative experience with math. Most respondents attributed this negative experience to a loss of interest in the subject (25%) or difficulty with the subject (27%). At this time, about one-fifth of the respondents recalled feeling mathematics was directly relevant to their career goals.

Social Experience in Math

Roughly half of the respondents agreed that men and women were treated differently in math classes in high school. These differences included men being encouraged more (42%) and teachers being condescending to women (31%). It is interesting, however, that when this is broken down by sex, women are more likely to say there were no differences in the way males and females were treated (67% vs 37%), and men are more likely to say that women are treated worse in math classes (22% vs 0%, p=.003).

About a third of the respondents felt they had been discouraged in math, and as a group, teachers accounted for the most discouraging agent (43%).

By high school respondents could easily describe a "typical" math type, and this type was considered by most respondents to be a male math type. (When asked to describe a "typical" math type, eighty respondents complied; thirty-five described a "female" math type and only thirteen described a "male" math type.)

Of the thirty five who described the female math type, 40% felt she was the same as the typical math type, i.e., male. The typical math type was described on a spectrum of qualities from anti-social and "nerd" (21%) to "very bright" and "good at everything" (40%). For the female math type, a distinct category appears: 14% of the respondents felt female math types "didn't show" they were math types.

Most of the respondents were friends with math types in high school (80%) and agreed that while math types were treated differently by teachers, this was preferential treatment such as extra help or encouragement.

High School

Most respondents (71%) attended public school, ranked in the top 90th percentile of their high school class (72%) and received two or more awards during high school (69%).

Most respondents (75%) had a group of friends rather than one or two close friends, and the activity shared most with friends was extra-curricular activities or socializing (70%). However, when analyzed by sex there is a significant difference between males and females and the t; ~f friends they chose: women were more likely to say they had intellectual friends (54%) and shared extra curricular activities with friends (27% vs 13%, p=.04).

Respondents reported that they had the most interest in extra-curricular activities in high school (42%) followed by academics (26%) and sports (10%). When broken down by sex, more men said their primary interest was sports and social life, and more women said their interests were in academics and extra-curricular activities (p=.03).

The mean number of math courses respondents took in high school was four, and typically calculus was taken as the last course (30%). Grades were distributed as follows: 54% A's, 10% A/B's, 28% B's, 7% C's, 1% D's and less than 1% F's. Forty per cent of the respondents said they enjoyed math and science the most in high school, while 32% reported enjoying it the least. A little over a third of the respondents said they were encouraged in math and science in high school, mostly by teachers (60%), while slightly fewer (21%) said they were discouraged in math and science, and reported this was mostly self discouragement. The types of encouragement and discouragement included advice about courses and talking to advanced students.

Career Plans

As could be expected, the majority of respondents while they were in high school expected to go to college and earn professional degrees. Only one person reported wanting to pursue an academic career in math or science.

The respondents felt that of any other group their parents had the most influence on their career plans (29%). Other respondents reported high school counselors or peers. Their parents wanted them to be professionals or in business. However, their was a difference between what respondents reported their mothers and fathers wanted them to be: the modal response respondents gave when asked what their mothers wanted them to be was "she wanted me to be happy," a response not attributed to any of the fathers.

CHAPTER V

FINDINGS

This chapter presents our major findings which are directly relevant to the question of attrition from mathematics as a social process. We do not include all data generated in the study. Rather, based on extensive preliminary analysis of a wide array of statistical tables and an intensive examination of the qualitative data, we focus our attention on those data which most represent the significant discoveries.

Our data are arranged longitudinally in order to depict the life history approach of the theoretical underpinnings and the methodological design of the study. We show how family attitudes toward mathematics was a factor in the attrition process, how educational influences and differential treatment by teachers affected students' perceptions of mathematics and of one another during high school, and how differentials in peer relations were affected by math stereotypes. Finally, we present findings specifically dealing with the attrition process. Throughout the presentation of data, we emphasize the complex interrelationships between ability levels and sex. That is, we assert that the issue of educational equity for males and females in mathematics is not one of sex *vs* ability, but one of interactive effects of sex and ability. This theme will be pursued in greater detail in the conclusions chapter of this report. For now, we merely wish to establish the empirical patterns using both statistical tables and in-depth quotes from the interviews.

Family, Education, and Peer Influences

Whereas there were no differences in family attitudes toward math when considering sex alone, sex differences within the high and low ability groups were manifested. In both groups, males were more likely than females not to have had mathematics emphasized by their families (Table 2). However, statistical significance appeared only in the high ability group. There, females were more likely than males to have had mathematics emphasized (48% vs 14%). A sense of family processes relevant to the response categories of Table 2 can be seen in the following quotes from interviews.

> My parents, ever since I can remember, told me how they didn't do very well in math. I think that probably had a big effect on me, because I didn't do very well. Not as well as I would have liked to, although I did like it. I liked the challenge. Their influence as I look back was probably negative. (low ability male) (3112)

> (How was the subject of math thought of in your family?) No one was particularly interested in it. No one had any desire to become a mathematician or anything like that. It was just a subject that everyone took and we hoped

Table 2

Sex Differences Within Levels of Ability (SAT-M) by Family Attitudes Towards Mathematics

	High*		Low**	
	Males (N=27)	Females (N=29)	Males (N=10)	Females (N=10)
Practical use	19 %	14 %	20 %	40 %
Equal with all	15	24	20	20
Emphasized more	[illegible]	48	20	30
Not emphasized	48	14	40	20
	100 %	100 %	100 %	100 %

*x^2 = 9.89, d.f.=3, p=.01

**not significant

> we did well in it. (Was it ever emphasized or deemphasized?) Well, our grades weren't always A's in math, and my father would sort of give us an out by saying that he was never particularly skillful in math, so in a way, you could say deemphasized. It wasn't pushed on us necessarily. (high ability male) (511)

High ability females from families in which math was emphasized reveal different family dynamics.

