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ABSTRACT

The materials in this publication were originally prepared for a set of conferences on Equity in Mathematics, organized by the National Council of Teachers of Mathematics with funding from the National Science Foundation. It is suggested that these materials may assist supervisors, teacher trainers, administrators, and teachers to design and conduct activities to promote mathematics equity. Among the papers included are those on planning a conference, successful intervention programs, workshops on strategies for promoting equity, and equity survey questions. Appendix A presents state-of-the-art papers on mathematics and Blacks, girls, Hispanics, language minority students, and Native Americans. A resource list of publications, materials, and organizations and a list of conference participants are also included. (MNS)

NCTM

EQUITY in MATHEMATICS

Handbook for Conducting EQUITY ACTIVITIES IN Mathematics Education

Handbook for Conducting

EQUITY ACTIVITIES IN Mathematics Education

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National Council of Teachers
of
Mathematics

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Forward

In a world that is becoming increasingly technological the ability and willingness to think quantitatively is essential for all. Not only will individuals be able to lead fuller lives if they have an appropriate education in mathematics, the contributions they will be able to make to society will make the world a better place for all of us to live.

This handbook is part of the National Council of Teachers of Mathematics' continuing effort to help people involved in mathematics education provide appropriate mathematics education for all, and encourage everybody to take advantage of that education.

Stephen S. Willoughby
President
National Council of Teachers
of Mathematics

August, 1983

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Introduction

In recent years there has been much concern expressed about underrepresented groups in mathematics education. These groups are composed of students who do not take advanced mathematics courses or fail to enter mathematics related vocations and careers in proportions to their population. The groups include girls, blacks, language minority students and native Americans. The National Council of Teachers of Mathematics in its Agenda for Action: Recommendations for School Mathematics in the 1980's addresses the need to assist underrepresented groups:

> All reasonable means should be employed to assure that everyone will have the foundation of mathematics learning essential to fulfilling his or her potential as a productive citizen. The currently underrepresented groups should be especially encouraged and helped (p. 18).
>
> Programs that will encourage a larger percentage of females and minority students to study more mathematics should be designed and supported (pp. 22-23).

As part of a commitment to these students, the Council developed a proposal for a set of conferences that would focus on helping elementary and secondary school educators to meet the needs of underrepresented groups. The grant proposal was funded by the National Science Foundation in 1981 in order to:

1. analyze information about the status of underrepresented groups in mathematics education;
2. develop awareness of common needs within and across groups and specific needs for specific groups.
3. present examples of successful intervention programs and instructional strategies;
4. outline steps necessary to provide increased participation and achievement in mathematics courses, vocations and careers;
5. develop plans for a continuing network among participants, the Council, and other interested persons or groups, to heighten awareness, share information, develop strategies and maintain support for teachers.

To accomplish these objectives a set of five conferences were organized. The first one, identified as the "Core Conference," was designed to bring together in February of 1982 at Reston, Virginia, a small group of recognized leaders from around the country to gather information, share ideas, develop a network, and thus to set directions for the second stage — a series of "Regional Conferences." These conferences were held in:

— Orlando, Florida, October 22-23, 1982;

— Albuquerque, New Mexico, November 19-20, 1982

— Baltimore, Maryland, January 28-29, 1983

— Minneapolis, Minnesota, February 18-19, 1983.

The meetings were attended by supervisors, administrators, teachers, counselors, and teacher-educators from the local, state and regional levels. The materials and ideas which resulted from the 'Core Conference' were presented at each of the 'Regional Conferences.'

THE HANDBOOK

As a result of the Regional Conferences, the materials included in this manual have been revised and refined. The materials include suggestions for:

— conducting mathematics equity surveys;

— designing and organizing equity conferences and other teacher in-service activities;

— developing networking strategies;

— developing curriculum and instructional strategies which deal with equity issues in mathematics;

In addition, a resource list of mathematics equity materials is included in the appendix, together with the 'state-of-the-art' papers on under-represented groups in mathematics which were presented at the Core conference.

It is hoped that the materials contained in this handbook will assist supervisors, teacher trainers, administrators and teachers to design and conduct mathematics equity activities. The suggestions given are not to be construed as a set of prescriptions aimed at stifling creativity; the suggestions presented are based on the experiences and the results of the Regional Equity Conferences.

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EQUITY ACTIVITIES: Content and Form

In planning an equity activity, whether it is a half-day inservice or two-day conference, one must be certain that the participants understand that there really is a problem and that there are strategies for addressing the problem. The definition of the problem actually involves two parts. One is the general problem of underrepresentation in mathematical study of specific groups. The second is the existence of the problem in the school system or school of the participant. Similarly, the strategies used to solve the problem address two different audiences. The first audience is students who are members of underrepresented groups. The second audience is composed of adults—educators, parents and the community—whose help is needed in solving the problem. In designing your equity activities, it is necessary that all aspects of participants' needs are addressed.

I. The Problem of Underrepresentation.

A. The General Problem

Considerable research exists on the problem of underrepresentation of the target groups in mathematical study. Participants in equity activities need to be aware of the existence of this research base and the limitations of the research. To provide background material to facilitate the presentation of this research base of the problem, five State of the Art papers were prepared; one addressing each of the underrepresented groups. These papers are included in Appendix A. In addition, The Resource List in Appendix B contains many references of materials that address that statement of the problems.

B. The Specific Problems of the Audience

Though some individuals are willing to exert considerable effort to solve problems of society at large, it is more likely that people will make a concerted effort to change the circumstances that directly affect themselves. It is, therefore, desirable to have the participants in an equity activity own the problem of underrepresentation of specific groups. It is essential that they not take on the blame for causing the problem but is is necessary for them to acknowledge that there is a problem and that they can be part of the solution.

There are two approaches to helping participants own the problem. One is to present them with local data documenting the existence of underrepresentation by the target groups. If there is little time, then this approach should be used.

A better way to have individuals own the problem is to have them collect data. The data need not involve large samples. The purpose of the collection of the data is to attach the problem to real people—their students.

Section V of this handbook contains sample surveys used to collect data for the NCTM Equity Conferences. If time permits, participants should be asked to collect data prior to the conference. During the conference, time should be alloted for the sharing of the data collected, defining the problem illustrated by the data, and designing and planning of interventions that address the problems defined. In this way, participants will own the problem, clearly define it and leave the equity conference with plans for addressing the problems.

II. Solutions to the Problem of Underrepresentation

Solving the problem of underrepresentation of specific groups in mathematical study requires attention to two groups--students and their significant others. Interventions aimed only at students have little chance of success if those adults who are important in their lives--parents, teachers, and counselors--do not support the students in their efforts. Programs aimed at only these significant others need to be supported by programs that involve students.

Section III of this handbook contains descriptions of intervention programs that have been successful in encouraging increased participation of members of the target groups in mathematical study. These descriptions are supplemented by the materials listed on the Resource List in Appendix B. Those items marked with an * are appropriate for use with students. Most of the materials listed address the problem of the underrepresentation of females. It will be necessary to modify some of these materials to include the other target groups. It is suggested that as many of these materials as possible be gathered and displayed at the conference. Time for participants to review these materials is then included in the agenda.

Section IV of the handbook includes outlines and handouts for the strategy development sessions conducted at the NCTM Equity Conferences. These sessions are designed to give participants specific methods and techniques for attacking the problem of underrepresentation. They provide participants with specific strategies that can be used locally to involve others in addressing this problem.

III. Sample Agenda

Following are sample agendas for equity activities. The particular agenda you select is dependent on the time available, the number of workshop leaders present, and the facilities at the conference site. How your conf[illegible] is packaged is less important than how you involve the particip[illegible] n the conferences.

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TWO-DAY CONFERENCE AGENDA

Day 1

8:30 a.m. — 9:00 a.m.	Registration
9:00 a.m. — 9:45 a.m.	Opening/Greetings, Overview of Conference
9:45 a.m. — 11:00 a.m.	Review: State of Art Papers — Blacks, Girls, Language Minorities, Native Americans
11:00 a.m. — 11:15 a.m.	Coffee Break
11:15 a.m. — 12:30 p.m.	Discussion of: Successful Intervention Program
12:30 p.m. — 1:45 p.m.	Lunch
1:45 p.m. — 3:45 p.m.	Sessions: Strategy Development
1:45 p.m. — 2:30 p.m.	1. Planning Equity Intervention Programs 2. Developing Awareness of Equity Issues 3. Planning Career Conferences 4. Reviewing Available Equity Materials
2:30 p.m. — 3:15 p.m.	1. Conducting Equity Workshops 2. Strategies for Improving Instruction and Achievement 3. Identifying and Utilizing Community Resources 4. Reviewing Available Equity Materials
3:15 p.m. — 4:00 p.m.	Sharing Equity Survey Results
4:00 p.m. — 4:15 p.m.	Wrap-up -- Day 1
5:00 p.m. — 6:00 p.m.	Social Hours
7:30 p.m. — 9:00 p.m.	Optional Reviewing Equity Materials Worksession

Day 2

8:30 a.m. — 8:45 a.m.	Opening
8:45 a.m. — 9:30 a.m.	Sessions: Strategy Development 1. Evaluation of Instructional Materials /or Equity 2. Networking 3. Influencing Professional Organizations 4. Repeat of a Day 1 Session
9:30 a.m. — 9:45 noon	Break
9:45 a.m. — 10:45 a.m.	Using Equity Survey Results
10:45 a.m. — 12:00 noon	Planning Follow-up Staff Development Activities
12:00 noon — 1:15 p.m.	Lunch
1:15 p.m. — 2:00 p.m.	Sessions: Strategy Development, Repeats based on Participant Requests
2:00 p.m. — 2:45 p.m.	General Session
2:45 p.m. — 4:00 p.m.	Worksession: Follow-up Staff Development Activities based on Survey Results

ONE DAY CONFERENCE AGENDA

8:30 a.m. — 9:00 a.m.	Registration
9:00 a.m. —10:30 a.m.	Overview of current research: Implication for Action
10:30 a.m. — 11:00 a.m.	Break and time to look at the materials
11:00 a.m. — 12:00 noon	Discussion of local situation and suggested interventions
12:00 noon — 1:30 p.m.	Lunch and material review
1:30 p.m. — 3:30 p.m.	Discussion and demonstration of specific intervention stragies (e.g. "Multiply Options, Subtracting Bias" tapes)

HALF DAY CONFERENCE AGENDA

3:30 p.m. — 4:00 p.m.	Registration and Coffee
4:00 p.m. — 4:20 p.m.	Welcome and Opening Remarks Rationale for this Conference Statement of the Local Situation
4:20 p.m. — 5:00 p.m.	Current Research: Implications for Action A look at how key factors and people impact on student choices regarding mathematics. Suggestions for action.
5:00 p.m. — 5:30 p.m.	Strategies for Change. Outlines of model programs, materials and resources that positively effect student attitudes about mathematical study.
5:30 p.m. — 5:40 p.m.	Break
5:40 p.m. — 6:20 p.m.	Designing intervention strategies
6:30 p.m. — 7:15 p.m.	Dinner
7:15 p.m. — 7:30 p.m.	Closing Remarks

Successful Intervention Programs

There are many intervention programs which have been successful in increasing the participation of underrepresented groups in mathematical study. At each regional conferences several of these successful programs were described.

The following are representative examples of intervention programs which illustrate different approaches to promote equity in mathematics education.

Multiplying Options & Subtracting Bias

One successful program that is readily available for use in equity activities is Multiplying Options Subtracting Bias.

The videotape and workshop intervention program is designed to eliminate sexism in mathematical study and in mathematics-related careers. The tapes and workshops were developed at the University of Wisconsin-Madison under the direction of Dr. Elizabeth Fennema.

Four 30-minute, full color videotapes, narrated by Marlo Thomas, each for a specific junior/senior high school audience, uses a variety of formats--candid interviews, dramatic vignettes, and expert testimony--to address the problem of mathematics avoidance and suggest some possible solutions. A 192 page facilitator's guide provides an overview of the workshops, detailed instructions on how the facilitator can prepare for conducting the workshops, and four separate step-by-step sets of workshop instructions for each of the target audiences.

Each of the tapes and workshops addresses a different audience. The intended audiences are:

A. Teachers
B. Students
C. Counselors
D. Parents

These tapes are an excellent example of materials developed for one target group--girls--which are appropriate for use with the other underrepresented groups. It is recommended that ancillary materials, such as the statistics dealing with the underrepresentation of your target group in the fields discussed in the tapes, be made available for use with the tapes.

The tapes are available for purchase from the National Council of Teachers of Mathematics and for essential from Women and Mathematics Education. (See Res[illegible] List--Appendix A)

Math Bridge Program

Don Birmingham
Minneapolis, Minnesota

THE PROGRAM:

The MATH BRIDGE Program is for Black, American Indian and Chicano eighth grade students who have an interest in and aptitude for math. The eighth grade year is crucial because this is the last chance for the student to make the decision to take four years of high school math. Students are identified, in January, for the program by their own math teacher. Last year, 177 students from 15 junior high and middle schools participated in the program.

The students are invited to attend, with their parents' knowledge and consent, four Saturday sessions at the University of Minnesota that emphasize college preparatory courses. Although the main emphasis is on math, the importance of physics, chemistry and four years of high school English is also heavily emphasized. Prior to the program, which was held in March last year, the selected students were visited at their schools by the Director and minority students enrolled in the Institute of Technology to inform the students about the program and encourage them to attend.

The students participate in computer math activities designed by junior high, senior high and University of Minnesota faculty. They also attend mini-seminars conducted by people from industry and University of Minnesota engineering faculty that are career related.

An awards banquet held in April recognized the achievements of those students who attended all of the Saturdays with a certificate and a calculator. One hundred sixteen students, from the 1982 program, participated in all four Saturday sessions. Students, their parents, principals, math teachers, university and community representatives attended the banquet.

We believe that this brief exposure to college preparatory courses will be a decisive factor in influencing a student to take them. We also regard this program as an identification mechanism. It introduces us to a large number of talented minority students early in their academic careers.

Since the MATH BRIDGE Program was implemented in 1976-1977, there have been 840 participants. The one hundred seventeen students who participated in the first program, were scheduled to graduate from high school in June of 1981. We were able to gather information on 63 of the 117 who returned questionnaires which asked for verification of graduation from high school and post-secondary educational plans. Twenty-one (eighteen percent) of the total number entered a four year engineering, computer science or science program directly from high school. Eight of the twenty-one applied and were accepted into the Institute of Technology at the University of Minnesota in the fall of 1981 and are presently in their second year.

Follow-up data on the 1982 graduates who participated in the 1977-1978 MATH BRIDGE Program has yet to be compiled. Follow-up is being done on the 18 students who enrolled in technical programs (not at the University of Minnesota) to determine how many completed their first year program.

FOLLOW-UP PROGRAM:

An intensive 9 through 12 grade program follows MATH BRIDGE. The program accomodates approximately 80 students who attend 20 Saturday sessions at the University of Minnesota. Fifteen of the sessions are curriculum based and emphasize math, English, computer programming and science. These classes are not designed to repeat what the students are getting in school daily but to provide supplemental work in the above areas. These students are given homework and tests, and are assigned letter grades in each course. The other five Saturdays are used for seminars in the following areas: current economic conditions, self-assertiveness, making a career choice, cultural awareness, and study skills. The seminars are conducted by university faculty, people from industry and other trained personnel. There is also a six week summer session which meets Monday through Thursday. The students attend classes that are directed toward the same areas that they work on during the Saturday sessions. During the summer the students have the opportunity to visit industry sites to obtain information about careers. Throughout the year, the students receive assistance in setting up their class schedule prior to the start of each trimester or semester. (Following is the curriculum outline for the 9 through 12 grade program).

For more information on the Institute of Technology Minority Affairs Program at the University of Minnesota, call Don Birmingham (612-373-2673).

9th Grade

I. ACADEMIC		
High School Curriculum Mathematics: two tracks A. General Mathematics B. Elementary Algebra	U Advance School Year Saturday Seminars General supplementary help as needed	U Advance Summer School A. Intro to Algebra B. General supplementary work
English General language and literature	General supplementary help as necessary	Basic grammar, sentences, paragraphs, short speeches, creative writing
Social Studies Civics	None	None
Science Physical Science	None	None
II. Personal JETS, JA	Interpersonal Skills large and small group social activities on-campus (dance, bowling), interpersonal relation-ships (video), conflict resolutions/parental/ /family, communication skills, public speaking (video), time management, stress management	

10th Grade

I. ACADEMIC		
High School Curriculum Mathematics: one track A. Elementary Algebra B. Geometry	U Advance School Year Saturday Seminars General supplementary help as needed	U Advance Summer School A. Review of Algebra B. Computer Math
English General language and literature	General supplementary help as necessary	Short essays, grammar review vocabulary development
Social Studies World Studies	International economics and technology	None
Science: two tracks A. Science 1, 2 3 B. Biology	General supplementary help as necessary	TBA
II. Personal JETS, JA	Personal Roles looking for part-time jobs, creative job searching, image/dress mock interviews, how to interview (video) applying for social security cards, maintaining self-image/ identity, pressure to play different roles, pressure to conform, campus tours, taking risks/being brave	

11th Grade

I. ACADEMIC	
High School Curriculum Mathematics: two tracks A. Geometry B. Algebra/ Trigonometry	U Advance School Year Saturday Seminars A. Computer Math B. Computer Math C. PSAT Preparation
English American Literature	*Minority writers, critical essays; oral presentations *PSAT Preparation
Social Studies U.S. History	Science, Technology and Society; Business, Government & Society
Science A. Biology B. Physics	
II. Personal JETS, JA	Looking at Careers career opportunities informational guest speakers spend a day "at work," role models gender/sex roles, guest speakers (college students—what college is like), possible jobs, possible majors

12th Grade

I. ACADEMIC		
High School Curriculum Mathematics: two tracks A. Advanced Algebra B. Calculus	U Advance School Year Saturday Seminars A. Trigonometry B. General Supplement C. SAT Preparation	University of Minnesota Summer School * Pre-calculus * Math Placement Test
English Pre-college focus	*Critical reading, essay exam, research papers, group discussion techniques, use of word processor	* General review of composition and grammatical principles
Social Studies Economics	Applied Economics	None
Science A. Chemistry B. Chemistry	A. Pre-College Chemistry Pre-College Biology B. Pre-College Physics	None
I. Personal JETS, JA	Looking at College college terminology "walk thru" registration process, preparing for admission, getting bulletins, etc. applying for college, applying for financial aid, housing budgets, University student organizations sponsored social activities athletic and cultural events	

Futures Unlimited Conferences

Arlene S. Chasek
New Brunswick, New Jersey

Inspired by the success of the "Expanding Your Horizons" in science and mathematics conferences from Mills College in Oakland, California, a grant proposal was written and submitted to the State of New Jersey, Division of Vocational Education and Career Preparation, Office for Equal Access to fund six math-based career conferences in New Jersey in 1981-82 and again in 1982-83 entitled Futures Unlimited: Expanding Vocational Choices.

The Futures Unlimited project is a day-long conference at a college for five hundred 7-12 grade female students, their teachers, counselors and other educational and industrial personnel. These conferences are designed to provide role models in skilled trades, technologies, business and industry who encourage students to choose careers based on personal interest rather than sex stereotypes; and to provide hands-on workshops in a variety of math, science, technology and computer laboratories. The conference sites included two year, four year, state and private institutions.

Counselor/teacher/parent workshops are included in the design of the conference to point out linkages among school, community, labor and business and to explore specific strategies in dealing with the math anxiety/math avoidance syndrome in females and to encourage students to select careers according to interest and skills, not gender.

The Futures Unlimited conferences were highly successful on many levels. Interest was so great that thousands of students from school district throughout the state had their applications returned due to limited space. Outcomes for host colleges were: to showcase the college —especially technological/ math/science facilities and faculty; bring 350-700 prospective students to spend a full day on campus; bring 100-200 educators, counselors and parents to campus to dialogue with college personnel. Outcomes for industry included: the opportunity to increase the pool of qualified candidates for future job openings; the visibility of their commitment to employ qualified females in business and high technology positions; and the dissemination of job requirements to educators and students. Outcomes for students were: to see the economic necessity for increased course taking of elective math and science, and math-related courses; to see the facilities and atmosphere available at the host college; and to see a wide range of economically rewarding nontraditional careers in high-growth technologies, business and the professions. Outcomes for educators included: an examination of math avoidance in girls, and training in how to implement field-testing strategies to overcome this problem; and understanding of math prerequisites for college majors, training programs and new technological demands of the labor force; and to develop linkages with New Jersey industry and labor supportive to women in nontraditional jobs.

Some of the "hands-on" workshops included accounting, agricultural economics, architecture, aviation, cartography, ceramic engineering, computer graphics, computer science, food science, geology, landscape architecture graphics, physics, regional planning, statistics, engineering technology, chemical, civil, electrical, industrial and mechanical engineering.

The role models included women working in the following: engineerring, actuary science, architecture, chemistry, regional planning, refinery technology, marine biology, telephone line installation, mathematics, computer science, biomedical engineering, data processing, pharmacology, accounting, sociology, communications, stock brokerage, medicine, dentistry, construction, financial analysis, revenue forecasting, employee relations, investor relations.

The Futures Unlimited conferences were honored as the "outstanding sex equity project of 1982" by the Northeast Network for Curriculum Coordination, a national organization working with the U.S. Department of Education regional offices in recognizing exemplary vocational projects.

Note: See Section IV-Career Conferences for additional suggestions.

AAA Math

Sandra Turner
Evanston, Illinois

Supposition

The supposition of this program was that anxiety about mathematics leads to avoidance of doing homework, of asking questions, and of taking optional courses. Avoidance of mathematics leads in turn, to a poor understanding of the avoided mathematics, resulting in poor performance on achievement measures. This lack of understanding creates a lack of confidence in one's ability, which increases the anxiety. Although factors other than anxiety can lead to avoidance and/or low achievement, an intervention program should be more effective if it includes components to reduce anxiety and increase achievement.

Program

Based on this supposition, an intervention program called AAA Math was designed and implemented in two large Tampa, Florida high schools. The intervention consisted of two-hour sessions held after school once a week for eight weeks during the fall of 1981. The sessions were team-led in each school by a guidance counselor and a mathematics teacher from that school. They were open to high school students, both male and female, studying college preparatory mathematics (geometry, algebra 2, trigonometry, or college review mathematics) whose lack of confidence or anxiety about mathematics had a debilitating effect on their achievement in mathematics (called at risk students) or led to their avoidance of mathematics (called mathematics-avoiders).

The sessions, organized through the Community Education Division, carried no credit. The 15 to 20 students in each group paid a $2.50 registration fee. The leaders were paid. Each session consisted of one hour of group counseling and career information with a second hour devoted to small group tutoring by a mathematics teacher and two students tutors.

The program was publicized by flyers and announcements in both the school bulletin and the local newspaper. In addition, counselors visited every mathematics class in geometry and above to explain the program. Significant adults in the student's lives were involved through a special evening session for parents and special faculty meetings for mathematics teachers and guidance counselors.

Results

Of the thirty-six students who regularly attended the sessions, both females and blacks were overrepresented in proportion to their percentage of school population. (The ratio of females to males was 3:1, as was the ratio of whites to blacks.) The program received very positive evaluation from both students and teachers. The students especially liked the tutoring, probably because it met an immediate short term need.

Assessing for Educational Equity: Minnesota Indian Girls and Mathematics

Jan Witthuhn
Minneapolis, Minnesota

Patterns of participation in high school mathematics courses in Minneapolis Public Schools have been monitored by sex and by race since 1976. When it became apparent that inequities existed, the Mathematics Department implemented a program for change. By 1980, the levels of enrollment for most groups had significantly improved, and the goal of equity in participation was nearly being realized. The participation of Indian girls, however, continued to be low.

National data indicates that American Indians are very poorly represented in professional fields for which mathematics is a "critical filter." Data, both national and local, suggests that school achievement levels of Indian children are consistently lower than achievement levels of other children, and that mathematics is the lowest area of achievement for Indian children. Research directed at sex equity has demonstrated that women tend to score lower than men on mathematics achievement tests. This has been shown to be true for Indians as well as for others. Sex equity research also suggests that achievement in mathematics is related to attitudes towards the field. Some have suggested that there are culturally based values and child rearing practices which tend to place Indian girls at a special disadvantage in the study of mathematics. Because of the great need to address the unique needs of Indians girls in the study of mathematics, the Minneapolis Indian Education Section began to focus part of its efforts on this area. Support for this project, in the form of a small one-year grant, was received from the Women Educational Equity Act (WEEA) Programs.

The objectives of the project were modest. Included were activities to assess the present level of enrollment and performance of Minnesota Indian girls in junior and senior high school mathematics courses, analyze existing data about the attitudes of those girls towards mathematics, assess the extent to which special programs already existed to assist Minnesota Indian girls with mathematics, develop community involvement and interest in research and programs in this area, and finally develop a series of recommendations and proposals for both research and direct service projects to improve the success of Minnesota Indian girls in mathematics over a three to five year period.

The 1980 census indicates that there are approximately 35,000 American Indian people living in Minnesota. This represents about 1% of the state's population. Indian students make up about 1.5% of the state's public school enrollment. Minnesota Indians are about evenly divided between urban and rural areas. Nearly 45% live in the Twin Cities metropolitan area alone. Another 41% live in eight northern Minnesota counties which include several reservations.

Of the eleven school districts which cooperated in this project, three were large urban districts, two were suburban, five were on or near reservations, and one was an Indian-controlled, non-public secondary school. Together the eleven districts enroll more than 47% of the Indian public school students in the entire state.

Each cooperating district received at least one visit from the project staff. The purpose of the first visit was to fully explain the project and to meet with school personnel identified by each district's superintendent. In every case, the project staff was warmly received. The project staff found that their concern about how Indian girls were doing in mathematics was widely shared, although most school districts had never examined their own records to determine whether Indians were underrepresented in classes or whether they were achieving as well as others. Each cooperating district agreed that such an examination was possible and would provide valuable information. A timeline for such an analysis was established with each school district. The project staff also learned about the types of programs available to Indian students in each district and shared ideas about promising programs.

In several cases, school districts requested assistance in reviewing records and completing the analysis. Project staff provided that assistance during the second visit. In all cases a commitment was made to share the results of the districts' analyses with the project staff and with other school districs. Only one of the original eleven participating school districts failed to provide the data as promised.

In order to supplement the data provided, an analysis was made of data on the ethnic composition of the highest level mathematics courses in each district. That data was taken from the State Department of Education's Minnesota Civil Rights Information System (MINCRIS). A three-way chi square test was used to determine whether the number of students who fell into each of eight categories formed by the cross-classification of each of eight categories formed by the cross-classification of race x sex x advanced math enrollment deviated from that which would be expected if all groups enrolled in advanced math in proportion to their numbers in the total school enrollment. The results for the participating school districts indicated that the proportion of girls and boys attending school was about the same for Indians and non-Indians. Yet the proportion of males enrolled in advanced mathematics courses was significantly higher than the proportion of females. Likewise, the proportion of non-Indians enrolled in advanced mathematics courses was significantly higher than the proportion of females. Furthermore, the interaction of race and sex with advanced mathematics enrollment was significant, with Indian females being proportionately the most underrepresneted group in those classes.

Besides a final report describing the results and detailing the situation in each cooperating school district, the project staff also prepared, printed, and disseminated an annotated bibliography of books and articles related to this topic. The staff also identified a number of Minneapolis Indian women who were employed in jobs for which strong backgrounds in mathematics and science are necessary. A poster high-lighting these women was designed by the project staff and was widely disseminated.

Information about the project and its results were shared with school districts, Indian educational and tribul leaders, parents, and interested organizations in Minnesota and throughout the nation.

Mayan Mathematics in the Classroom

Vera Preston
Stillwater, Oklahoma

There are many advantages to using Mayan mathematics as an enrichment activity in any curriculum. One is to emphasize Native American achievements to both Native Americans and others in order to develop an appreciation of the Mayan, Aztec, and Inca cultures. Another is to motivate Native Americans by letting them know that the Mayans, Aztecs, and Incas had a highly developed mathematical system. The system helps all students learn a mathematical system that is easy and practically foolproof for addition and subtraction. By learning a few basic facts, multiplication and division problems are easy. The Mayan system gives students concrete experience in a base twenty system. It leads to discussions about how other base systems might have evolved. The most important reason for using the Mayan mathematical system as an enrichment activity is that all students in the class have an interest in some aspect of the Mayan culture. It improves motivation of students and helps to maintain interest throughout the year.

My seventh and eighth grade mathematics classes, composed primarily of Native American students, first began the study of Mayan, Aztec, and Inca mathematics in order to have a project to enter in our county fair. In addition to books and maps, we had drawings of Mayan glyphs for the months, the days of the months, the various time periods, Mayan gods, and a copy of the Dresden Codex, one of the three Mayan books that survived the burning of books by the Spaniards. We had a few classes devoted to the Mayas, Aztecs, and Incas and the Mayan number system. The Mayas used a place value numeration system with a symbol for zero. The base was twenty when counting items and determining distances. An adjusted base twenty system was used for counting time. All students wrote papers describing the Mayan number system. Some students also chose to draw some of the glyphs representing part of the Dresden Codex or glyphs representing the months or days of the months.

When the material was first presented, the students were allowed to look at the materials and choose the ones in which they were most interested. Everyone quickly chose something. There were students on the floor trying to translate the Dresden Codex using the charts of the glyphs for the days, months, and time periods. Some students were drawing glyphs of the days, months, or the Nine Mayan gods. Other students were making charts of the numbers. It was fascinating to me to see one topic so eagerly accepted by so many different students at so many different ability levels. Four of the papers were chosen to be used in the exhibit at the county fair. The exhibit we entered won a blue ribbon!

Later in the year, we used kidney beans to represent the red mollusk symbol for zero, soybeans to represent the dot symbol for one, and toothpicks to represent the bar symbol for five. An object was used to represent zero because the Mayas used the shell for this purpose. Together we represented the numbers one through fifty. Each student then represented other numbers in the Mayan number system. As we discussed the material we had learned before and added information to the previous materials, one of the students asked me if the Mayans were Indians. His tone of voice indicated that he wanted to confirm that Indians had indeed been responsible for the mathematical ability that produced a calendar more accurate than the one we use today. The calculations necessary to produce the calendar and the predictions of various celestial occurrences were extensive.

The information on the Mayans and their mathematical system and the materials used to represent the Mayan numerals have been presented to many age groups during the 1982-83 school year. When it was used in the fifth grade at Red Rock, the students later asked to do their problems in the Mayan system because it was easier. In a weekend workshop for Stillwater gifted students, the children from grades second through sixth enjoyed making their own Mayan numerals. In May, 1983, the Mayan material was presented to all the sixth and seventh grade extended studies classes at the Stillwater, Oklahoma, Middle School. They asked many questions about the culture. They also enjoyed making Mayan numerals.

After presenting the material to various age groups, I have found that the younger groups prefer more hands-on experience with the materials and the older ones want both the hands-on experience and historical and cultural information about the Mayas, Aztecs, and Incas.

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Workshops on Strategies for Promoting Equity

The workshops described in this section of the handbook were designed to give participants methods and techniques for attacking the problem of underrepresentation in mathematics education. Each workshop is independent and can be used alone as a separate in-service activity. Used together they form a comprehensive program for an equity conference. (See sample agendas, pages 5 and 6).

The workshops show how to involve others in addressing the inequities in mathematics educators. Handouts for each topic are accompanied by brief narratives of background information for the workshop leader.

Planning Equity Intervention Programs

Ross Taylor
Minneapolis, Minnesota

Planning Equity Intervention Programs involves the same general steps and procedures that you follow in planning any type of program. Six major components in any type of plan are as follows:

1. Stating goals
2. Assessing the status quo
3. Seeking information
4. Developing the plan
5. Implementing the plan
6. Evaluating

Implementing equity intervention programs involves change. A reference that presents ideas on planning for change in mathematics is the NCTM professional reference book entitled Changing School Mathematics: A Responsive Process. The chapters on planning and on gathering support for change should be of particular interest to persons planning equity intervention programs.

The six major planning components of equity intervention programs have special factors that should be considered.

1. Stating goals

In stating goals for equity programs it is best to state them in terms of improving the situation rather than immediately achieving total equity. If the goal is stated to increase participation and achievement for minorities and/or young women then any improvement will be seen as a success. Since nothing succeeds like success further efforts can build on initial successes.

2. Assessing the status quo

Mathematicians tend to be problem solvers and to solve a problem you need to first fully understand exactly what the problem is. In the case of equity we can do this by assessing the specific situation with respect to participation in mathematics courses, achievement in mathematics or attitudes about mathematics. In some cases initial information will be readily available but in other cases specific studies must be made. The results of the status quo assessment will indicate the specific problems that need to be addressed. Furthermore, this information can be used as base-line data in the evaluation. With this information in hand it will be possible to determine when inequities are decreased.

3. Seeking Information

Rather than going out and attempting to reinvent the wheel it appears to be more productive to see what programs have been successful in similar situations and implement those components of the programs which apply to your situation. One source of information is the National Council of

Teachers of Mathematics national headquarters office. Many more sources of information are listed in the National Council of Teachers of Mathematics Handbook on Equity in Mathematics.