> (How was mathematics looked upon?) It was very important. We've all had a lot of math, and my brother and sister and I would always be ahead in math when we got into high school. And it was just looked upon as being very important. I enjoyed it alot. And my brother did, too. My sister doesn't like it that much, and I know that she does get pressure from home to do better in math and to spend more time doing it. But, I don't know if that's because my parents view math as being so important, or just because my brother and I always did so well in it and she doesn't. (293)

An example of a low ability female whose family stressed the practical use of math is depicted in the following passage.

> It was something you dealt with on a day to day thing, like checkbooks or things like that, but I don't know that it was considered that essential.

> I am now very sorry that I don't have a better background. (But when you were growing up?) There just wasn't any emphasis on it. I mean, you had to know how to add and subtract, things like that, but I never was pushed to take algebra or calculus, or anything like that. You had to have the basic skills to be able to get along. But, there wasn't anything special. (733)

While these ability/sex differences in family influence occur, Table 3 shows that high and low ability groups received general academic encouragement from different sources. High ability individuals tended to be more encouraged by teachers (69%) while low ability individuals received more from family (45%). In light of Table 2, this finding suggests that high ability females may have received a broader based source of encouragement, which encompassed both teachers at school and parents at home.

Table 4 shows sex variation within ability levels of perceptions of whether high school teachers treated female students differently than male students. While those in the low ability category showed no differences in their responses, those of the high ability category did. Surprisingly, females were more likely than males to respond that females were not treated differently (69% vs 30%).

> In high school, I had one woman math teacher and the other three were men but I don't remember any difference. The classes were pretty evenly balanced

Table 3

Levels of Ability (SAT-M) by
Primary Source of Encouragement
During High School

	High (N=26)	Low (N=9)
Family	31 %	45 %
Teachers	69	33
Self-motivation	0	22
	100 %	100 %

x^2 = 7.57, d.f.=2, p=.02

Table 4

Sex Differences Within Levels of Ability (SAT-M) of Perceptions of Whether Women were Treated Differently by High School Teachers

	High*		Low**	
	Males (N=23)	Females (N=26)	Males (N=9)	Females (N=10)
No	30 %	69 %	56 %	60 %
Yes	52	31	44	40
Don't know	17	0	0	0
	100 %	100 %	100 %	100 %

*x^2 = 9.49, d.f.=2,p=.008

**not significant

> for freshman, sophomore, and junior years. My senior year it was the calculus/physics class, so it was maybe 25 men to 8 women, something like that. So that was the first time there had been a definite difference in the number of men to women in the class. But I don't think there was any difference in the way they treated us. (high ability female) (3615)

Of those who did feel females were treated differently, sex differences showed up only in the high ability group (Table 5). Men reported that teachers were condescending to the female students (27%) and that they interacted more with the male students (37%). Females reported that men were encouraged more by teachers (57%) and that women were told they didn't need math (14%).

> I don't know, let's say it came time for prom or something. And they'd ask the guys, well, didn't you get a date or something? Well, why not ask so and so? She's over here and she's real nice looking. So there was more of a father daughter thing there. (And what was the relationship with the guys in the class?) It was just one guy to another guy. It was no big deal. Maybe if a guy was on the basketball team or something there was more of a coach player thing. But it was more of a man to man thing. And it seemed to be

Table 5

Sex Differences Within Ability Levels (SAT-M) of Perceptions of How Women Were Treated in High School Mathematics Classes

	High*		Low**	
	Males (N=11)	Females (N=7)	Males (N=4)	Females (N=4)
Condescending to women	27 %	0 %	50 %	25 %
Men encouraged more	0	58	0	25
Women told no need for math	0	14	0	25
Teachers harder on women	18	0	0	25
More interaction with men	37	14	25	0
Women encouraged more	18	14	25	0
	100 %	100 %	100 %	100 %

*x^2 = 11.82, d.f.=5, p=.03

**not significant

more condescending towards a woman in that there would be comments about physical appearance. If they'd worn a dress or looked nice or something. (Did this ever spill over into the classroom when you were doing math?) There might be, you know, some subtle comment made in the middle of a lecture--somebody had worn a dress or something like that. Or, not a whole lot. I think after class there was more of a -- just the idea that it was much more common for a male professor to compliment one of the girls in the class than just one of the guys in the class. (high ability male) (1732)

(Did the math teachers, from your perspective, ever treat females differently than males?) The basketball coach. He really did. (Tell me about that.) He was a real bigot in every sense of the word. I mean he was anti-female, anti-black, and you know -- of course, he never said anything, but it was obvious to me and everyone else. (What would he do to them?) Well he'd call on boys before he'd call on girls -- he would shuffle comments off -- he was a very stereotyped man -- you know what I mean. I had no respect for the guy -- he didn't like me. (high ability male) (2268)

Table 6 contains data on sex differences within ability levels of experiences with high school math teachers, which

Table 6

Sex Differences Within Ability Levels (SAT-M) of Experiences with High School Mathematics Teachers

	High*		Low**	
	Males (N=28)	Females (N=29)	Males (N=11)	Females (N=10)
Mostly positive	61 %	69 %	55 %	30 %
Neutral	11	24	27	20
Mostly negative	28	7	18	50
	100 %	100 %	100 %	100 %