Another type of information to seek is the identification of the human and financial resources that are needed to implement the program. The section in the NCTM handbook on equity in mathematics entitled "Obtaining Resources for Equity Programs" gives some ideas on how to find human and financial resources in your location that can help your program.

4. Developing the plan

Any plan is more likely to be successful if specific components of the plan are defined at the beginning. In particular, objectives should be clearly stated. Specific tasks should be defined and specific times that the tasks are to be completed should be stated. In addition, the persons responsible for each specific task should be assigned. If these steps are taken and recorded in writing then it will be possible to monitor the plan to determine if sufficient progress is being made.

5. Implement the plan

There are specific components of plans for equity intervention programs that are different from plans for other types of programs. Any equity intervention program needs to begin with an awareness of the equity issues involved. Generally an equity intervention program includes the broadening of the awareness of equity issues.

There is ample evidence that the major reason the students take mathematics courses and apply themselves to learning mathematics is the notion that mathematics will be useful to them. Therefore the provision of career information is an important component of any equity intervention program in mathematics.

The situation may be such that special equity compensatory programs which specifically address young women or specific minorities are necessary.

Consideration should be given to pluralistic learning materials to see that women and minorities are equitably represented. Learning materials should avoid sterotypes and should present women and minorities in problem solving situations.

Staff development is a key component of most equity intervention programs. First of all, awareness needs to be established for teachers, for administrators and for counselors. Staff development should include the provision of career information and the identification of factors which contribute to inequities. The development of strategies for involving parents and encouraging their students to learn more mathematics can prove to be very helpful.

6. Evaluating

The evaluation plan should address the specific goals and objectives of the program using assessment information as base-line data. Then that data can be compared with similar data collected after the program has been in operation. If the objectives, the tasks, the time-table and the responsibilities are well stated in the plan then evaluation can be used to monitor the progress in the development and implementation of the plan. The evaluation information can be used to refine and improve the program noting the weak points that need shoring up and the strong points that should be replicated in other locations.

Publicity is sometimes needed at the beginning to create awareness and seek support. Otherwise initial publicity should be downplayed. If you are low key at the beginning with publicity then you can quietly bury any mistakes or make the necessary changes. Once successes are achieved, then they can be publicized to the world giving all persons involved their share of the credit. That will pave the way for even more success.

PLANNING EQUITY INTERVENTION PROGRAMS

1. State goals
   a. Increased particiption and achievement for students.
   b. Increased awareness for staff.
   c. Increased involvement by parents and community.

2. Assess the status quo
   a. Information on participation and achievement.
   b. Information on attitudes.

3. Seek information
   a. What programs have been successful?
   b. What resources are available?

4. Develop the plan
   a. State objectives.
   b. Define tasks.
   c. Develop timetable.
   d. Assign responsibilities.

5. Implement the plan.
   Give consideration to the following:
   a. Awareness of equity issues.
   b. Career information.
   c. Equity compensatory programs.
   d. Pluralistic learning materials.
   e. Parent involvement.

6. Evaluate
   a. Evaluation plan addresses the specific goals and objectives.
   b. Assessment information can be used as baseline data.
   c. Use evaluation information to refine and improve the program.
   d. Publicize successes.

Developing School and Community Awareness

Helen Cheek
Stillwater, Oklahoma

I. PLANNING THE MESSAGE

The Fennema video tapes (teacher, counselor, and/or parent versions) are an excellent program for either the faculty or parents. The documentation with the tapes give excellent step-by-step instructions for conducting the program. The MAA tapes make a good follow-up program on the importance of mathematics to various careers. The EQUALS material is also an excellent source for providing in-service or staff development programs on mathematics equity.

Speakers from local industry might be used with or instead of the MAA video tape series. Employers explaining what mathematics background they are looking for in employees are effective, as are local role models who now use mathematics in their own jobs and can show how it has helped them become successful.

II. REACHING THE AUDIENCE

Ask the district administration or staff development committee for permission to plan an equity workshop for the faculty. This request is more apt to be granted if you have collected some data on the lack of participation in mathematics by your target group in the district. Another possibility is the program chairperson of your local classroom teachers organization. Find out who plans the program for your state or local affiliated group's conferences. Ask to be on the program or to have tapes available for the program.

The meeting of your local parent teacher organization is an opportune time to build awareness among parents and faculty at the same time. Often the parents who need to know about the importance of mathematics for their children do not attend the meetings. Some large rural districts (e.g. public schools on Indian Reservations in Arizona) run their regular bus runs for parents meetings and provide babysitting during the meeting as well. The babysitting is also often used in urban areas to encourage parents participation. At least one district was successful by showing films in the school library to children during meeting IF the children were brought to the library by their parents. (The children wanted to attend and as a result brought their parents.) Having a double program--one by the students--has been successful in most areas to increase parent attendance.

Special workshops for parents on how to help their children at home in mathematics can serve the double function of allowing an opportunity to bring the message of the importance of mathematics to their children's future. Such workshops can be part of a community school program, offered by one teacher in that teacher's regular classroom, or offered in other buildings in the community (e.g., churches, tribal halls, community buildings, etc.). Two things are important to remember about such workshops. One is that many parents whom you are trying to reach are very uncomfortable visiting a school. The second is that providing each family with a simple math game (something easily made in quantity by the teacher) is a good way to begin the workshop and a good incentive for attendance.

In small towns the local newspaper is both a good place to advertise special programs and workshops for parents and often will publish articles on the importance of mathematics for all students and how parents can help encourage their children in mathematics. Many large cities have small neighborhood papers, often throw aways, that are widely read by parents. Many of these papers carry free advertisements for public interest activities. Occasionally they will print articles on topics such as mathematics equity if the copy is provided by local teachers.

DEVELOPING SCHOOL AND COMMUNITY AWARENESS OF EQUITY ISSUES

I. PLANNING THE MESSAGE

A. Fennema and/or MAA tapes can provide a program for faculty or parents

B. Speakers from local industry and government agencies to describe the need for math in the job market.

C. Programs on math anxiety and successful methods for overcoming it.

D. Speakers on math equity: the historic and cultural reasons for your target groups' failure to participate in mathematics.

E. Role model speakers (local if possible) who use mathematics in successful careers.

II. REACHING THE AUDIENCE

A. Faculty meetings.

B. District in-service staff development.

C. Local mathematics education conferences.

D. Parent-teachers organization.

1. Send bus for parents
2. Provide babysitters
3. Program by the children

E. Community school programs.

F. Special workshops for parents.

G. Local newspapers and newsletter.

1. Advertisement
2. Education

Obtaining Resources for Equity Programs

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Most equity programs require financial and/or human resources. In seeking out resources use the FOWGI principle (Find Out Who's Got It). Funding sources include federal, state, and local governments. Usually there is some person or agency within a school district, college or university that monitors federal, state, and local grants. These grantspersons also tend to have information about funding from private fundations, national corporations, local businesses, and or/individuals. Elementary and secondary schools sometimes supply funds for equity programs out of their own resources. In some cases higher education provides sources of funding, particularly when colleges and universities want to increase their female or minority enrollments.

Human resources can often be as valuable as financial resources. individuals can provide staff development, supply career information for students, or possibly do special tutoring for the targeted populations of students. These individuals can be found in higher education, in business and industry and in organizations that are oriented to women or minorities. They can also be found in professional organizations such as professional societies of engineers. School district personnel or private individuals can also serve as valuable resources.

When seeking support from a university or business, do not just try to deal with the organization; but rather identify key individuals within the organization that have a specific commitment to the cause of equity in education. For example a number of corporations have organizations of visiting women scientists who visit schools to talk to the students about the relationship of science and mathematics to their future. It is productive to work through the networks of individuals who are interested in equity issues.

There are a number of strategies that you can use that are helpful in the equity efforts. First look for organizations and individuals with objectives similar to your own. For example suppose a school district wishes to increase minority participation in high school pre-college mathematics courses and a nearby university desires to increase its minority enrollment. They have similar objectives and they can work together with common programs that will help each of them meet their objectives.

Get organizations and individuals to support activities where your objectives and their objectives most closely coincide. For example, business who wish to increase their technically oriented minority employees will be most interested in working with schools at the senior high school level; the payoff in terms of an increased number of minority employees will come much sooner for them.

In working with individuals inside and outside of your organization, have them develop ownership by participating in the planning and the development of the program. It may be difficult to get support for a completed program of your own. It is easier to get support for a program in which all of the interested parties participate in the planning.

In the beginning, a priority should be placed on areas where the most progress can be made. For example, it is easier to increase participation by providing information about the importance of mathematics to the future than it is to compensate for low achievement that has accummulated over a long period of time. Work for early success. This is particularly important if funding is sought on a year to year basis. Funding for a succeeding year is more likely to be obtained if you can show some evidence of success.

Activities that cost the least should receive priority. For example, it is relatively inexpensive to inform teachers, counselors, administrtators, students and parents of the importance of mathematics to the future of the students. These efforts can yield early success and can serve as a foundation for dealing with the tougher issues on a longer on-going basis.

Make effective use of publicity. Early publicity should deal with gathering support and for creating awareness of the equity issues. it is best to be low key initially about expected results of the program; then no one will be disappointed. Once successes are achieved then they should be widely publicized giving all persons involved due credit. In that way more support will be generated for future activities.

Be sure to distinguish clearly between resources that are needed initially to make a change and the ongoing resources that are needed to maintain the change. "Soft money" resources that may not continue on an ongoing basis chould be used for things like staff development that are needed to make the initial changes. "Hard money" which is available on a ongoing basis is needed for activities that are maintained year after year.

Resources from federal funds and private foundations are usually available only for a fixed duration of time so, they should be used to make the initial change. Resources that will continue to be available year after year can be used to maintain the change. Such resources are usually available from sources within the organization. It is possible to find external human resources such as visiting scientists that will continue to be available year after year. Business and industry can provide ongoing resources if there is a potential for furnishing a continuing supply of well qualified female and minority technically oriented employees.

Place a priority on obtaining local resources. Those are the resources upon which can have the most influence for continuing funding year after year.

Here are some final thoughts. To achieve your goal you need high expectations and commitment. You usually need imagination, determination and money. With enough imagination and determination you can expect to get the money and the human resources you will need to move ahead toward making equity in mathematics a reality.

OBTAINING RESOURCES FOR EQUITY PROGRAMS

A. SOURCES OF FUNDING
1. Government (Federal, State and Local)
2. Elementary/Secondary Schools
3. Higher Education
4. Private Foundations
5. National Corporations
6. Local Business and Industry
7. Individuals

B. HUMAN RESOURCES
1. Higher Education
2. Business and Industry
3. Equity Oriented Organizations
4. Professional Organizations
5. School District Personnel
6. Individuals

C. STRATEGIES
1. Locate organization and individuals with objectives similar to your own.
2. Get them to support activities where objectives most closely coincide.
3. Develop "ownership" in the program.
4. Place a priority on areas where the most progress can be made.
5. Work for early success—particularly if funding is year to year.
6. Place a priority on activities that cost the least.
7. Make effective use of publicity.
8. Distinguish between resources needed to make change and resources needed to maintain change.
9. Look for resources that will continue to be available year after year if needed.
10. Place a priority on local resources.

D. ADDITIONAL THOUGHTS
1. You usually need imagination, determination and money.
2. With enough imagination and determination you can often get the money.

Involving Professional Organizations

Genevieve Knight
Hampton, Virginia

In order to ensure that your equity efforts are successful, you should attempt to involve professional organizations and implement plans for ongoing professional activities. Two outlines are included to assist you in Getting the Ear of Professional Organizations and Planning Ongoing Profesisonal Activities.

Getting the Ear of Professional Organizations

Review the literature for groups whose programs include equity activities (see Appendix B of this manual), secure written information from national headquarters, and make personal contact with the nearest level of the groups. Attend meetings and become acquainted with individual organizational policies and objectives. The key factor is to prepare a document in which the philosophy, aims, objectives, and activities of your efforts are clearly described. Using the document as a working paper, establish a cooperative relationship and actively engage in activities with the selected organization. Be prepared to make available information and individual workers to the target organization.

Planning Ongoing Professional Activities

The ten item outline is a suggestive format that you might use to plan your ongoing activities. Organizations vary in degrees of professional activities. Carefully consider the size, structure, programs, resources and long range plans in generating particular program plans. Using the various components of the manual collectively as a composite unit, develop a flavor for making equity efforts workable. As equity becomes a part of your designated unit, professional activities soon take an equal treatment approach to all issues and concerns.

GETTING THE EAR OF PROFESSIONAL ORGANIZATIONS

I. Mathematical Sciences

A. Acquire literature from available groups. (See Resource list)

B. Contact.

1. Local groups
2. State/Regional groups
3. National Headquarters

C. Become a member and attend meetings.

D. Establish.

1. Advisory Boards
2. Career Workshops
3. Speaker Exchanges
4. Visiting "Teacherships"
5. Seminars for Parents
6. Forums for Community Input
7. Coorespondence Links with Editors of Publications
8. Reciprocal Relationships
9. Mutual Trust and Concerns
10. Educational Task Forces

II. Other Professional Groups

A. Acquire literature and establish an exchange of ideas and concerns.

B. Select appropriate activities from mathematical sciences list.

III. Comments/Notes

WORKING WITH PROFESSIONAL ORGANIZATIONS

I. IDENTIFY TARGET GROUP

II. PROMOTE AWARENESS OF EQUITY ISSUES

III. ENCOURAGE COOPERATIVE BRAINSTORMING

IV. IDENTIFY SOURCES AND RESOURCES

V. ESTABLISH OBJECTIVES AND LONG RANGE PLANS

VI. PLAN ACTIVITIES: INDIVIDUAL—GROUP—COLLECTIVE

VII. DEVELOP ACTIVITIES

IX. EVALUATE ACTIVITIES

X. RECYCLE

Building and Using Networks

Judith Jacobs
Fairfax, Virginia

Creating or breaking into established networks can provide valuable resources to help you reach your Equity goals. This workshop will provide guidance in the "how-tos' of organizing local networks.

First and foremost, networking is an active process. All members of the network must actively participate in order for the network to succeed, and for all goals to be achieved. You should not expect every member of the network to support your particular issue. Networking involves cooperation, a team effort that helps all individuals achieve their personal goals. You use other people's strengths to achieve your goals while they use your strengths to achieve their goals.

Once you have decided to establish a network you need to find others to join you. You can find these individuals in traditional education organizations or traditional civil rights organizations. You can also find them in activitist groups or at meetings. A commonality of concern is the first requirement for membership. Realize that you do not have to like all of the politics nor the people with whom you network. In planning the first meeting, be sensitive to areas of potential conflict. In setting times for the first three meetings do not eliminate participants by always conflicting with the same activities. Remember that different groups have commitments at different times. Check on the local sports schedules, the religious observance patterns, and other meetings of your community. No time will be conflict free, but everyone should be able to attend one of the times.

Do not overwhelm the group by having too many people at your first meetings. Networks are informal structures and personal interaction is a major part of networking. The use of first names and ignoring titles helps make everyone feel like an equal contributor. Though superstars are valuable, the success of the network is dependent on everyone feeling valued and important.

Though the goal of your network is to increase the participation of your target group in mathematical studies and careers, this goal is too general to get people involved. Attack a small problem on which closure can be reached in a relatively short period of time. Plan a career conference, prepare a list of individuals (role models) who can speak to students on careers using mathematics, or arrange a presentation to the local school board on the issue. Do something that can make the network members feel that they have accomplished a task. While working on specific tasks you can involve more individuals in doing things. While doing, people can be talking about general issues and changes that need to be made. Let the general follow the specific. Keep people involved and they will stay committed.

Remember, the members of the network are there to meet their needs not yours. Keep time requirements to a minimum. Start on time, socialize after the meeting so some can leave if they want. A network is organized around specific goals. Do not broaden the goals much or you'll lose some of your best workers who are task-oriented.

NETWORKING

I. PURPOSES

A. To develop and use contacts to get inside information, advice, ideas, leads, referrals, moral support

B. To know who to call about what

C. To link people to people

D. To help people become more effective

E. To beat the system that isolates

F. To provide emotional support, i.e., instant understanding

G. To increase the visibility of target group leaders

H. To increase the target group power base

II. A network is a team and, in adversity, a gang that transforms.

ISSUES INTO ACTION

III.

A. Networks are organized around an issue such as EQUITY.

B. They can be sub-organized around issues such as EQUITY FOR THE TARGET GROUP.

IV.

A. Networks are mutual - use organizations.

B. Everyone deals from a position of strength. Each person actively contributes information and expertise.

C. Individuals are there because of more or less naked self-interest.

D. Warning: Do not assume every member of your network supports your particular issue.

V. Where to begin: First steps in building a network

A. Identifying resources

1. Realize you need other people
2. Seek out people from old established groups such as National Council of Teachers of Mathematics, Women and Mathematics Education, National Association for the Advancement of Colored People.
3. Seek out people from outside your usual professional associations, such as parent groups, activists organizations, or those you meet at conferences.

B. Before the first meeting

1. With a core of 2-3 people who agree with need for a network, generate a list of 20 names.
2. Set a date, time and place for first three meetings. Check for conflicts.
3. Focus on an easily definable, relatively small problem.
4. Have a printed agenda and statement of purpose.
5. Have at the meeting
   Name Tags (first name basis)
   Copy of Agenda
   List of Attendees
   Self-help refreshments

C. The first meeting

1. Greet people as they arrive.
2. Have people wear a name tag. Here's one:
   Name tag —
      Name ______________________
      I am expert in ______________________
      I am interested in ______________________
3. Start on time
4. Introduce yourself. Say a few words on what prompted you to call things together
5. Have people introduce themselves and state why they came, or their special interest
6. Delegate tasks at the first meeting.
   a. Send out summary and reminder to those on list.
   b. Talk to those who didn't show.
   c. Write a statement of purpose.
   d. Generate list of questions to be discussed at next meeting (at end of first meeting — distribute with summary).

D. Follow-up to the first meeting

1. Try to talk with all attendees after the meeting — get them to reinvest in group.
2. Arrange for someone else to chair the next meeting. The leadership should be fluid and informed.

VI. GENERAL PROCEDURES

A. After basic questions are settled, open up membership. (You may have started with open membership to all).

B. Involve newcomers. Let them do something as soon as you can — even if you must make up the job.

C. Rotate the essential jobs, sharing control and responsibility.

D. Keep in touch between meetings.

E. Reach at least one decision per meeting.

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Conducting Equity Activities

Gilbert Cuevas
Miami, Florida

The following are suggestions to assist you in the decisions that need to be made in planning, designing and implementating of educational and training activities. The three basic areas which need to be addressed are: CONTENT, AUDIENCE, AND 'MECHANICS.'

A. CONTENT: The results of student/school/district surveys should be used in deciding what aspects of mathematics equity issues will be addressed in the proposed conference/workshop. Among the most commonly listed general areas are --increasing participation of minorities/girls attitudes toward mathematics; concerns in mathematics, etc.

In addition, possible strategies for dealing with the content areas(s) selected must be identified. These strategies may include ways for dealing with curriculum and/or methods of instruction, as well as, use of instructional materials, and student counseling approaches.

B. AUDIENCE: It is important that a target audience be identified. During initial equity activities it is recommended that the audience be as homogeneous as possible (in terms of roles) to increase the likelihood of positive impact. Among the different groups which may be considered are --students, teachers, administrators, counselors, school board members, representatives from the business community, etc. Also, the conference planners must decide the LEVEL at which the activities will take place. A basic question to be asked here is --what will the activities provide for the participants? Awareness? Involvement? Commitment? These are the levels which were referred to.

C. 'MECHANICS': Once the needs have been assessed (survey), the content identified, and audience selected, there are other areas which must be addressed. These are areas which deal with the actual design and implementation of the conference/workshop activities.

1. Designing the Conference/Workshop

   a. Objectives --based on the needs identified on a survey and the participants to be involved in the activities, specific workshop goals/objectives must be specified.

   b. Resources --resources may include organizations (e.g., local NCTM affiliate group), educators, consultants, business leaders and the participants themselves. Also, books, films, tapes, games can be considered as resources for conducting learning activities.

   c. Activities --these refer to the sequence of events that will take place during the conference/workshop that lead to the goals or objectives. Activities may include presentations, demonstrations, discussions, gaming, problem-solving simulations, and brainstorming.

d. Finances -- it is important to determine if you can afford the goals you have set for the conference. In planning the activities, it is suggested that a 'budgeting-by-objectives' approach be used.

e. Arrangements --these include not only the facilities where the activities will take place, but also making sure that materials have been secured, consultants/facilitators have been contacted, and participants have been informed. In addition, the scheduling of the Conference must be carefully planned. Sometimes 'after-school' workshops are not feasible or week-end retreats' may be too expensive.

2. Coordinating the Equity Conference/Workshop

a. 'Setting-Up' -- this refers to the physical set-up for the activities, as well as preparing the participants for a learning climate which contributes to the accomplishment of the conferences goals. Setting the 'climate' includes discussions of the purpose of the activities, participant and facilitator's expectations of the workshop; overall, the participants must have a feeling of 'ownership' of the workshop --they must want to do what has been planned for them.

b. Facilitating the Activities -- some of the questions which need to be addressed in this area are:

-- Are all the necessary materials available?

-- Is the scheduling of activities/workshop sessions appropriate?

-- Are breaks scheduled appropriately? Sufficiently?

-- Are the methods of instruction paced appropriately? (Too much lecture, not enough group involvement)

3. Evaluating the Conference/Workshop

These basic questions need to be answered regarding the effectiveness of any training activity:

-- Were the goals of the workshop met?

-- How did the participants feel at the end of the activities?

-- As a result of the workshop, were there any changes implemented concerning underrepresented groups in mathematics education?

The first two questions deal with the immediate effects of the activities; the third question addresses the long-range impact of the workshop on district practices as they relate to minorities and girls in mathematics.

The checklist that follows is a summary of the issues discussed in this section. Please feel free to adapt it to fit your individual needs and training focus.

CONDUCTING MATHEMATICS EQUITY CONFERENCES/WORKSHOPS
A SUMMARY CHECKLIST

PLANNING THE ACTIVITIES

---

1. Needs to be addressed:

2. Conference goals/objectives:

3. General content

4. Strategies to be addressed:

— Curriculum:______________

— Instruction:______________

— Materials:______________

— Counseling:______________

— Other:______________

5. Audience (check)

_____students _____administrators

_____teachers _____counselors

_____parents _____business leaders

_____other:____________________

6. Level (check)

_____awareness

_____involvement

_____commitment

DESIGNING THE ACTIVITIES

7. List resources

8. Budget

9. Describe agenda, type of activities

10. Arrangements

    a. Facilities

    b. Facilitators

EVALUATING THE ACTIVITIES

11. List items to assess

    a. workshop objectives

    b. participant reactions

    c. long-range impact (describe strategies to be used)

Career Conferences

Judith Jacobs
Fairfax, Virginia

Conferences highlighting careers in mathematics and sciences are designed to show members of groups underrepresented in these fields that there are opportunities for them. Such conferences are designed to expand the career horizons of participants.

Local circumstances will determine precisely how your career conference will be organized. There have been many different versions based on the suggestions in the Career Conferences handout.

Decisions will be made based on availability of funds, speakers and facilities. Some decisions will be political ones. For example, should social science careers be included? Many members of the target groups are already in social science careers so why encourage more to enter these fields. On the other hand, social science fields require more and more mathematics and, therefore, it is valid to include them in a career designed to encourage the study of mathematics. You may decide this question based on who is willing to fund the conference.

Though the primary goal of career conferences is to impact on students' course taking decisions, one should not ignore the value the conferences have for networking among the planners of the conference. This networking can lead to internship opportunities and summer employment for students.

Career conferences are a vehicle for involving parents, educators, and non-school personnel in promoting equity through mathematics. You can start small (a half-day workshop) and work up to a multi-day conference. All, both students and adults, can benefit from the experience.

CAREER CONFERENCES

I. GOALS:

A. To encourage target group members to prepare for careers that use mathematics

B. To provide information on employment opportunities for target group members in fields requiring mathematics

C. To meet and form personal contacts with role models who are currently working in mathematics related fields

D. To promote networking among individuals who are concerned with promoting equity in these fields

II. THE PARTICIPANTS:

A. Students in grades seven through twelve

B. Their significant others: parents, teachers, counselors
Note: Though many sessions would be open to all, it is often desirable to have some separate sessions for (a) seventh and eighth graders, (b) ninth and tenth graders, (c) eleventh and twelfth graders, and (d) adults.

III. PRESENTERS:

A. Determine what fields should be represented. This is often determined by whom you can get

B. In career workshops, combine members of high-visibility and low visibility fields, e.g., an engineer and an anthropologist

C. Personal traits:
Competent, personable, communicative, sympathetic to equity issues, humorous.
It is less important for workshop leaders to be eminent then to be good at presenting ideas.

D. Many presenters may need help in developing math and science activities that are appropriate for the audience. This is particularly true at the junior high school level

E. Issues:

1. Should only target group members be presenters?

   a. Yes — This develops a sense of community and collective power for the participants. It maximizes the effect of role models.
   b. No — The current scientific leadership is comprised of white males — including them as presentors increases their, the establishment's, awareness and commitment to equity issues. It lets participants know that white males can be supportive of target group members entrance into mathematics — related careers. It is essential though, that target group members are highly visible as leaders at the conference.

IV. THE CONFERENCES:

A. Length — one, two or multi-day workshops
Note: one day with interaction at mealtime can be sufficient. Longer than one day should involve some field trips.

B. Types of sessions

1. Opening — keynote speaker or panel
2. Workshops — career or math/science workshops
3. Sessions for adults

C. Panel discussion or keynote speaker

1. Try to inspire not awe
2. Talk about themselves, their education and their jobs
3. Remember: will be talking to an audience from 12 years old to adults

D. Career Workshops:
Topics to be included

1. Courses needed
2. Financing an education
3. Career options
4. Reactions of family to entrance into this field
5. Reaction of majority group members to target group members
6. Combining a career with a family

E. Math/Science Workshops

1. Hands-on workshops
2. On topics not in the curriculum
3. Help students understand how mathematics and science are used
4. Some suggestions: Gambling, Pin-hole cameras, Test tube detections, Linear programming

F. Workshops for Adults

Parents, teachers and counselors should be provided with information on career opportunities. Some topics for workshops include:

1. Financial aid
2. The problem of math avoidance
3. Multipying Options and Subtraction Bias tapes (see Resource List)

V. RECRUITMENT OF PARTICIPANTS

A. Who is the audience?

1. Those already interested in mathematics and science
2. Those who are undecided about their future goals

B. Scheduling the conference

1. Be careful about conflicts: SAT's, local sport meets
2. When:
    a. Evening
    b. Saturday
    c. Mid-semester break

C. Publicity

1. Direct mailings to school
2. Campus and community newspapers
3. Posters
4. University faculty announcements in courses which teachers are enrolled
5. Students who have previously attended

VI. HANDOUTS:

A. Students should be given materials to take home. These might include:

1. Descriptions of programs at local college and universities
2. Don't Knock It, Unlock It brochures, The Math You Need in High School (see Resource List)
3. Brochures on different careers

B. You can often get local businesses to pay for running off this material

C. Contact professional organizations to obtain materials for distribution

VII. REFERENCE:

Krienberg, Nancy. Ideas for Developing and Conducting a Women in Science Career Workshop, Washington, D.C.: National Science Foundation

Evaluating Instructional Materials for Bias

Gilbert Cuevas
Miami, Florida

> The treatment of minorities and women in elementary and secondary textbooks has long been an issue of concern to groups representing minorities and females, because they believe that textbooks used in schools throughout the Nation do not accurately and fairly portray the diversity of the American population (U.S. Commission on Civil Rights, 1980, p. 1).

Three basic premises underlie the above statement: First, the United States is a pluralistic society, second, the school curriculum (including instructional materials) should reflect the composition of the society. And, third, there is evidence in the literature that instructional materials play a role in the student's development of self-concept and self-esteem, and the effect these variables have on achievement.

In evaluating mathematics instructional materials for social bias, two concerns need to be addressed: the one concern deals with the problem of exclusion, or not including women and members of minority groups in textbook content, illustrations and examples. The other concern is stereotyping, or representing people in distorted, inaccurate or simplistic ways. The evaluation instrument is designed to address these two concerns. Educators must keep in mind as they review and evaluate materials that the goal to be achieved is one of balance in the way mathematics instructional materials portray people and groups—there should be a striving for equality and fairness.

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[1] U.S. Commission on Civil Rights. Characters in texbooks: A review of the literature. D.C.: U.S. Printing Office, 1980.

HOW TO TELL IF A TEXTBOOK* OR WORKBOOK IS BIASED AND NEEDS SUPPLEMENTATION

* Math, Science, Health, Elementary Social Studies (except World Cultures), Economics, Civics and Government, Psychology, Sociology, Law, Language Arts (including dictionaries) Spelling, Drama, Handwriting, Business Education, Home Economics, Industrial Arts, Vocational Education, Consumer Education, etc.

	YES	NO	N/A
1. Are most of the "people" illustrations of boys or men?	___	___	___
2. Are most of the "people" illustrations of persons who are European or Euroamerican?	___	___	___
3. Are men/boys in illustrations and exercises generally portrayed as <u>active</u>, that is, as doers, thinkers, leaders, problem-solvers, decision-makers and women/girls as <u>passive</u>, that is, as watchers or standers-by?	___	___	___
4. Are men generally portrayed in traditional male careers and women in traditional female careers or roles?	___	___	___
5. In the portrayals of non-Euroamericans, are they generally in passive roles, i.e., watching rather than doing, non-contributive in the situation, having problems but not solving them, etc.?	___	___	___
6. Are persons of ethnic or racial groups stereotyped in any way (i.e., American Indians as "primitive," feathered characters, Asian Americans as laundry or restaurant workers, Black Aermican as athletes or slaves, Hispanics as rancheros or siesta takers, etc.)?	___	___	___
7. Does the book exclude characters who are physically disabled, obese, "homely," etc? If portrayed, are they generally inactive, dependent, non-productive?	___	___	___
8. Are the elderly generally ignored? If portrayed, are they inactive, incompetent, quaint, evil or foolish?	___	___	___
9. In the "history of . . ." section, are women's contributions generally ignored or mentioned only in token ways?	___	___	___

IF ONE OR MORE OF THE ABOVE QUESTIONS CAN BE ANSWERED WITH A 'YES,' THE BOOK IS PROBABLY BIASED IN THAT RESPECT AND SHOULD BE SUPPLEMENTED IN SOME WAY TO BALANCE THE CURRICULUM.

Developed by Dr. Ruth A. Gudinas, Curriculum Specialist, Department of Human Relations, Madison, Wisconsin Metropolitan School District.

Increasing Achievement in Mathematics

Helen Cheek
Stillwater, Oklahoma

This session can be didactic or group discussion in nature with the handout prepared for participants serving as an outline. The comments which follow are points which can be discussed under each heading of the outline by the workshop leader. These are followed by questions which can be asked to elicit discussion among participants if a non-didactic session is planned.

I. THE NEED FOR CURRICULUM OBJECTIVES AND EVALUATION

When teachers own the mathematics curriculum because they have been involved in formulating it, they are more apt to attempt to follow the curriculum and agree with the objectives. Teachers who attempt to write such a curriculum without outside guidance, however, are often quite frustrated in the process and limited in their scope. Such curricula are likely to follow closely the last textbook series the district or school has been using for mathematics. It is suggested that each member of the curriculum planning committee be given a copy of AN AGENDA FOR ACTION in preparation for their task. This will help guide them in planning curriculum objectives.

A. Why must teachers be involved in writing the curriculum?

B. Why shouldn't the textbook series adopted by the school serve as the curriculum guide?

C. What outside expertise is needed?

Teachers are not the only determinants of the success or non-success of a curriculum. It is always important that students and their parents know what is expected of them. It is also vital that administrators know, and agree with, the curriculum's objectives because they will be evaluating the teachers' performance in terms of meeting these objectives. It is also important that administrators help plan evaluations of student progress in terms of the curriculum objectives. No program can be evaluated as successful or unsuccessful without looking at the objectives of the program and determining whether or not these objectives were met.

A. How do parents and administrators impact upon the success of the curriculum?

B. What happens to a process oriented curriculum when it is evaluated with standardized instruments which are product oriented? What message are the teachers receiving?

C. Do we also need normed-referenced testing for credibility?

II. THE NEED FOR HIGH EXPECTATIONS

When administrators and/or teachers explain away widespread failure in mathematics as being caused by some attribute of the students, they are demonstrating one of the primary reasons their students are not succeeding. If administrators and teachers have high expectations for the mathematical achievement, students will probably also have such expectations. Special efforts might be required to be sure that parents also hold such expectations because parent expectations effect individual children even more than their teacher's expectations.

A. How do expectations affect achievement?

B. What can be done to raise expectations?

III. THE NEED FOR PRINCIPAL'S SUPPORT

Recent research on the role of the principal has shown the elementary principal to be the key to achievement. The high school principal does not seem to have this impact on achievement in specific subject areas.