*$x^2 = 5.43$, d.f.=2, $p=.06$

**not significant

shows a pattern of responses generally consistent with those of Table 5. Although the low ability females were more likely than low ability males to state they had negative experiences, most respondents reported positive responses. A few examples:

> My math teachers were usually my favorite teachers. Mr. D and another teacher -- they were very good humored people, not like they'd turn me off to mathematics because they were encouraging. (high ability male) (2586)

> (What were your math teachers like in high school?) In high school I had some pretty good math teachers. I'd say out of all the teachers I had at the school, they were probably the best. I had Brother John L, who was pretty sharp, personable, and friendly. He was a very good professor, I had him, I think, three out of the four years I was there. Another year I had a lady who was -- she was okay, too. She wasn't a bad teacher. (What did you like about them?) I think their ability to explain something, that, say, the night before you had no idea what to do, and you would walk into the class and they were very adept at transferring their knowledge onto students. (high ability male) (1497)

I really enjoyed all my math teachers. They were very helpful and they were very direct and they usually presented things in a clear, concise manner. My trigonometry teacher was excellent -- very good at making us do proofs and emphasizing that if you wanted to go into the higher math, trig was very essential. He was very good at showing us how to apply the different areas. (high ability female) (2626)

(What were your experiences in high school math?) They were very good, and in trigonometry I remember I was very happy that I was finally learning what signs, cosigns, and tangent meant. I also remember that my older sister had dropped trigonometry, because she wasn't doing very well in it. I remember she was having a big problem with her teacher, and my parents had to go in, so I was finally taking a class that had caused her so many problems. But I h : wonderful teachers. We had excellent teachers. There were the teacher who taught MIA, modern introduction to algebra, there were two MIA teachers and two calculus teachers. They were the same teachers. They each taught calculus and MIA, and I had a different one each year and they were both very good. In senior year there were two calculus classes and one of them was the group of kids that went to that program I told you about, and so they had to have the morning class because they went to that program after that. And we were in the other class and there were only nine of us in that class, which was wonderful, because you can ask questions. You can go over every problem almost in class, and so it was very good. I think that was the first time the teachers really treated you like, like not so superior. Like he would really help you and you didn't feel stupid asking questions, and he joked around with us and it was just real realxed and it was real, real good. (You said they were good teachers. What makes a teacher good?) The way they taught us calculus. I took a calculus class when I got here and I was very, very disappointed in it. We would learn the hardest way of doing something, the long way and the theory behind it, and then slowly we'd get to all the shortcuts and it was just really amazing. They taught us not only how to do something, but why you're doing it and the area under a curve. If you can't visualize what you're trying to do in calculus, it's almost impossible. I mean it's real hard to do. They were just really good at visualizing and explaining how and why these work, and you learn

> the theory. And they say to you, you're not going to understand. You don't understand this now but you will someday, you know, and then the revelation of that you can do this process in two steps it took you two pages when you were learning how to do it, the hard way. I don't know, it was just that kind of a constant building up and it wasn't just do this, you know, this is how you do it. (high ability female) (349-50)

Twice as many high ability females as males had neutral feelings about their math teachers (24% vs 11%) while four times as many high ability males as females had mostly negative experiences (28% vs 7%). The following high ability female illustrates a neutral response.

> My algebra teacher I remember was a black woman. She had a lot of energy. I really thought that she knew the stuff and that she was very bright, but I also felt that in the sense that she knew it so well that it was hard for her to explain it to someone who was hearing it for the first time. So, it was the kind of thing where you'd catch up on what she was teaching sort of two days later when she was on to something else. I liked her, you know, but I didn't think as far as explaining it real carefully that she was very good at that. My geometry teacher -- I never felt one way or the other about him. I liked the work, I mean he was teaching

it adequately. (2513-14)

And, some illustrations of high ability males who had mostly negative experiences.

> Probably the fact that I really wasn't interested in the material led me to take an indifferent attitude toward the class, and that would give me an indifferent attitude toward the professor, or should I say teacher at this level. What I didn't like about the one I had for junior and senior year would be that rush, rush attitude. I mean there were a few students who were really bottoming out in our classes, and I didn't understand everything he taught and these people were doing worse than I was. I could just imagine myself in their position. And he really didn't seem to be too concerned. He was more concerned with covering a certain amount of material. My freshman and sophomore year teacher, he just didn't seem to have any real commitment toward teaching math. He was sort of a, 'this is math--we're covering this--and sort of the same thing.' So that would be the major complaint, if you would call it a complaint, would be that their life wasn't math. They didn't certainly communicate the urgency or the wonderful aspect of math. (518-19)

> The math teachers just gave the impression of being alot colder and interested in something that had no

> meaning to it. It was utterly meaningless about learning all these equations, and they were very stoic. A few of them had crew cuts which just intensified the image. (1328)

Table 7 shows the extent to which males and females within the high and low ability categories were friends with the stereotypical "math types" or those who were identified by their peers as people who were competent at and involved in math. Again, no sex differences appear in the low ability category, but statistically significant differences occured in the high ability category. Succintly, males were both more likely than females to say they were not friends with math types (50% vs 14%) and to say that they were a math type (25% vs 14%). Females were more likely to say they were friends with math types (73% vs 25%). The quotes from the interviews add detail to these friendship patterns.

> (What does that mean, 'stereotypical ween'?*) You know, wire glasses, and just really intense. Knew everything about computers. The typical high school genuis type. There were about three or four of them in the advanced class. (Males or females?) Males. (No females?) No. That doesn't mean they were the best. It just means

*The term "ween" is one used by Northwestern students to generically refer to anyone who is perceived as overly involved in mathematics, engineering, or computer science.