A. How does a principal indicate support for a mathematics curriculum?

B. What support is needed at the high school level?

IV. THE NEED FOR APPROPRIATE MATERIALS AND APPROACHES

Results from numerous Math Clinics and Math Anxiety Clinics at universities and remedial mathematics programs in the schools, indicate that we tend to spend too little time building concepts before attempting to establish patterns with drill and practice activities. How much time is spent at the concrete or enactive stage depends on the particular class, however, there appears to be more harm done by proceeding too quickly to the symbolic stage than too slowly. This is equally true in high school, junior high school and elementary school. The learning cycle approach advocated in the NCTM publication MATHEMATICAL EXPERIENCES (Volume 1 and 2) is most appropriate in introducing new concepts through general mathematics courses. There are many commercial materials and books for teachers giving concrete manipulative approaches which are very appropriate for first year algebra students. For example, see Key Curriculum Company's Math Tiles, Algebra in Concrete by Mary Laycock, and Solid Sense in Mathematics by Laycock and Smart. Geoboards and constructions are concrete activities for geometry students.

A. Are the use of manipulative materials to introduce concepts above third grade a waste of time?

B. Might the emphasis on building concepts be even more important for some targeted groups?

C. Are applications at the upper grade levels the same as manipulatives in the primary grades.

Curriculum objectives are not likely to be met if instruction is not directed toward them. Although research does not indicate that calculators are harmful, it does indicate that some uses are inappropriate (e.g.; using the calculator to check long paper and pencil algorithms). One of the most serious problems facing the mathematics curriculum in many parts of the country today is the selection of appropriate software for microcomputers. Too many schools are making hardware purchases first, then buying whatever software fits their hardware and budget instead of finding software that meets their curriculum objectives and then purchasing the hardware necessary to use that software. If software does not meet the objectives of the curriculum, it is probably useless at best and counterproductive at worst.

A. How might we help teachers direct their instruction toward the objectives of the mathematics curriculum?

B. What are appropriate uses of the calculator and/or computer in the mathematics classroom?

V. THE NEED FOR SYSTEMATIC REVIEW

Elementary teachers with self-contained classrooms should plan a five to ten minute review of basic facts and skills previously studied at some time each day other than the regular mathematics program. Such a review first thing in the morning, after recess, or after lunch serves as a quick way to help children focus on learning tasks as they return to the classroom. It is easier to help children retain facts and skills than it is to help them relearn them. Such reviews can be self-checking by having the problems on an overhead transparency and at the end of the review period displaying the answers on the overhead via a second transparency (This also reduces teacher preparation time as they can be reused during the same year as well as from year to year.)

Mathematics teachers in departmentalized classes should plan a five minute review at the beginning of each class period. This helps to develop task orientation as soon as students enter the classroom and also prevents wasting instructional time at the beginning of each period while the teacher attends clerical duty such as roll. This is also a way to maintain basic arithmetic skills in higher mathematics classes without spending instructional time on arithmetic.

A. Is daily review worth giving up instructional time? Is it necessary to give up instructional time for review?

B. How can this be accomplished without overloading teachers with paperwork?

VI. THE NEED TO MAINTAIN AND IMPROVE TEACHER'S SKILLS AND KNOWLEDGE

Some states require teachers to update skills annually (e.g., Oklahoma). Encourage your state (or local districts) to approve conferences of the NCTM and the local affiliated groups for staff development credit.

A. Does your school recognize attendance at conferences such as this as staff development?

B. How could teachers in your district be encouraged to take more mathematics courses? Should junior high and high school mathematics teachers also be encouraged to take more mathematics courses?

NATIONAL COUNCIL OF
Teachers of Mathematics
NCTM

EQUITY in MATHEMATICS

INCREASING ACHIEVEMENT IN MATHEMATICS

I. District (school) Curriculum Guide with clearly stated objectives and evaluation matched to objectives.

A. Teachers must be involved in curriculum writing (assisted by person with background in math curriculum).
B. Curriculum must have objectives for all basic skill areas (see NCSM list of basic skills).
C. Teachers, students, parents, and administrators must all be aware of curriculum objectives.
D. Criterion referenced testing of objectives needed. [see: Educational R & D Report, Volume 5, #3, Fall 1982. Available from Council for Educational Development and Research, 1518 K Street, N.W., Washington, D.C. 20005.]

II. High expectations for mathematical achievement must be held by administrators, teachers, parents, and students.

III. Commitment and support of the mathematical curriculum by the building principal (especially at the elementary school level).

IV. Appropriate use of materials and approaches.

A. Use manipulative materials to introduce concepts and build understanding (at all levels).
B. Instruction should be directed towards curriculum objectives.
C. Most research indicated calculators to be helpful. None shows it to be harmful.
D. Computers are helpful but software needs to be carefully chosen with curriculum objectives in mind.

V. Maintain skills through Systematic Review.

A. Review 5 to 10 minutes daily (or three times a week). Use this as both review and management technique.
B. Follow-up on student weakness observed in review.

VI. Maintain and Improve Teachers' Skills and Knowledge

A. Regular in-service programs.
B. Encourage membership in NCTM and affiliated groups.
C. Staff development programs for elementary teachers should encourage teachers to take math.

Primary Sources: B. Ross Taylor, Patricia Hess, Marilyn Suydam, and Shirley Frye

Equity Survey Questions

The following seven survey questions developed by the NCTM Equity Conference Advisory Council were mailed to participants in advance of the conferences. Participants were asked to choose at least one survey question appropriate to their own situation, conduct the necessary research and bring the results to the conference. If none of the questions were appropriate, the participant was invited to prepare a question, research it and share the results at the conference. In this way every participant arrived at the conference with current data on the mathematics education equity problems of their own school, community or region. The data was shared with other participants and used as the focus of sessions set aside for participants to plan their own follow up equity in mathematics education activities.

The EQUALS Handbook published by the Lawrence Hall of Science, University of California at Berkeley, was the source of both the idea of requiring participants to bring their own data to the conference and/for several of the survey questions asked. Questions 1, 3 and 4 were adapted from questions used in EQUALS Conferences by asking for data on race and ethnic background as well as sex of students.

One problem that the Advisory Council found with these forms was the disagreement of terminology for describing ethnic background. For this reason, one column of the forms has been left blank for future users to complete. This column should be headed with the appropriate term in your region to describe students of European ancestry who speak English as a native language. In some areas the term white was appropriate, and some the term was Anglo. Some regions reported these students under the sections captioned Native Americans. If the latter is apt to occur in your region you may want to change that heading to American Indian to prevent confusion.

PLANNING FOLLOW UP ACTIVITIES

One or more sessions at the conference should be devoted to participants using the data they have collected to plan follow-up activities. If several participants are from the same area -- school district, community, or region -- these participants should be grouped with one facilitator to plan jointly so that a coordinated effort can be made. At the NCTM Regional Equity Conferences participants from the host state used this opportunity to coordinate statewide planning with officers of the local affiliated NCTM groups, state department of education personnel, regional desegregation center representatives and local teachers, counselors and administrators.

Many participants will be the only representatives of their school or community. Such participants can be asked to form groups representing their areas of interest: elementary, junior high, high school, teacher education, state department of education personnel, etc. These groups then share their problems, brainstorm possible solutions, and plan strategies together. While their problems will not be identical, such groupings allow participants to work with peers on similar problems and to share ideas that have been or might be successful. Facilitators of such groups could share programs and materials that have proven successful in other areas and materials that have proven successful in other areas and that are appropriate to the groups problem.

For Equity in Mathematics Education Conferences to be successful in initiating change it is important that participants arrive at the conference with data they have collected that has helped them to identify the problem areas in their own school or community. It is equally important that participants leave with a plan of action for attacking the problems their surveys have uncovered.

Mathematics Equity Conference

This survey is appropriate only in schools where optional math courses are offered.

Examine enrollments in all math classes in your school(s). Report numbers and percents by ethnic groups, race, and/or sex of students.

Course		Total #/%	#/%	Hispanics #/%	Blacks #/%	Native American #/%	Asian #/%	Other #/%
GENERAL MATH (basic skills, consumer math, business math)	Male							
	Female							
	Total							
ALGEBRA I (first year algebra even if given in more than two semesters	Male							
	Female							
	Total							
GEOMETRY	Male							
	Female							
	Total							
ALGEBRA II (second year algebra with or without trigonometry)	Male							
	Female							
	Total							
TRIGONOMETRY (analytical geometry, precalculus & other advanced math)	Male							
	Female							
	Total							
CALCULUS (anlaytical geometry, precalculus & other advanced math)	Male							
	Female							
	Total							
COMPUTER SCIENCE (analytical, precalculus & other advanced math)	Male							
	Female							
	Total							

Directions to Researcher: Write one paragraph summarizing your data and identifying the problem you feel needs to be addressed in your school(s). Bring this to the Mathematics Equity Conference along with your completed chart.

Name of Researcher ______________________________

School(s) Surveyed ______________________________

Grade Level(s) surveyed ______________________________

Total number of students Male ______ Female ______

Total ethnic and racial minority population of school:

Hispanic _____ Black _____ Native American _____ Asian _____

Other _____

Sentence Completion Task

Name____________________ Age____ Sex________ Date____________

1. On weekends I spend my time ______________________________________.

2. When I grow up I hope to work as ______________________________________.

3. I do not like people who ______________________________________.

4. My parents want me to study more ______________________________________.

5. I look forward to ______________________________________.

6. The subject in school that will help me most when I get a job is ______________________________________.

7. When I grow up my parents want me to work as ______________________________________.

8. When I was younger ______________________________________.

Mathematics Equity Conference

This survey is appropriate in grades three through twelve.

Survey Question 2

Duplicate the Sentence Completion Task and administer it to at least 20 pupils. This can be administered in a group setting for most children. It is permissible to have children dictate their responses if necessary. DIRECTIONS TO RESEARCHER: Identify each answer sheet by race or ethnic group. Divide the form into groups of targeted and untargeted students. Look for patterns to the answers for numbers 2, 4, 5 and 7. If possible, summarize your data using a graph display of your data. Write one paragraph summarizing your data and identifying the problem you feel needs to be addressed in your school. Bring this to the Mathematics Equity Conference along with your data.

Survey Question 3

This activity is appropriate in grades Kindergarten through third grade (wording can be modified for grades 4-6).

Ask your students to: "Draw a picture of yourself when you are grown-up and at work." Have each student write or dictate to you some statements about the picture which are then recorded on the picture. Please indicate, sex, race, and/or ethnic background of child.

Please tally the data from your class by sex, race and/or ethnic group accompanying chart (see question 4). Look for patterns that emerge. What conclusions can you draw?

Write one paragraph summarizing your data and identifying the problem you feel needs to be addressed in your school. Bring this to the Mathematics Equity Conference along with your pictures and summary.

Survey Question 4

Have at least ten of your teachers or teacher education students make up five story problems related to one or more targeted groups. Analyze these problems for sterotypic projections.

Survey Question 5

Survey the programs of local, state, regional and/or national professional conferences over the past three years for sessions dealing with equity. Share the data you find, listing any especially relevant sessions found.

Survey Question 6

Survey five counselors. Ask them to list all the jobs they can think of which requires three or more years of high school math. Summarize the responses and bring both your summary and the lists.

Please make duplicate copies of any data submitted. We will not be able to return any submitted data.

Mathematics Equity Conference

Survey Question 7

Imagine you are 30 years old. Describe a typical Wednesday in your life.

DIRECTIONS TO RESEARCHER: Ask your students to "Imagine you are 30 years old. Describe a typical Wednesday in your life." Give students a full piece of paper so they are free to write as much as they want. Be sure students indicate whether they are male or female.

There are many interesting ways "Typical Wednesday" could be analyzed. For this research project, please focus on these two aspects:

(1) occupational choices (2) family responsibility

For both of these, please tally your data by sex on the accompanying charts. Record your students' choices in the most appropriate categories. Look for patterns that emerge. What conclusions can you draw?

		Total	Hispanic	Black	Native American	Asian	Other
SCIENTIST (Engineer, Computer scientist)	M						
	F						
PROFESSIONAL ATHLETE	M						
	F						
TRUCK DRIVER (Carpenter, Mechanic, Train Engineer)	M						
	F						
POLICE OFFICER (Military, Firefighter)	M						
	F						
EXECUTIVE (Businessperson, Executive)	M						
	F						
DOCTOR (Lawyer, Architect, Airplane Pilot)	M						
	F						
VETERINARIAN (Forest Ranger)	M						
	F						
ROCK STAR (Singer, Disc Jockey, Musician)	M						
	F						
REPORTER (Writer--all media)	M						
	F						
TEACHER	M						
	F						
NURSE (Lab Technician)	M						
	F						
BALLERINA (Model, Movie Star)	M						
	F						
SECRETARY (Flight Attendant, Beautician)	M						
	F						
UNPAID WORKER (Homemaker, Parent)	M						
	F						
OTHER	M						
	F						

Appendix A

State of The Art Papers

The following papers were delivered at the Equity in Mathematics Core Conferences held in Reston, Virginia, February 19-21, 1982.

Blacks and Mathematics

Martin L. Johnson
College Park, Maryland

During the seventies much attention was focused on the status of blacks in relation to mathematics and the mathematical sciences. A calamitous set of interrelated occurences served as catalyst for this long overdue attention. The black population of the United States was approximately 11.6% of the total population in 1976 yet less than 5% of all BS degrees in Mathematics was awarded to blacks; less than 3% of all BS degrees in Engineering was awarded to blacks (National Science Foundation, 1980(a)). Black high school students were enrolling in mathematics courses at an alarmingly low rate and were continuing to perform at a level lower than many other groups of students as measured by standardized tests. These facts, among others, dictated that a serious look at the mathematical education of black youth was needed.

The participation of blacks in mathematics courses and the mathematical achievement of blacks at the pre-college years are concerns that must receive national attention. Each concern represents highly complex, multidimensional issues having far reaching consequences. In this paper I will review efforts to document the various dimensions of the problem and report on attempts of researchers to find effective solutions.

Participation in Mathematics Courses

All available data on participation of high school students in mathematics courses indicate that blacks are enrolling in fewer mathematics courses than most other racial/ethnic subgroups. The National Longitudinal Study of the High School Class of 1972 (NLS-72) reported that the average number of semesters of mathematics taken from 10th to 12th grade was 3.4 and 3.8 for black and white students, respectively (Vetter, Babco, & McIntire, 1979). Almost 50% of the black students enrolled in mathematics for 0-2 semesters and less than 20% enrolled for six or more semesters. Table 1 includes participation rates of the high school class of 1972 by racial/ethnic group.

The High School and Beyond Study, a national longitudinal study for the 1980's reported that substantial racial differences still exist in the number of mathematics and science courses taken by high school seniors (Peng, Fetters & Kolstad, 1981). In 1980, only 35% of all black seniors reported having taken three years or more of mathematics. Only 19% of all black seniors took three years or more of science (see Table 2).

Although the data in Table 2 reveal a very low participation rate in mathematics courses by blakcs, the larger picture indicates that between 1977 and 1980 the percentages of black students taking specific mathematics courses such as Algebra I, Algebra II, and Geometry actually increased. The 1977-78 assessment of the National Assessment of Educational Progress indicated that among 17-year-olds the percentage of black and white students who had taken Algebra I was 55% and 75% respectively. The percentage of 17-year-old black and white students who had taken Algebra II was 24% and 38%, and for those who had taken Geometry, 31% and 55% respectively. These data are reported in Table 3 (NAEP, 1979). In the High School and Beyond Study, the percentage of black and white high school seniors who had taken Algebra II was 39% and 50%, and for those who had taken Geometry, 38% and 60%. Percentages for all subgroups in the class of 1980 are given in Table 4.

The consequence of taking so few mathematics courses in high school are severe. Sells (1978) reported that career choices, in particular careers in the mathematical, physical and biological sciences are seriously limited without four years of secondary school mathematics, including Algebra I, Algebra II, Geometry and at least one year of pre-calculus mathematics. The NLS-72 reported that a positive correlation existed between the number of semesters of mathematics completed in high school and the completion of the bachelor's degree on schedule (in the fall of 1976). Further, students with more mathematics and science coursework in high school were more likely to choose science and other quantitative fields in

Table 1

Participation Rates in High School Mathematics Courses by Racial/Ethnic Group

Racial/Ethnic group	Semesters of High School Mathematics 10th through 12th Grade 0-2	3-5	6 or more	total	average semesters
American Indian	63.3	25.9	10.9	100.0	2.6
Black	42.2	38.4	19.4	100.0	3.4
Hispanic	43.7	39.0	17.3	100.0	3.3
Asian American	23.1	29.4	47.6	100.0	4.6
White	36.7	33.3	30.0	100.0	3.8

Source: Adapted from Vetter, Betty M., Babco, Eleanor L., and McIntire, Judith E., Manpower Comments, November 1979, p. 20

Table 2

Percentage of 1980 High School Seniors Taking Three Years or More of Coursework in Mathematics and Science, by Racial/Ethnic Group

Racial/Ethnic group	Mathematics	Science
American Indian/ Alaskan Native	22	12
Black	35	19
Hispanic	27	14
Asian American	48	32
White	33	23

Source: National Center for Educational Statistics, High School and Beyond, 1981, p. 2.