Table 7

Sex Differences Within Levels of Math Ability (SAT-M) of Friendship Ties with "Math Types"

	HIGH*		LOW**	
	Males (N=16)	Females (N=22)	Males (N=8)	Females (N=8)
No	50 %	14 %	38 %	37 %
Yes	25	72	62	50
Was one	25	14	0	13
	100 %	100 %	100 %	100 %

*x^2 = 8.88, d.f.=2, p=.01

**not significant

they were that intense. (Were they fun?) No. (Did you hang around with any of them?) No. I mean, in school, we would converse, but... (What was the stereotype of the ween in high school?) Well, we had those people who were so intense. I think they did advanced work more than the other people. I guess their weening paid off. Because there was one guy who was a year ahead in the math program though he was in my class. By the time he was a senior he was taking all kinds of college calculus courses. (I was just wondering if you could describe them for me?) They were all very nice. They didn't really fit in completely with the crowd. It was just below that level. Which would be my crowd. But, we got along. (high ability male) (1861)

(What does that mean?) Kind of like the slide rule in the belt mentality. Someone who's burrowed into a hole of math and literally doesn't think a whole lot about the outside world or something. So they were that way, even though there were a couple of sharp math teachers, and a couple I got along with fairly well. I would say on the whole they were more of the -- I don't know, subnormal is a bad word -- but they were kind of the weird ones or something.

(What were the students who were really into mathematics like?) Well, that's exactly what they were like. They were the kind who would have the calculator case on their belts and thick glasses and greasy hair, and things like that, and you know, instead of going to parties or dances they'd stay after school and play with the computer or something like that. And, because we'd just have gotten, it wasn't even a computer, it was probably a huge calculator or something that could do certain things, so they would be the type that would be in the chess club or the war games club and things like that. (What do you think they did for fun?) Chess and war games I suppose. I don't know. They just weren't the group I really hung around with, even though they were in my calculus class there were some of them or something, there were alot of my friends and people who kind of felt the same way I did about math. Even the engineers or something. Well, math was never something they particularly liked and so if there was a model of a math person, you know he wasn't the kind of person I hung around with. (high ability male) (246-7)

(Did you ever know any math types personally, run around with them?) Oh, math types. My friend was really into math, too. No, basically all of the people I ran around with knew alot of math and were very good in math. Whether they were math types, I really don't know. (Do you think you're one of those people? One of those people that were really into math?) Well, I was really into math in high school. But now coming to college I realize, boy, maybe I wasn't (laughter) really into math. (Did your teachers in your math courses treat math types differently?) Well, basically when I entered high school I was already on a higher level than most of the other people. Because during the 7th and 8th grades we had the chance to take algebra, whereas most other people just took basic math, like, you know, fractions and all this stuff. Whereas we took algebra so when we entered high school, the first course that was offered to us was geometry and for the other people it was just algebra. So like before I even got into school we were already math types and we were all together in the same groups, so it wasn't like we could tell that he had a distinction between people. (high ability female) (701)

(What were they like?) Well, they were very into math but then they weren't eccentric about it. Like I have a friend who's here and she was a double major and she was honors and she was always into

> math and science but she could also handle English very well. But her first love is computers and anything to do with computers. And then I have another friend who is really wacky in a nice way. She's just a real nice person and she loves computers and she's really off in computers, but I mean she can deal with it. She wasn't close-minded and she liked to have fun and she could deal with everyday life, and he could too, but I couldn't stand the way he'd act sometimes. (high ability female) (3563)

The Attrition Process

We now switch our attention from how sex and ability affected the experiences students had with mathematics to the process of attrition itself. Here we are concerned with those factors we were able to detect which contributed to students' devaluations of mathematics to the point where they decided not to take any more courses in the subject. We regard the pattern of not having taken any more mathematics after a given point (i.e., Set 1, Set 2, Set 3 students) as the point of attrition; we regard the decision making, evaluations of self in relation to mathematics, and various influence factors as the attrition process. The remainder of this chapter will pertain to that process.

Table 8 shows sex differences in the reasons the

Table 8

Sex Differences in Reasons for why Mathematics Became Less Important

	Males (N=28)	Females (N=29)
Career change	46 %	17 %
Poor teacher	11	17
Didn't do well	25	17
Not encouraged	4	17
Never liked it	14	25
Still enjoy	0	7
	100 %	100 %

x^2 = 9.85, d.f.=5, p=.07

students attributed to math having become less important to them. As hypothesized in the research proposal, males were more likely than females to attribute that decline in interest to career change (46% vs 17%) and low performance (25% vs 17%). Females, on the other hand, reported that their not having been encouraged (17% vs 4%) and that they never did like math (25% vs 14%) were the major factors in the decline in the importance of math for them.

Interview responses from the male's pattern of responses in Table 8 are typified by the following:

> (Was there a time when your feelings or your interest changed regarding mathematics?) Well (long pause), I guess when I came over here, mathematics didn't really fit into being a lawyer. I still always liked the math, but it never really fit in. So I guess after the calculus and all that, which was pretty much required, I kinda just threw it off to the side and said, well, I like it and everything but it doesn't really fit into what I'd like to do later on. (2036)
>
> (Can you sort of explain to me the change in feelings you had about math?) Well, it was very gradual. I mean it was never a case of being important. It was safe -- okay. Through grade school and probably including junior high all

subjects got equal weight. Nothing was more or less important. You know, maybe one year I'd like one more, maybe another year, something else more. It was probably more dependent on the teacher than the subject. That would probably include junior high, which was probably a transition time when I started thinking more about the future. It became accelerated in high school -- you have to think about college, your major and what are you going to do after college, and if you're pre-med you have to decide now. And prepare yourself for that. And so in looking ahead again that would be where I started trying to probably put more interest or more time into the subjects, that I saw preparing it for my future that whatever it was would deal in some way with that. I think another thing that would contribute to that is the fact that I read alot, and in my reading I don't read math books. I do read some biographies of mathematicians or scientists, but they don't deal directly with the sciences or math whereas any book you read is going to tie in somehow to social studies, to history or sociology or economics, things like that. So my outside reading would add more to those classes even if it wasn't intended to, it just would. As I said earlier, I am a very people-oriented person which in my mind is much

> more consistent with the social sciences than it is with math and science, although its not necessarily true. In the back of my mind it was where that whole area was together and that's what I was more concerned with. And I just put less effort into math. (24-5)

Responses which typify the female pattern in Table 8 also can be illustrated with interview quotes.

> I didn't like math. I just basically didn't like it. And I couldn't say why. I would always just say that's because it doesn't come as easy to you as these other things and that's probably really why I didn't like it. (Any other reasons?) Well, math interests some people. It doesn't really interest me. Sciences really don't interest me either. I mean, I can watch a documentary about some scientific thing about a half hour, but when I'm through with it, it doesn't interest me. It isn't something I want to keep at and constantly pursue. And I knew that. It's just not my interest. (Did you like your math classes?) They were OK. They were just like -- I guess honestly, out of all the classes that I went to -- math was the one I looked least forward to going to. (946)

> ...it's almost as if I learn things five years later than everyone else. I finally caught onto

how algebra worked when I was a senior (laughter.) It's like it took just a litt~ le bit longer for me to understand --to get the logio c down. I don't think I'm stypid, but I don't undere stand how that happened. I just needed more repitition. . (Did you like math?) No. I still hate math. (Whatt was it like for you to do it, to do the homewoork?) Like a chore. I didn't want to be there, butt unlike the University system where you don't have too go to all your classes, there was no way to avoid it. (Was math required?) It was up untol was a junior and I still took it junior year and senior year. I took advanced algebra and trigonometry and then calculus. (What was your idea behind that?) Eecause I knew that I would have to take calculus here as a freshman. That's why I put myself through it the not to lose anything. To not forget. Be able to improwe myself at all. (Did you like your math courses?) No. (How would you rank them in comparison with your other classes?) Average to poor. I just did not like them as much as the others. (So you think there was a time when your feelings changed about mathematics?) I think, like I said before, certain suubjects under math would interest me and I do better and feel better about it, but it would always seem to return to the original thought that I don't want to like it after awhile. I mean, fine, I could have a month

> or two where it would pick up but it would always return to the idea that I don't really like this. I don't really understand it. And I'm not going to spend much time on it because I don't feel that it's necessary or worth it. (1959-96)

Table 9 shows how ability level differentiates the responses to why math became less important to the students. The career change response (36% vs 24%) is more characteristic of the high ability category, but the magnitude was not as great as that for sex, shown in Table 8. The "never liked math" far and away was reported by the low ability group (38% vs 8%). The major difference was that "poor teachers" showed up in Table 9, with high ability responses indicating an almost four-fold increase over low ability responses (19% vs 5%).

While Table 9 provides useful additional information regarding why math became less important to students, the complex relationships between ability level and sex are more clearly depicted in Table 10. That table shows sex variations within ability levels, and indicates that the sex differentiation within the low level group (46% vs 0%) is much greater than within the high group (46% vs 26%).

In other words, it is only the low ability females who do not attribute the declining importance of math to career change. Moreover, none of the low ability males attribute it to poor teaching, and it is the low ability

Table 9

Levels of Math Ability (SAT-M) by Reasons for why Mathematics Became Less Important

	High (N=36)	Low (N=21)
Career change	37 %	24 %
Poor teacher	19	5
Didn't do well	22	19
Not encouraged	8	14
Never liked it	8	38
Still enjoys	6	0
	100 %	100 %

x^2 = 10.44, d.f.=5, p=.06

Table 10

Sex Differences Within Levels of Ability (SAT-M) by Why Mathematics Became Less Important

	Low ~~High~~**		High ~~Low~~*	
	Males (N=11)	Females (N=10)	Males (N=17)	Females (N=19)
Career change	46 %	0 %	47 %	26 %
Poor teacher	0	10	18	21
Didn't do well	27	10	23	21
Not encouraged	0	30	6	11
Never liked	27	50	6	11
Still enjoys	0	0	0	11
	100 %	100 %	100 %	100 %

*x^2 = 10.48, d.f.=4, p=.03

**not significant

females who account for most of the responses of "not being encouraged" (30%). Low ability females also are the most likely to respond that they never liked math (50%). In general, then, Table 10 shows that there is much greater sex differentiation within the low ability category than in the high ability category.

The following quotes from the interviews give additional detail to that pattern.