Table 3

Percentage of 17-Year-Olds Who Had Taken Algebra I, Algebra II and Geometry in 1977-78, by Race

Mathematics Course	Race Black	White
Algebra I	55	75
Algebra II	24	39
Geometry	31	55

Source: National Assessment of Educational Progress, Mathematical Knowledge and Skills, p. 45.

Table 4

Percentage of 1980 High School Seniors Taking Mathematics and Science Courses by Course Title and Racial/Ethnic Group

Mathematics Course	Racial/Ethnic Group American Indian	Black	Hispanics	Asian	White
Algebra I	61	68	67	88	81
Algebra II	32	39	38	76	50
Geometry	34	38	39	79	60
Trigonometry	17	15	15	50	27
Calculus	5	5	4	22	8
Physics	17	19	15	35	20
Chemistry	24	28	26	59	39

Source: National Center for Educational Statistics, High School and Beyond 1981, p. 5.

college, both black and white (Peng, Fetters, & Kolstad, 1981. 40).

The low black enrollment in mathematics is also seen in post-secondary study. Few black students are majoring in the mathematical sciences in college. Obviously, enrollment in high school mathematics courses impacts on this in a major way. In 1975-76, blacks earned 2.9% of the 45.6 thousand BS degrees awarded in engineering, 5.8% (out of 5.6 thousand) of the BS degrees in computer science, 4.9% (15.9) in mathematics, and 2.9% (21.2) in physical science (National Science Foundation, 1980 (a)). The proportion of blacks in the U.S. population in 1977 was 11.6% hence the above data show the serious underrepresentation of blacks in highly quantitative areas of study. There is little reason to expect that these trends have changed significantly in the last five years or that it will change significantly in the near future. Only 48% of the black students in the High School and Beyond sample expect to pursue a 4-year college degree. Although the career choices of blacks were not identified, the percentage of the total sample planning to enroll in various scientific fields were as follows: engineering—10%, computer and information sciences—5%, biological sciences—5%, physical sciences—2%, mathematics—1% (Peng, Fetters, & Kolstad, 1981).

Mathematical Achievement

The mathematical achievement of black students, as measured by the National Assessment of Educational Progress, continues to lag behind the achievement of white students in every test category and at each age level; 9, 13 and 17 (NAEP, 1980). Table 5 contains data showing the mean performance percentages of black students across all categories tested in the 1977-78 national assessment. Although these data are sobering to say the least, they represent a significant positive change from the 1972-73 national assessment. Nine-year-old black students "showed significant increases in performance and performance relative to the nation on the entire set of exercises and on the knowledge, skill and computation subsets of exercises. In addition, this group showed a significant increase in performance, relative to the nation, on mathematical application exercises" (NAEP, 1980, p. 12). Black 13-year-olds showed a significant increase in performance, relative to the nation, on mathematical skill exercises. Black 17-year-olds showed an increase on consumer problem exercises and no loss in performance in knowledge computation and reading graphs and tables, however, the mean performance of black 17-year-olds declined on many exercise sets with approximately 20 percentage points separating black and white test scores.

The NAEP findings suggest that serious problems exist in our mathematics classrooms for black students. An in-depth study of the origin of these problems as well as the plight of learners of all ethnic/racial groups must be undertaken immediately. One recent study reported that more than a fourth of all 1980 high school seniors had taken remedial coursework in mathematics (Peng, Fetters, & Kolstad, 1981). Overall, high school students are performing poorly in mathematics!!

Contributing Factors

The above data on enrollment patterns and achievement of black students in mathematics confirm what has been recognized by black educators for years; black students and white students are not achieving at the same level. Naturally, the question of "Why?" is asked. At this time there are no definitive answers to this question. There are some beliefs and speculations about: (a) factors that have a major impact on black students, and (b) how black students learn in the current school environment.

Wilson (1978) has attempted to analyze the growth, development and education of the black child in today's society. According to Wilson, a black child's performance in a classroom reflects that child's socialization in a hostile, racist society. Wilson argues that schools exist to maintain and to perpetuate a cultural way of life. Most schools do not show sensitivity to black culture and hence it should not be surprising to find that the black child's academic performance "lag behind" that of whites in a school system designed to maintain white dominance.

Wilson states that black parents must take the major responsibility for socializing and educating black children in a way to increase achievement motivation and to decrease the black child's high need for dependency and low need for achievement. Such an emphasis would result in changes in the behavioral, motivational, and cognitive functioning of black children (Wilson, 1978).

Table 5

Mean Performance Percentages
of Black 9, 13, and 17 Year-Olds on 1977-78
National Assessment of Educational Progress

Title of Set of Mathematics Exercise	Age 9		Age 13		Age 17	
	Mean Percentage		Mean Percentage		Mean Percentage	
	Nation	Black	Nation	Black	Nation	Black
Mathematical Knowledge	65.94	54.92	66.87	52.82	71.01	56.24
Numbers & Numeration	67.45	55.41	71.20	56.75	77.90	63.03
Place Value	63.43	50.19	70.86	50.86	———	———
Basic Facts	76.90	64.08	90.80	80.60	93.74	86.79
Ordering	66.19	60.03	54.04	40.72	64.48	40.96
Number and Oper. Prop.	45.92	35.50	63.26	49.22	77.24	61.54
Geometry Knowledge	58.74	50.08	57.30	44.87	67.53	50.44
Meas. Knowledge	65.82	58.86	69.79	53.57	78.71	62.27
Mathematical Skills	43.34	32.55	51.88	35.10	58.97	41.39
Computation	35.44	26.65	51.68	35.26	67.17	49.60
Whole Number Comp.	52.36	40.12	82.67	69.49	87.54	79.48
Measurement Skills	52.91	41.60	54.75	33.53	56.72	33.26
Making Measurements	63.59	50.90	70.92	46.58	———	———
Reading Graphs & Tab.	58.91	43.73	68.85	52.22	72.56	55.96
Geometric Manipulation	44.44	33.63	45.81	33.41	54.76	35.87
Algebraic Manipulation	39.36	27.57	52.17	33.58	39.99	25.05
Solving Equation	44.52	34.32	63.74	43.93	35.20	17.95
Math Understanding	39.60	29.31	51.72	36.96	58.01	40.65
Math Applications	37.75	27.08	43.34	29.69	43.48	25.66
Routine Problems	36.66	24.03	41.43	26.90	41.55	23.03
One-step word Problems	44.34	20.10	52.08	33.72	57.09	35.38
Computation-Fractions			51.40	31.96	65.82	47.88
Computation-Decimals			54.70	32.95	75.22	54.72
Computation-Integers			38.22	27.54	68.09	48.19
Finding Perimeter, Area and Volume			45.06	27.53	———	———
Plotting Points			57.04	32.57		
Estimation			35.75	19.38	49.63	30.12
Multistep Word Problem			36.82	24.17	35.10	15.93
Graph & Table Prob.			55.26	35.62	63.19	40.91
Geometric Problems			25.86	19.53	36.77	20.82
Comb, Stat, and Probab.			35.52	21.70	25.50	13.47
Nonroutine Problems					40.49	23.40
Measurement Problems					33.08	13.38

Source: National Assessment of Educational Progress, Mathematical Technical Report: Summary Volume

Other factors commonly mentioned as reasons for lack of interest in taking mathematics by black students are: (1) lack of black role models, (2) lack of significant others, such as parents, who have interest in mathematical achievement, (3) lack of positive career counseling, (4) viewing mathematics as a subject for white males, (5) inability to see the usefulness and relevance of mathematics to their lives, both present and future, and of course, (6) lack of success in previous mathematics courses. These factors are all interrelated and have historical roots in centuries of institutionalized racism that perpetuated unequal education for black people. It should be pointed out that very little research has been conducted that attempted to ask black students why they did not take more mathematics. Much of what is "known" relative to why blacks do not take more mathematics is juxtaposed from the research on "women and mathematics." The effects of sex discrimination and mathematics participation and/or achievement have been extensively research and reported (Jacobs, 1978). Similar studies of racial discrimination and its effects on mathematics achievement are not available at this time.

The effects of a lack of black role models in science and mathematics, including a lack of black mathematics teachers, on a student's choice of what mathematics to take in high school have not been sufficiently researched. Certainly, all participants in the educational process realize the importance of making students aware of the contributions of black scientists, both past and present, to the history of this nation. It seems reasonable that black students would seek to emulate black men and women who serve as strong role models, however, there is little research to support this contention.

Parents, relatives, and friends play a major role in a student's choice of mathematics or mathematics related career at the college level. Carey (1977) reported that 32% of the engineering students entering Purdue University in 1973 stated that their choice was heavily influenced by a relative, 26% said friends and high school courses, while only 14% said teachers and high school counselors. Careful research on the relative influence of parents, teachers, and counselors on the decision of black high school students to take advanced mathematics is in its embryonic stage.

The perceived usefulness of mathematics has often been stated as a factor influencing how much mathematics a student will take. Matthews (1980) reported that black females viewed advanced mathematics courses as essential when preparing for college entrance requirements but not useful to their future careers. Black males tended not to make this distinction.

Overall, a few definitive reasons can be given for the acute underrepresentation of blacks in advanced mathematics classes. Equally elusive is an explanation for their consistent underachievement on mathematics tests. Research programs must begin immediately to address these issues, including a study of the learning environment of the mathematics classroom. Careful investigation of what teachers do, how they interact with black students, and the effects of this interaction on students' performance is desperately needed.

Intervention Studies

During the last two decades, research on minorities and mathematics education issues has been largely neglected (Ortiz-Franco, 1981). Even in 1982, only a small number of research studies aimed exclusively at the problems of blacks and mathematics can be identified.

A project designed to motivate black students toward careers involving mathematics is Blacks and Mathematics (BAM). BAM was funded by the Mathematics Association of America and has three major objectives:

1. to provide role models to encourage more black students to consider mathematics-based careers;
2. to influence counselors, teachers and parents to direct more black students into mathematics-based careers in which blacks are underrepresented;
3. to inform students, teachers, guidance personnel, and parents of the large number and variety of careers for which mathematics is a prerequisite.

BAM began its program during school year 1980-81. Results of this project are unavailable at this time.

Only four studies are found among the more than 90 projects funded by the National Science Foundation, Directorate of Science Education, Division of Science Education and Research, Fiscal Year 1980, that plan to investigate factors related to mathematics course-taking among blacks and minorities. These projects are listed below.

Pernaul, Jane. Role Models for Adolescent Girls in Science and Mathematics. (SED 79-19023) Ending Date 02-28-81.

Cohen, Arthur. Science Education for Women, Minority, and the Physically Handicapped Students in Community Colleges. (SED 79-20222) Ending Date 12-31-82.

Scherrei, Rita. A Longitudinal Study of Women and Minorities in Science and Engineering. (SED 80-17651) Ending Date 05-31-82.

LeBold, William. Improving Access and Guidance in Engineering: Research into Contributing Factors. (SED 79-19613) Ending Date 12-31-82.

The National Institute of Education, through its Learning and Development Unit, has funded a small set of studies on minorities and mathematics education. Of the 19 projects funded, seven address issues pertaining to blacks or include minority students in their samples. The findings of the four projects listed below should add significantly to current knowledge in this area.

Gaston, Jerry. Factors Inhibiting Science Careers for Black Women. (NIE-G-78-0139).
Johnson, Robert. Psychosocial Factors Affecting the Mathematical Orientation of Black Americans. (NIE-G-79-0093)
Marrett, Cora. Minority Female Involvement in High School Science and Mathematics. (NIE-G-79-0110)
Morse, Linda. Relationship of Significant Others, Parental and Teacher Influences to the Development of Self-Concept, Science Attitudes and Achievement Among Adolescent Girls. (NIE-G-79-0159)

Future Directions

The problems discussed in this paper are very complex and will require a multitude of efforts if they are to be solved. Mathematics educators, parents, boards of education and the general public all have a responsibility in this problem-solving endeavor.

A major research thrust is needed to document what the actual problems are, why they exist, and the extent of their existence. Definitive reasons are needed as to why black students are failing to enroll in the mathematics courses so important for success in a mathematics related career. Are parents, counselors, teachers, and others really aware of the importance of mathematics to the student's future? What actually happens in the elementary school that contributes to a student's decision to take only the minimum number of mathematics courses needed for high school graduation? Are teachers prepared to teach to each student's strengths and show evidence of realizing that children process mathematics in many different ways? It is encouraging to see NIE begin to fund research in this area but a major commitment of resources is needed.

Research paradigms that include sociological factors and consider the total context in which learning occurs must be utilized. Cross-discipline teams of researchers, including minority researchers, must be formed. Further, a new look at the usefulness of typical, experimental-control designs using group data must be taken. Many of the questions posed here must be answered by clinical studies involving individual students through a case-study method. Longitudinal studies are also called for. New instruments must be designed; instruments sensitive to the idiosyncrasies of black students. Matthews (1981) points out, correctly so, that we have few, if any, test instruments, that have been standardized on black samples. Validity questions must be raised about many instruments currently being used.

The results of our research must be disseminated effectively to parents, teachers, and others who influence the decision making process of black students. As we wait for the results of research currently in progress, mathematics educators must increase their efforts to educate parents and the general public of the mathematical plight of black students. Mathematical educators should take the lead in demanding that teachers teach mathematics to all their students and that educational practices which impact negatively on black students, such as inflexible "ability grouping" and the use of admittedly biased standardized I.Q. and achievement tests be discontinued. Finally, teacher training programs must prepare teachers to teach in multicultural settings. Teachers need to know mathematics and how to relate to black students. This nation can no longer afford insensitive teachers who blame the victim for his or her underachievement!!!

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Girls and Mathematics

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In order for me to write a "state of the art" review about anything, I have to believe that knowledge exists which is socially significant, educationally important, and based on firm scholarship. Without any one of these three, it would be a waste of time for me to write, and anyone else to read, such a paper. I firmly believe that there is knowledge about women and mathematics that meets these criteria.

The problem of women and mathematics is socially significant and educationally important. If one is committed to the belief that women should have the same opportunity as do men to participate in all aspects of society, then the issue of sex-related differences in mathematics becomes vital. Without adequate preparation in mathematics, people are effectively filtered out of most post-secondary education options and an increasing number of jobs and professions. The option of career advancement or change in adulthood is also severely handicapped by a lack of mathematical training. While inadequate training in mathematics hampers everyone, many more females than males fail to achieve their full potential in mathematics. This appears to me to be one of the most serious inequities in education that currently exists. Without mathematical knowledge and skills, women will never be able to achieve equity in society.

There is a firm knowledge base about women and mathematics. There are a great many data from a large variety of sources about enrollment patterns in high schools and universities. Data about achievement by females and males are available from national, state and local assessments. Sex has been included as a variable in mathematics education research for decades and since about 1974, studies have been done which have increased significantly the knowledge of factors related to sex differences in mathematics. In addition, many intervention programs have been designed and implemented. These programs, while in most cases ot well evaluated, have increased the intuitive knowledge that many have about the extent of the problem and procedures which might be effective in its solution.

I am not going to review all of these data and studies in this paper. There are available other reviews with you my synthesis of what the problem is what causes it, and some possible solutions. Hopefully, the synthesis is based on the knowledge I have gained by studying the problem intensively for about a decade and through my contact with many others involved in the area. I would like to caution you, however, that I plan to raise serious questions about many ideas which permeate the rhetoric about women and mathematics. I am deeply committed to achieving equity in mathematics education for females, as well as all other groups. However, I do not believe that equity can be achieved unless we base decisions for action on firmly established knowledge.

What is the Problem?

There are three components of the problem: participation in mathematics courses in secondary and post secondary years, participation in adult mathematics-related occupations, and achievement or performance in mathematics. While there have been sex-related differences in the percentages of females and males who are enrolled in mathematics classes in secondary schools, the best information we have on a nationwide basis is that these differences are not dramatic until post secondary education. Consider the information collected in two national surveys and reported recently by Armstrong (1981). While these data always show that more males than females elect mathematics courses, with the differences increasing at more advanced levels, such differences do not appear dramatic—nor do they explain the extreme differences found in participation in mathematics related careers.