> (When did you first start thinking of switching out of it?) Probably the same quarter that I stopped taking the classes -- it was about the end of fall quarter, I guess. I was in Physics and Math and had a couple of I.E.'s. I just decided that in the upcoming quarters that I was just going to have an awful lot of classes that I didn't want to take. I wasn't interested in them in the least and they weren't going to benefit me at all for what I perceived as my career goals, so I decided to get out. (Was there any change in your career plans when you decided to get out?) They were pretty well undecided. No, not really. (Or did any change in your career plans encourage you at all?) They aren't well defined at this point. You know I'm going to business school next year. I couldn't say what industry I'm going to get

into. I couldn't say if I'm going to study finance or mixed finance or marketing. That may be a disadvantage to some people and alot of people find it distressing, but I don't. (But basically you're stuck with that?) Yeah. (Would you characterize your change out of tech as abrupt or gradual?) It was fairly abrupt. (Did you discuss your switching majors with anyone?) I pretty well decided on my own. (male) (3427-28)

(Did the switch out of tech have anything to do with a shift in your career plans?) Yes, because I decided that a career in engineering wasn't what I wanted anymore. I didn't think the work that I would be doing would be that interesting to me, so I just decided I didn't want to do that. (female) (3395)

(How long were you in tech before you changed to your current major?) I just went into CAS this winter. (How serious were you about tech?) At first I was kind of into it, but after that it phased out. I was still kind of into it, but by the time the end of fall quarter came along I was thinking about switching. And I was talking to a counselor at Scott Hall about, you know, different careers, majors, and I was like, "gee, I want to get out of here." I never really was into it. (So would you characterize your change as abrupt or gradual?) Gradual, but towards the end it really accelerated, because I realized, I just kind of flipped over. (When did you first start thinking about switching out?) I don't think until the counselor mentioned it. I didn't even think of it, I just thought, "what can I do to do better in here?" (Oh, so you went to see the counselor to see how you could do better?) Well, I was trying to think of a career at that time, and then after that a major to follow. I went through the catalogue and I was thinking of speech, my sister's area, and "what should I do," and then I just came up with history. (So you went to talk to a counselor about a career and your counselor suggested to you to change your major?) No. I don't know if I thought of something that I wanted to get out, or she did. Probably I did. We just talked alot and she gave me a couple of vocational interest tests, and math showed up but not the engineering type. One of them said I should be a computer systems analyst. Ha, ha -- I was like -- "I can't do it" and other things, you know, that weren't math. (Would you say the switch out of tech had anything to do with the change in your career plans?) Um, kind of a reason for it. (Which came first, the change in your major or the change in your career plans? Or, they kind of coincided?) Coincided. I mean, the change in careers was a result of the change in the way I was thinking at the time. I want to do what I am interested in now, and that will hopefully result in something I am interested in working in as a result of graduation. (female) (3533-34)

Our final data table, (Table 11), pertains to students' assesments of whether or not taking college mathematics is realistic in the face of the labor force demands of our society. Their responses show that three times as many high ability students feel it is not realistic (44% vs 15%) while nearly twice as many low ability students feel that it is realistic if in fact the person has no ability (60% vs 27%).

If they don't like it, first of all, and they have desire to have anything to do with numbers and they just want to be an English teacher or something. I don't know, I'm prejudiced. Like my boyfriend says, you need math in everyday life. I don't see that. Maybe, you know, I already have myself set that I don't want to use it for anything. That's why I

Table 11

Levels of Math Ability (SAT-M) by Assessment of Whether it is Realistic to Complete College Without Taking Mathematics

	High (N=48)	Low (N=20)
No	44 %	15 %
Depends on job	6	0
Need some	15	10
Not if want to be well-rounded	4	0
Yes, if no ability	27	60
Realistic, not smart	4	15
	100 %	100 %

x^2 = 12.02, d.f.=5, p=.03

think like that, but I don't see alot of the stuff. Now basic math. Everybody needs basic math obviously to survive. Beyond that, unless you're going to use it and apply it to something like computers, or apply it to construction work or something, I don't see what else it can be used for. (low ability female) (2500)

(Do you think it's realistic for a person to go through college and not take math?) Sure. I did. (Do you think it would be okay for other people to do that?) Sure, depending on what they were interested in and what they wanted to do. If they're not interested in math and they don't do well in math and they don't like it, well, why should they take it? I mean, it's true that it's part of a learning thing but sometimes people just -- you know, sometimes if you really hate something that much, you're not going to learn very well. And if someone does not really like math, I mean that's not my case, but if there is a case where someone really does not like math, and has no desire to learn, why should they? (high ability female) (1107)

(Do you think it's realistic for a person to go through college without taking math?) Not really.

(Well, how do you see that?) Anything you're going to get stuck having to do will have something to do with math. The biggest example would be the TA I had for econ. In fact my professor I had for corporate finance, he also happened to teach in Kellogg's Graduate School of Management in the finance department. We're saying such things as, stuff that we are teaching right now isn't really that sophisticated, where it isn't really that much less sophisticated than what we are teaching over at GSM. Because alot of people that you're getting into the management program over there have had almost no math background at all. So he said alot of them are coming out with humanities backgrounds and music backgrounds. I asked him why that is and he said, well, it's very simple. Curators for museums, managers for ballet troupes, managers for symphonies, etc., having symphonies and all need managers for them. They need people with the training -- which they will get over at the graduate program. And these people come out with their undergraduate degree in music and some kind of fine arts or some kind of humanities because they don't have that heavy of a math background. They can't go and do super technical math on it. But you do need something because even coming out with a humanities degree, anything you're going to be working with that, you're going to have to have it. (high ability male) (2785-6)

Summary

This chapter consists of the basic data for our report. We focused on the major factors which contributed to the attrition process out of mathematics, and we expressed those factors through quantitative and qualitative analysis. The data form the basis for concluding that neither ability nor sex alone can account for the attrition process. Rather, attrition is caught up in a complex pattern of interactive effects. It is those effects to which we now direct our attention in the last chapter of our report.

CHAPTER VI

CONCLUSIONS

This chapter presents the major conclusions of our study and the recommendations and policy implications which flow from them. In proposing the conclusions to follow, we remind the reader that ours was not a study of the causes of sex inequality in mathematics. Rather, it was one designed to uncover the processes of attrition from mathematics, to depict those processes as accurately as possible, and to discover the extent to which attrition from mathematics entails long term sex differentiated processes. To that end we offer the following conclusions and implications.

1. The major finding, and the one from which all substantive conclusions and recommendations must stem, is that sex and ability in mathematics are not opposed to one another. The debates in educational and policy making circles, whether in the old form of the so-called nature-nurture dilemma or in its modern form of attempts to explain math achievement in terms of exogenous or endogenous factors, are wholly misled and ultimately fruitless ones. By systematically controlling for sex, ability levels and persistence in mathematics, we have

shown beyond doubt that sex and ability are highly interactive. They cannot be considered separately in the ideological guise of "sex vs ability" which has the effect of so clouding the issues at hand that observers are prevented from seeing the problem. It is almost moot to hear trained professionals say, "Of course there are bright women in mathematics;" it is a sorry state of affairs to then watch those professionals trudge off and fall into those ideological and scientistic dualisms which gave rise to the "sex vs ability" misnomer. We therefore emphasize most strongly and without hesitation that sex and ability are complex recursive factors which at best symbolize the underlying societal processes which produce them. Without appreciating this major and pivotal conclusion, much of this investigation will make little sense.

2. Greater sex variation was found in the high ability group than in the low ability group. This conclusion applies to the majority of the statistical tables presented in Chapter 5. What is interesting about this finding is that it holds regardless of differential persistence levels in mathematics. That is, it is as true of those who take no math in college as it is for those who major in math in college and then change majors. We propose as a general account of this pattern that ability be

regarded conceptually as the perception of relevance. That is, ability in this sense pertains less to the capacity to produce "correct answers" to problems as it does to a set of assumptions which orients the person to the world. Succintly, it is what our research group came to call the "yawn hypothesis." High ability females assumed they would be able to perform well when needed and thus tended not to perceive as obstacles those factors (such as differential treatment by teachers) which typically are regarded as obstacles. Oddly, high ability males tended to observe such factors and describe them in the interviews. We conclude that such obstacles in fact exist, but that men's and women's taken-for-granted worlds intervene between perception and performance. Women experience such obstacles as a "normal" (yawn) part of their lives, and the high ability women tended to shrug them off. Men do not experience them as a normal part of their lives, and thus are more prone to notice them when they occur. This interpretation reinforces the contention found elsewhere in the literature that multiple social and psychological processes are filters which render useless the hypothesis of the one-to-one relationship between ability and performance.

3. Differentials in family attitudes toward

mathematics were found for males and females who persisted to the same levels of mathematics education. This finding pertained only to high ability students. While it cannot be concluded that positive family attitudes and encouragement led these females to acquire high ability, it can be concluded that such attitudes are very much a part of the process contributing to equality in persistence. If stated in the obverse, i.e., males persisted as far as females without such encouragement and attitudes, part of the societal fabric which favors male achievement in mathematics is revealed.

4. Low ability females were the most prone to have had negative experiences with mathematics teachers. This finding suggests a pattern of the reinforcement of disadvantage, and is one of the most pointed examples of how the interactive relationship of sex and ability has an overall negative additive effect. Strongly implied in this effect is that the stereotyping of females is not a universal gender phenomenon but a selective one. That is, gender/math stereotyping is directed more towards low ability females, not just females in general. We feel this finding is a major discovery which has profound implications for educational processes and policy,

5. A surprisingly high proportion of high

ability males reported negative experiences with mathematics teachers. Our interpretation of this finding is that sex differentials in such negative experiences are a direct function of the vocational orientation males have towards mathematics. The negative experiences revealed in the interviews clearly indicate that males who reported these experiences felt their teachers were not competent enough. Males' expectations, grounded in their vocational orientation, led them to conceive of this perceived incompetence as a disadvantage for them.

6. Patterns of friendship with those students consensually regarded as the stereotypical "math types" were highly sex differentiated within the high ability group. Females overwhelmingly reported that they were friends with math types, which probably reflects sex ratios favoring males in math classes. Males, on the other hand, tended to report they were not friends with math types. Our interpretation of this pattern hinges on what is known about group pressure and identity among youth. Males who are not math types but who have a high level of ability in math do not select math types as friends in order to differentiate themselves from those individuals. In a word, we are proposing that these males feel that if they

associate with math types, others will think they too are math types.

7. The interactive effects of sex and ability manifest themselves in students' accounts of why they came to regard math as less valuable for their lives. Males attributed the decline to career plans shift; females attributed it to lack of encouragement and never having liked math. That "female response," however, was accounted for mostly by the low ability group. It is clear that of all respondents, low ability females had the most negative attitudes toward mathematics. This finding strengthens our earlier conclusion regarding the reinforcement of disadvantage among this group.

Recommendations

The policy recommendations which are consistent with the purposes of this study and its findings cannot be stated in simple, programmatic terms. The reason is that our study pertained to elucidating those various social processes which contribute to differential and common levels of persistence in mathematics. By its very nature, therefore, we have little to offer a specific department or university as a quick and easy solution to sex inequity in mathematics education. Of course, we endorse those policies already enacted and established as well as those suggested by other studies which would increase the number of females who survive the elementary and secondary school years as "successes" still interested in mathematics. Beyond those, we offer the following recommendations and guidelines which are consistent with this study.

It is clear that low ability women represent a very identifiable target population for enrichment courses and special instructional attention. The pattern of the reinforcement of disadvantage we identified is a broad-based one, however, which includes non-encouraging family attitudes, math/gender stereotyping at school, and negative attitudes toward math on the part of the student.