Instead of data collected from a nationwide sample, consider data collected in a more restricted area—the State of Wyoming (1978). Indeed strong differences are evident in mathematical preparedness between girls and boys.

What happens when we look at individual schools rather than compiling across the nation or state? Wide variation in enrollment patterns exist, with more females than males actually enrollment in advanced mathematics classes in some schools. I am convinced that while enrollment trends may be encouraging on a broad scale, it is only by looking at individual schools that meaningful assessment of females' enrollment in advanced mathematics courses can be made.

*Portions of this paper were presented at the American Association for the Advancement of Science Annual Meeting, Washington, D.C., January 1982.

Table 1

National Sex Differences in Participation in High School Mathematics Courses[a]

	NAEP[c]		WIM[d]	
	Females	Males	Females	Males
Algebra I	74	71	79	81
Geometry	51	52	55	59
Algebra II	36	38	42	54
Trigonometry	17	21	27	31
Probability/ Statistics	8	10	5	10
Computer Programming	8	10	13	18
Precalculus	b	=	18	22
Calculus	4	6	7	8

[a]From Armstrong, J.M. Achievement and Participation of Women in Mathematics: Results of Two National Survey. Journal for Research in Mathematics Education, 12, 5, November 1981, 356-373.

[b]Precalculus and Calculus combined.

[c]Collected by self report of 17 year olds.

[d]Collected by self report of high school seniors.

Table 2

Percent of College Bound Seniors Attaining Each of Sex Levels of Mathematical Preparedness *

	Percent	
Level	Female	Male
1**	15	30
2	21	36
3	54	64
4	71	78
5	93	94
6	100	100

*Kansky, B., & Olson, M. Mathematical Preparation Versus Career Aspirations: Study of Wyoming 1978 High School Seniors (The Science and Mathematics Teaching Center, Box 3992 University Station, Laramie, Wyoming 82071), p. 13.

**Level 1 is the highest level of mathematical preparedness.

From Fennema, E. The Sex Factors of Fennema, E. (Ed). Mathematics Education Research: Implications for the 80's. Association for Supervision and Curriculum Development 1981, pp. 92-110.

All the data available indicate that the differential enrollment is greatest in post-secondary mathematics courses and in all programs where mathematics is a key component (such as Engineering or Computer Science).[4] By adulthood, the vast majority of people who use mathematics are male.

Differences in Achievement

Before 1974, most studies reported male superiority in mathematics learning (Fennema, 1978). These studies usually used random samples of females and males in secondary schools. Since traditionally, females have not chosen to study mathematics as often as have males in advanced secondary school classes, a population of males who had spent more time studying mathematics was being compared to a population of females who had studied less mathematics. Since the single most important influence on learning mathematics is studying mathematics, it would indeed be strange if males had not scored higher on mathematics achievement than did females.

During the 1974-78 years, there were a number of studies published which indicated that sex differences in favor of males were not as strong as had been believed previously. I hypothesized at about this time that sex differences in mathematics might be eliminated if schools would somehow ensure that girls elect to study mathematics as often as boys did. However, within the last 2-3 years, a number of studies have been reported which have made me at least partially reject that hypothesis. These studies have carefully controlled the number of mathematics courses studied by both girls and boys and have also used items of differing cognitive complexity to assess learning.

The California State Assessment of Mathematics was done in 1978 (Student Achievement in California Schools, 1978). Students in Grades 6 and 12 (12- and 18-year-olds) who reported studying the same number of mathematics courses, were tested on a variety of content areas with items of differing cognitive levels. A committee was named to evaluate the results and concluded that girls outachieved boys in computational or lower cognitive level tasks while boys tended to score higher on higher cognitive level tasks. Armstrong (1980) collected data from a sample of students from the entire U.S. and concluded, "Twelfth grade males scored significantly higher than females on the problem-solving subtest. Thirteen-year-old females scored significantly higher on the lower level mathematical skill of computation." The Mathematics Assessment of the Second National Assessment of Educational Progress indicated also that females were somewhat better in computational tasks than were males, while males outachieved females in higher level cognitive tasks (Fennema and and Carpenter, 1981). Just how strong are the reported differences. In a meta analysis of studies dealing with quantitative ability (which from an inspection of the studies used can be roughly equated with mathematics achievement), Hyde (1981) concluded that gender differences, while statistically significant, are in actuality quite small. Sex differences accounted for little of the variability in overall performance on the tests used in the studies she reported.

One can only conclude from a variety of sources that while sex-related differences in achievement are not always found, when they are found, they indicate that boys outachieve girls in high level cognitive tasks. Differences in both course enrollment and achievement are very school specific. In some schools, no differences are found, while in others, differences are consistently found.

Why Differences Exist

What is the cause of these sex-related differences in mathematics, both election to study, and achievement? Involved is the cognitive acquisition of mathematics by females, as well as the attitudes or affective beliefs held by females, male peers, parents and educators toward females as learners of mathematics. The cognitive and affective components are so intertwined that it is difficult if not impossible to separate them. Not only are they intertwined, but they are developed over a period of years in a complex social matrix which involves home, community, and school. In addition to these social and educational influences, there has been increasing discussion in the last few years about the influences of genetic variables. It is outside the scope of this paper to discuss the arguments about genetic differences (See Stage, 1981; Fennema, 1981 for a more thorough discussion). However, the knowledge base from which conclusions about genetic differences are drawn is very small and conclusions are usually based on poorly interpreted data. In addition, the the genetic argument, even if it were true, could never explain the large differences found in participation in mathematics-related careers. Therefore, it is more sensible to focus on variables which are amenable to change.

One cognitive variable which many believe might help in understanding sex-related differences is spatial visualization, or the ability to manipulate rigid figures mentally. Even though the existence of many sex-related differences is currently being challenged, the evidence is still persuasive that in many cultures, male superiority on tasks that require spatial visualization is evident beginnig during adolescence (Fennema, 1975; Maccoby and Jacklin, 1974). The relationship between mathematics and spatial visualization is logically evident. In mathematical terms, spatial visualization requires rotation, reflection, or translation of rigid figures. These are important ideas in geometry. Many mathematicians believe that all of mathematical though involves geometrical ideas (Bronowski, 1947). Therefore, if spatial visualization items are geometrical in character and if mathematical thought involves geometrical ideas, spatial visualization and mathematics are inseparably intertwined.

Not only are spatial visualization skills related to ideas within the structure of mathematics, but spatial representations are being increasingly included in the teaching of mathematics. For example, the Piagetian conservation tasks which are becoming part of many school programs, involve focusing on currect spatial attributes before quantity, length, and volume are conserved. Most concrete and pictorial representations of arithmetical, geometrical, and algebraic ideas appear to be heavily reliant on spatial attributes. The number line, which is used extensively to represent whole numbers and operations on them, is a spatial representation. Illustrating the commutativity of multiplication by turning an array 90 degrees, involves a direct spatial visualization skill.

Although the relation between the content of mathematics, instruction in mathematics, and spatial visualization skills appears logical, results from empirical studies which have explored the relationship are not consistent. Such studies are usually correlational, which gives little information on the impact spatial visualization has on learning mathematics. The hypothesis that I and my colleagues are currently investigating is that the critical relationship between mathematics and spatial visualization is not direct, but quite indirect. In involves the translation of words and/or mathematical symbols into a form where spatial visualizaion skills can be utilized.

We know that females tend to score lower on spatial visualization tests than do males. What we do not know is if females differ from males in their ability to visualize mathematics. Also not known is if good spatial visualizers are better at this translation than are poor spatial visualizers. However, I am increasingly convinced that there is no direct causal relationship between spatial visualization skills, and the learning of mathematics in a broad, general sense. While I am continuing to investigate the impact of spatial visualization skills I am less convinced than I was that spatial visualization is important in helping understand sex-related differences in the studying and learning of mathematics.

Classrooms don't appear to use mathematical representations which either encourage or require the use of spatial visualization skills. While some primary mathematics programs encourage the use of concrete and pictorial representations of mathematical ideas, by the time children are 10 to 11 years old, symbolic representations are used almost exclusively. Perhaps boys, more than girls, utilize the concrete representations during primary years, and thus, develop higher skills in using spatial visualization in learning mathematics. As far as I know, however, no one is investigating a hypothesis.

Affective Variables

If sex-related differences in mathematics can't be explained by cognitive variables, are there other variables which will help? Several variables that I label as affective provide important insight into why females elect not to study mathematics beyond minimal requirements and are not learning mathematics as well as are males.

Affective variables have to do with feelings, beliefs, and attitudes. The affective domain is a complicated one and has received less attention than the cognitive domain, partly because variables within this domain are difficult to define, measure, and understand. All too often, all affective variables have been lumped together into one large conglomerate and labeled as attitudes. However, this type of combining often masks many important things.

There has been an increasing amount of literature published which deals with specific affective variables and their relationship to sex-related differences in mathematics study (Fox et al., 1979; Fennema, 1978; Reyes, 1980). Two well-defined variables (confidence and perceptions of usefulness) are closely related to studying mathematics, and one other complex variable (causal attributions) has been hypothesized to be an important determinant of electing to study mathematics (Wolleat et al., 1980).

Confidence in learning mathematics is related to self-esteem in general. High confidence in mathematics appears to be located at one end of a continuum and anxiety toward learning mathematics at the other end. Confidence in mathematics is a belief that one has the ability to learn new mathematics and to perform well on mathematical tasks. It often is measured by Likert-type scales which include items such as: I am sure that can learn mathematics; I can good grades in math; or I'm no good in math.

The literature strongly supports that fact that there are sex-related differences in the confidence-anxiety dimension. It appears reasonable to believe that lesser confidence, or greater anxiety on the part of females is an important variable which helps explain sex-related differences in mathematics studying.

While evidence exists in abundance that there are sex-related differences in this confidence/anxiety dimension related to mathematics, much is unknown about its true effect or how such feelings are developed. The reltionship between spatial-visual processes and the confidence/anxiety dimension has not been explored. What effect do feelings of confidence have on cognitive processes involved in learning mathematics and in solving mathematical problems and vice versa? Are feelings of confidence stable within individuals across time and across a variety of mathematics activities? Does lessening anxiety increase either learning or the willingness to elect to study mathematics? Do low levels of confidence affect females differently than they do males? Are there really sex differences in confidence toward mathematics, or (as many have hypothesized, Nash, 1979) are females just more willing to admit their feelings than are males?

Currently, there are many studies underway which will help in answering these questions. Until they are available though, one must just accept the evidence that females, across a wide age range, do report more anxiety and less confidence toward mathematics than do males.

Even when females succees in mathematics, they attribute their success to factors other than their own ability, such as luck, much more than do males (Wolleat et al., 1980). Females' causal attribution patterns are different from those of males and causal attribution theory holds promise in helping understand sex-related differences in mathematics. Causal attribution has to do with what one believes causes successes and failures. In one model (Weiner, 1974), attributions of causes of success and failure are categorized into a 2 x 2 matrix with locus of control (internal-external) being one dimension, and stability and instability the other.

One can believe that success or failure occurs in mathematics because one is smart or dumb (ability), one tried or did not try (effort), the mathematics one is doing is easy or difficult (task), or one has or doesn't have a good teacher (luck/environment).

Pattern of causal attributions affect persistence in achievement-orineted behavior. In a somewhat simplistic summary, if one attributes success to an internal, stable dimension (ability), then one expects success in the future and will continue to strive in that area. If one attributes success to an unstale or an external cause (e.g. the teacher), then one will not be as confident of success in the future and will be less apt to strive or persist. A somewhat different situation is true of failure attributions. If one attributes failure to unstable causes such as effort, one might work harder the next time and failure could be avoided. With this situation, the tendency to approach or persist at tasks will be encouraged. Attribution of failure to a stable cause, on the other hand, will lead one to believe that failure can't be avoided.

While we must be careful of overgeneralizing data and concluding that all males behave one way and all females another way, many studies have reported that females and males tend to exhibit different attributionsal patterns (Deaux, 1976; Bar-Tal & Frieze, 1977). Males tend to attribute successes to internal causes, and failures to external or unstable causes. Females tend to at-

	Internal	External
Stable	Ability	Task
Unstable	Effort	Luck/ Environment

Figure 1

tribute successes to external or unstable causes and failures to internal causes. This attributional pattern has been observed in mathematics (Wolleat et al., 1980) as well as in other areas and probably affects both long term persistence (election of courses) and short term persistence (sticking with a hard problem). This particular combination of attributions (success attributed externally and failure attributed internally) has been hypothesized to strongly affect academic achievement and, in particular, females' achievement.

Another effective variable which helps explain females not electing to take mathematics is the perceived usefulness to them of mathematics (Fox, 1980; Fennema, 1973). Mathematics is a difficult subject and not particularly enjoyable for many learners. Why should one study it if it is of no future use? Females in secondary schools as a group indicate that they do not feel they will use mathematics in the future. Females, more than males, respond negatively to such items as: I'll need mathematics for my future work or mathematics is a worthwhile and useful subject. Males, as a group, are much more apt to report that mathematics is essential for whatever career they plan. As early as sixth grade, these sex differences appear. If females do not see mathematics-related careers as possibilities, they will also not see mathematics as useful.

In addition to indicating more negative beliefs than do males on these specific affective variables, females also report that they perceive that parents, teachers, and counselors are not positive toward them as learners of mathematics. In addition, males, more than females, starting at least as early as grade six, stereotype mathematics as a male domain at much higher levels than do females.

Society's sterotyping of mathematics as a male domain, is at least a partial cause of girls' less positive attitudes toward mathematics. While females deny that mathematics is a male domain, everything else in society is at variance with this denial. Of course, the main users and teachers of mathematics are male. Male peers, much more than females, say that mathematics is a male domain. Evidence also exists in abundance (Fox, 1980) that parents, teachers, and counselors believe that mathematics is a more appropriate activity for males than it is for females. These beliefs are undoubtedly communicated to girls in a variety of subtle and not so subtle ways. 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.

While the evidence is strong that there are sex-related differences in confidence in mathematics, perceived usefulness of mathematics and causal attributions of success and failure in mathematics, I'm always somewhat puzzled as to what implications such knowledge has for planning change. I have no trouble saying and believing that females should learn mathematics to the limits of their ability, that if they were more confident, they would learn mathematics better, and that if they perceived mathematics as more useful or attributed success and failure differently, they would persist in studying mathematics. Certainly just having that knowledge gives me only limited power to promote change. Changing beliefs and actions by learners, while not impossible, is difficult. However, educational systems can promote such change, and an understanding of how schools influence females' beliefs about mathematics is helpful.

Educational Variables

While the entire social milieu influences how well one learns as well as how one feels about mathematics, the most important influences occur within the classroom where mathematics is taught. Learning environments for girls and boys within classrooms, while appearing to be the same, differ a great deal. The most important component of the learning environment is the teacher. Part of the teacher's influence is in the learner's development of sex role standards. These sex role standrds include definitions of acceptable achievement in the various subjects. The differential standards for mathematics achievement is communicated to boys and girls through differential treatment as well as differential expectations of success. To start with, teachers interact more with boys than they do with girls. Boys generally receive more criticism for their behavior than do girls and boys also receive more praise and positive feedback than do girls. Boys just seem to be more salient in the teacher's view than do girls.

Many people feel that differential treatment of girls and boys is a result partially of differential teacher expectation of success or failure by girls and boys. The relevant discussion goes something like this. Because of society beliefs that males are better at mathematics than are females, teachers expect that boys will understand high cognitive level mathematics better and girls will do better on low level mathematics tasks like computation. This belief is communicated in a variety of subtle and not so subtle ways to both boys and girls. For example, a teacher might encourage boys more than girls to stick with hard mathematical tasks until solutions are found. The teacher, with good motivation about preventing failure, assists the girls more than boys to find the solution to hard problems. Teachers might call on boys more often to respond to high level cognitive questions and call on girls more often to respond to low level tasks. If this type of behavior occurs, boys and girls could intuit that boys were better at high level cognitive tasks and girls were better at low level cognitive tasks. Not only could students conclude that such mathematics was more important for boys since teachers encouraged boys more than girls to succeed in such tasks. In addition to these subtle messages boys would actually be practicing high level cognitive tasks more than would girls. Since students learn what they practice, boys would learn to do the problem-solving activites better than would girls.

The hypothesis of differential teacher expectation is intuitively logical and indeed, Brophy and Good (1974) report that teachers' expectacies are related to the way they interact with students. An interesting study by Becker (1981) which was done in 10th grade geometry classes, confirms this also. Becker hypothesizes that the sex-related differences she found in teacher/student interactions were strongly related to differential teacher expectancies. However, other studies designed explicitly to examine teacher expectancies report that teachers have higher expectancies of success for girls than for boys (Fennema et al., 1980). Once again, no clear cut conclusion about teacher expectancies of girls and boys in learning mathematics can be reached.