These factors increase the magnitude of the problem and consequently the solutions. Therefore, the means of encouraging young females must be accordingly broad. This issue is one of the most difficult policy questions of all, because it involves the private spheres of family and friendship participation. However, after-school clubs or activities involving mathematics might be designed to help females overcome negative influences. Educational institutions, teachers, and parents can encourage females to play at mathematics as males do. This kind of encouragement would help provide for them a set of values, self-perceptions, and facts about the world that they can use in making decisions later in life.

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APPENDIX A

SAMPLE INTERVIEW GUIDE

Undergraduate Schedule , Set 3, Females

A. High School and Family Background

1. From among academic subjects, sports, social life, extra-curricular activities and the like, what were you most interested in and involved in when in high school?

2. What were you most interested in academically? What was it you liked about that?

3. What were you the least interested in academically? What was it you disliked about that?

4. Tell me about your study habits when you were in high school. (a)hours/day of study and (b) mostly alone or mostly with others?

5. Did anyone encourage you to follow through with any particular subject? Discourage you with any particular subject?

6. Who were your best friends in high school? Who did you spend the most time with? What did you do together? Common interests? Academics?

7. What were your career plans when you were in high school? Who was influential in helping you form those plans? How?

8. What did your mother and father want you to be? (If respondents says "anything I wanted," try to get specific. Probe.)

B. Social History of Mathematics

9. How was the subject of mathematics generally thought of in your family? Was it emphasized? How?

10. What is your earliest recollection of mathematics? Tell me about that.

11. Tell me about your experiences with mathematics when you were in elementary school. Did you like math then? Did you do well or not?

11a. What were your feelings about mathematics when you were in high school? Tell me about them. Did you like your math courses? How did they rank in comparison to your other courses?

12. What were your feelings about mathematics when you were in high school? Tell me about them. Did you like your math courses? How did they rank in comparison to your other courses?

13. Was there a time when things changed concerning your feelings or experiences with math? (If "no", tell the puberty story.)

14. When you were in high school, did you ever think of math as something that would be important for your career or life's work?

15. Tell me about your math teachers in high school. What did you like and dislike about them? Were they encouraging of you continuing in math?

16. Did you ever notice whether your math teachers treated you differently from the male students? Tell me about that. AND, did you ever _feel_ any different in math classes?

17. Did you ever encounter any discouragement from anyone concerning math? If not overt discouragement, how about negative overtones to how someone would talk to you about math? Friends? Counselors?

18. Compare your math teachers with your other high school teachers.

19. What were the students who were really into math like? Males? Females? Did you know any of them personally? Ever run around with any of them?

20. Did teachers in your math courses treat the "math types" any differently than the others? Tell me about that.

21. How important did your parents think math was for getting a job? Did they ever discuss this with you? Did they encourage or discourage you from taking math?

22. IF RESPONDENT HAS BROTHERS OR SISTERS: What about your brothers/sisters? Did your parents ever stress math for them?

C. College Experiences

23. Why did you decide to come to Northwestern?

24. Was the math requirement here at NU ever a consideration in your decision? Did you know before you enrolled what the math requirement was? Tell me about that.

25. How did you come to major in (name their major)? Probe.

26. Why did you decide to take the math courses that you did?

27. Tell me about those courses. Content. Teachers (good/bad/ etc) Level of competition (too much, not enough, etc.) Other students.

28. Tell me about your math professors in college. What do you like or dislike about them? Were they encouraging of you to continue in math?

29. Did you ever notice whether your college math teachers treated you differently from the male students? Did you feel different?

30. Do you plan on taking other courses in math? Should you? Have you gotten any advice from anyone that you should take more math?

31. Will you take computer science or statistics? Why or why not?

32. LOOK AT SAMPLE SHEET FOR DISJUNCTIVENESS, AND DO COMPARISON QUESTIONS BETWEEN H.S. AND COLLEGE MATH, SAT's, # OF COURSES, GRADES.

33. What is the stereotype about math majors in college? Probe for male/female comparisons. Do you know any people who fit/do not fit that stereotype? How are high school and college stereotypes similar or different?

34. How different do you think you are from the typical math major?

35. How many hours a day do you study? Mostly alone or with others?

36. Who are your best friends here at NU? Sexes? Majors? What do you do together?

37. This question may be difficult for you to answer, but I'd like you to try to reconstruct the process whereby you came to see math as not paramount in your academic life.

38. Have you heard the term "math anxiety". If YES, ASK: Have you ever experienced such anxiety? When? Tell me about it. Did it play a part in your decision not to take certain courses? If NO, SAY: It is a form of anxiety about doing math involving a fear of failure which intereferes with actually doing math. Have you ever experienced anything like that? How about a loss of confidence?

D. Work and Family Aspirations

39. What do you see yourself doing when you finish your degree?

40. Is there any particular job you are especially interested in obtaining? How did you come to select that job?

41. What do you see as the greatest difficulty in getting where you want to go professionally? How do you plan on overcoming those difficulties?

42. Have you considered going to graduate school? In what area? Where? For what degree? If not, why not?

43. To what extent is marriage a part of your plans for the future? What about children?

44. What options do you see open to you in terms of home and work? How do you see problems of coordinating home and work obligations getting worked out? What compromises are you willing to make? What will you give up and not give up?

45. What does your family think about your career plans and aspirations? Are they supportive? Do they think you are being realistic?

46. What does your family think about your family plans?

47. Given the technological boom in our society, do you have enough mathematics to make yourself competitive in the job market?

48. Is it realistic for a person to try to get through college without taking mathematics?