The problem of differential treatment of male and female students by teacher is well documented and I have no doubt that it strongly influences learning. It is easy to conclude that, but the longer I study the problem, the more complex it becomes. Most overt behavior by teachers appears to be nonsexist and fair to most students. In many cases, teachers interact more with boys because they feel they must to maintain control. Many negative interactions occur between boys and teachers. On the surface, teachers' interaction with girls are more positive and what I have always considered to be good educational practice. However, the end result appears to be negative. I believe that at least a partial result is that females, more so than males, are not reaching one of the important goals of mathematics education, that of becoming thinkers who are independent problem solvers and who do well in high level cognitive tasks. Girls, much more than boys, fail to become autonomous, in mathematics. This is indicated girls' more negative attitudes related to the ability to perform high level cognitive tasks, specifically, confidence in learning mathematics and attributional patterns which indicates lack of control in mathematics outcomes as well as lowered performance in problem-solving tasks. In order to become increasingly autonomous one must develop confidence in one's ability to do difficult learning tasks and also believe that one is in control of the outcomes of achievement striving.

Not too much is known about how one becomes an autonomous learner. It is believed that dependent/independent behaviors are developed by the socialization process, mainly with social interactions. Young girls, more so than boys, are encouraged to be dependent. Girls receive more protection and less pressure for establishing themselves as individuals separate from parents. Because of this, girls are less likely to engage in independent exploration of their worlds (Hoffman, 1975). Because of the sex-typed social reinforcement of dependent/independent behaviors, children enter school with girls tending to be more dependent on others and boys tending to be more self-reliant. What appears to happen is that schools merely reinforce and further develop in girls and boys the dependent/independent behaviors they bring to school. This set of behaviors is particularly apparent in mathematics.

What prohibits girls, more than boys, from becomeing autonomous learners of mathematics? It would be nice if an answer to this question could be written which would be both accurate and easily understood, but that is not possible. The factors that cause behavior are many, varied and interact in a complex way. Indeed, there probably are as many combinations of causative factors as there are individuals. Many influences on development of behaviors are subtle and difficult to identify. However, I firmly believe that a large component of development of autonomous learning behaviors in mathematics takes place in mathematics classrooms.

Changing Schools

Can schools be changed so that females learn better and elect to study more mathematics? All too often, comments are addressed to me that imply that schools can't do much. The argument goes lke this. Becaue mathematics is stereotyped male, and because stereotyping of sex roles is so deeply embedded in society, schools are powerless to improve females' studying of mathematics until society changes. Let me say as loudly and emphatically as I can that the argument is fallacious. Schools can increase females' studying and learning of mathematics. Let me cite some evidence that shows strongly that schools can be effective. I want to talk specifically about two intervention programs in the U.S. that have been intensivey evaluated. The first program, called MULTIPLYING OPTIONS AND SUBTRACTING BIAS is aimed specifically at increasing females' belief of the usefulness of mathematics (Fennema et al., 1981). The rationale behind this program is that merely telling high school females about the importance of mathematics is insufficient. Forces which influence these girls to make their decisions are complex and deeply embedded in societal beliefs about the roles of males and females. Asking adolescent girls to change their behavior without changing the forces operating upon them would place a very heavy burden on their shoulders. What should be done is to change the educational environment of these females so that they can recognize the importance of mathematics. MULTIPLYING OPTIONS AND SUBTRACTING BIAS was designed to change four significant groups' beliefs and behavior about women and mathematics.

MULTIPLYING OPTIONS AND SUBTRACTING BIAS is composed of four workshops: one each for students, teachers, counselors, and parents. Each of the four workshops is built around a unique version of a videotape designed explicitly for the target audience. Narrated by Marlo Thomas, the tapes use a variety of formats, candid interviews, dramatic vignettes, and expert testimony to describe the problem of mathematics avoidance for the target audience. The videotapes and accompanying workshop activities make the target audiences aware of the stereotyping of mathematics as a male domain which currently exists, females' feelings of confidence toward mathematics, the usefulness of mathematics for all people, and differential treatment of females as learners of mathematics. Discussed specifically are plans for action by each group. The workshops, each of which is about two hours long, are designed to impact on a total school.

An extensive evaluation of this program (Fennema et al., 1981) indicated that the MULTIPLYING OPTIONS AND SUBTRACTING BIAS series can substantially influence students' attitudes about mathematics, the sterotyping of mathematics and their willingless to take more mathematics courses.

The other intervention program is one developed, planned and implemented by the San Francisco Bay Area Network for Women in Science (now called the

Math/Science Network). The Network is a unique cooperative effort undertaken by scientists, mathematicians, technicians, and eduators from 20 colleges and universities, 15 school districts, and a number of corporations, government agencies, and foundations. The goal of the Network is to increase young women's participation in mathematical studies and to motivate them to enter careers in science and technology. While the evaluation was much more extensive than I am reporting, I would like to report to you the evaluation of seven conferences which took place in the spring of 1977 and 1978 (Perl & Cronkite. 1979). Supported by the Women's Educational Equity Act of the federal government, these conferences were designed to increase the entry of women into mathematics/science-oriented careers.

These one-day conferences involved bringing junior and senior high school girls together in a central location. They were presented with a general session with a panel or main speaker, one or two hands-on science/mathmatics workshops, and one or more career workshops which provided opportunities for interaction with women working in math/science-related fields. Subjects of this evaluation were 2,215 females who volunteered to attend the conferences. Pre-and post-conference questionnaires were administered and responses analyzed. The evaluators concluded that "the conference (1) increased participants' exposure to women in a vareity of technical and scientific fields, (2) increased participants' awareness of the importance of taking mathematics and science-related courses, and (3) increased participants' plans to take more than two years of high school mathematics."

The two intervention programs described indicated quite clearly that it is possible to change females' mathematics behavior, and to do so in relatively short periods of time.

Conclusion

Let me start the concluding remarks with some unproven statements that I often hear.

1. Females prefer to learn their mathematics in classroom discussions. Males prefer to work individually.

2. Classroom interactions are more important to females than they are to males.

3. Females are passive; males are active.

4. Female teachers teach mathematics more poorly than do male teachers.

These conclusions come from intuitive belief, isolated studies, and/or a poorly done or interpreted piece of research (see Fennema, 1981, for an expanded discussion).

Statements such as these are causing me major concern. Am I, and others who are deeply concerned with helping women achieve equity helping females to achieve true equity in mathematics education? Or are we helping to perpetrate the myth that there are large and nonchangeable sex-related differences in mathematics? Are we, indeed, creating a new mythology of female inadequacy in the learning of mathematics?

There are some statements which I believe are based on sound evidence.

1. There are still sex-related differences in electing to study mathematics in high school. While not as dramatic as were once suggested, females tend not to study, as much as do males, the most advanced mathematics courses and courses peripheral to math, such as computer science, statistics, and physics. It appears that the size of the differences varies tremendously by school and by region of country. At the post high school levels, differences are still large.

2. Even when amount of mathematics studied is controlled, females appear not to be learning mathematics as well as are males in some instances. That trend should be of concern to us all. When females excel, it is in lower level cognitive tasks. Even when females and males report they have been enrolled in the same mathematics courses, males perform better on more difficult and complex tasks.

3. There are psychological variables which may help in understanding sex-related differences. Females, as a group, more than males, as a group have less confidence in learning mathematics, perceive mathematics to be less useful to them, and attribute successes and failures in mathematics differently.

4. The classroom learning environments are different for females and males in a variety of ways.

5. Males perform better than females on tests of spatial visualization although the impact of spatial visualization on the learning of mathematics is largely unknown.

6. Within schools lies a major portion of causation of sex-related differences in mathematics.

This last statement, while sounding unduly harsh to many, is the most positive thing I have said in this paper, and indeed makes the problem of females and mathematics solvable. Schools can influence what happens. Schools do make a difference. Schools can solve the problem of females and mathematics.

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Hispanic Students and Mathematics

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The Problem

The problem generating this paper can be simply stated as follows: A substantial majority of Hispanic students enrolled in public schools across the country have not achieved adequately with regard to established criteria, nor comparably with their white cohorts in mathematics as determined by standardized tests or other means used to measure success, i.e., course grades, enrollment in advanced mathematics courses, percentages of math majors, degrees earned in mathematics, or representation on math-related occupations. Since the status of underachievement in schools by Hispanics has been well documented and generally known by educators, verification of this unacceptable status warrants only minor treatment in this paper.

In order to show the magnitude of the condition facing educators and being endured by past and present generations of Hispanic youngsters, enrollment numbers and projections of Hispanic student enrollment are helpful. In 1979, the United States Census Bureau reported that there were 3.5 million Hispanics between the ages of 5 and 17 years. A study conducted by the National Center for Educational Statistics projected that the 1980 2.4 million limited-English-proficient (LEP) children ages 5 to 14 will increase to 2.8 million in 1990 and to 3.4 million by the year 2000. Spanish LEP's move from 1.8 million or 71 percent of all LEPs in 1976 to 2.6 million or 77 percent of all LEP's in the year 2000. Concurrently with this projected increase of Hispanic student enrollment in public schools, two counter-productive phenomena continue to persist. One event is that Hispanic students continue to leave school prior to satisfacotrily completing all twelve grades. For example, in 1971 the U.S. Commission on Civil Rights reported that 40.7 percent of Mexican Americans residing in the five southwestern states did not complete high school (Commission Report II). In 1976 or five years later, 9.6 was the median years of school completed by Hispanics while 12 years was the median for the total population (U.S. Census, 1977). While Mexican Americans are only one sub-group of the Hispanic population, they represent 65 percent of the total Hispanic population; the largest sub-group (Census, 1979).

Paralleling the early-withdrawal-from-school phenomenon is the underrepresentation of Hispanics in mathematics and science courses in junior and senior high schools. While no data were found specifically showing Hispanic percentages of enrollment in elected or advanced mathematics and science courses, two studies lend some support for under-enrollment in such classes. Results of the 1977-78 National Assessment of Educational Progress (NAEP) reveal that the majority of 17-year olds took only two years of mathematics courses and black students appeared to take about one year less of high school mathematics (Anick, Carpenter & Smith, 1981). Hispanic enrollment in mathematics e courses probably reflects more the black student pattern than the white student enrollment. In a study conducted in Tucson, Arizona with focus on attitudes toward science, MacCorquodale (Note 1) concluded that many Mexican American junior high students stop taking mathematics and science courses after they had completed the minimum requirements.

With regard to mathematics achievement by Hispanics, the second mathematics assessment by NAEP graphically showed that in terms of student outcomes, serious inequities exist in the mathematics education of Hispanics and blacks. For 9-year old Hispanics, the NAEP indicated they were 9 percentage points behind the national average; 13-year old Hispanics were 13 percentages below, and 17-year old Hispanics were 12 percentage points behind the national average (Anick et al., 1981). Assessment by states Hispanic mathematics achievement may reveal a worse set of scores. For example, Texas has approximately 974,000 Mexican American students enrolled out of 3 million or 30 percent, and the 1980-81 results of a state mandated testing program called Texas Assessment of Basic Skills (TABS) show that the percentage of Hispanics achieving mastery in mathematics in grades nine and ten are 60 and 46 respectively. In comparison to their white Texas grade-level peers, Mexican American are 24 and 9 percentge points behind at each grade level assessed (Texas Education Agency, 1981).

Before leaving the discussion of mathematics achievement by Hispanics, it is important to point out early that one trend appears to exist even though the above statistics do not reveal it: While Hispanics are achieving less in mathematics in comparison to their white cohorts, they are scoring better than most other minority groups with the exception of Asian Americans. Also when comparing Hispanic mathematics scores to other scores made by Hispanics on skills such as reading or content areas such as social studies, the mathematics scores appear to be slightly better for Hispanics.

Finally, documentation of inadequate participation in mathematics by Hispanics can be illustrated by under-representation in mathematics-related occupations. As with other minority group members, Hispanic professionals are concentrated in education, public affairs, and the social sciences (National Science Foundation, 1980). More telling, of the 44,800 mathematicians reported in the 1970 labor force, only 637 or 1.3 percent were of Spanish surname origin (Vetter & Babco, 1975).

All of the above information goes toward characterizing the problem to be: Hispanics are not proportionately participating in mathematics education nor are those few who are partaking in mathematics doing so to a satisfactory level. Consequently, Hispanics are grossly under-represented in mathematics -related careers and as a result inequities in society continue to prevail.

Rooting the Problem

Since the problem in the foregoing discussion has been defined to be three-fold (disproportional participation in mathematics education, under-achievement in mathematics, and under-representation in mathematics -related careers), it seems wise to separate the discussion about possible causes to coincide with each of these three problem areas.

As has tried to be shown, Hispanic student underparticipation in mathematics education is only one problem of the greater concern, i.e., early exit from schooling and general underachievement in most academic subjects. The question of why the holding power of schools with regard to Hispanics is weak has been responded to in multiple ways. The United States Commission on Civil Rights, 1971-74 studies on the Mexican American experience in schools in the southwest (probably the most comprehensive study conducted on any Hispanic group) ties the weak school holding power to negative attitudes and treatment by school personnel toward Mexican American student. Briefly but specifically, the Commission's study carefully documents the following unjust practices: creating and maintaining inadequate and segregated school facilities, disproportionally high school suspensions, excess amount of corporal punishment, exclusion from extracurricular activities, unwarranted placement in EMR classes, high concentration of placement into non-academic tracks, over-reliance on grade retention, and until more recently, the prohibition of the Spanish language on school grounds. Furthermore, the U.S. Commission and other researchers contribute the results of such unfavorable treatment to be motivated by prejudicial attitudes, stereotypic thoughts, and racial feelings harbored by school administrators and teachers toward Hispanic and other minority group members. Such cognitive and affective attributes do not solely reside with educators. Legislators also manifest such beliefs by drafting and maintaining state laws which skew school finance formulae against districts enrolling a majority of minority youngsters. Laymen elected or appointed to hold state or local school board positions also institute policies which adversely affect minority student populations, like adopting an English-as-a-second-language program only for LEP's rather than a bilingual education program.

Discontinuation of the above practices has occured only recently, unfortunately not sufficiently and primarily sporadically. While these unwanted policies, practices and treatment have been reduced, mainly due to litigation, favorable alternatives have been slow to emerge. More about constructive pedagogical approaches will be presented later in this paper.

Before discussing possible explanations for Hispanic underachievement in math education, discussion will address the underrepresentation of Hispanics in mathematic-related careers. As was presented earlier, and will be elaborated on in the next section, the disproportionately large number of Hispanics not participating in mathematics-related careers is primarily due to the inadequate accumulation of mathematics education or an insufficient amount of math preparation. It is important to examine the factor of motivation when discussing persistence, especially when viewing the subject of mathematics. Contrary to the commonly held perception that minority students have lower occupational aspirations than their white peers, research by Anderson and Johnson (1971), Espinoza, Fernandez and Dornbusch (1977), and Juarez and Kuvlesky (1969) indicate the opposite. Furthermore, these same researchers found that parents of Hispanics view the importance of education for their children as much as Anglo parents. Not only do Hispanics consider school to be of high value, but they also link success in school with success in the world of work (Espinoza et al., 1977). When MacCorquodale (Note 1) asked junior high school students in Tucson how important science was in terms of the work they expected to do, Mexican American males perceived science as the most important. While no studies were found providing information about Hispanic students' attitudes toward mathematics, Anick et al. (1981), when analyzing NAEP data, found that black students like mathematics , thought it was important, wanted to do well and would work hard to do so, in addition to wanting to take more mathematics and even entering a career using the subject. While no direct relationship can be made between black attitudes toward mathematics and Hispanic students, it is encouraging to note that Hispanic educational status and experience are most simlar to the black education experience. Consequently, the small amount of studies available seem to indicate the problem locus of underrepresentation of Hispanics in mathematics-related careers is not within the Hispanic personality.

Underinclusion of Hispanics in mathematics-related careers can better be attributed to external variables like the lack of role models. Role models are important since their presence indicates to students the likelihood of their entering the profession. Moreover, role models have the opportunity to become mentors, identifying and encouraging students to move toward certain careers. As students enter college and come closer to entering the profession, role models can become sponsors, providing aspirants with counsel about how to acquire a position. While the function of counseling can and is assumed by role models, it is directly and primarily the task of school counselors. Yet, experience, literature on school counselors, and studies conducted on school counseling reveal that because of high school student to counselor ratios and traditional stereotypic views of minorities, Hispanics have minimal contact with counselors, and what lttle time is spent with them is not devoted to educational and/or career planning.

Finally, small numbers of Hispanics are found in math-related careers because of discriminatory hiring practices and because of minimal career information provided by schools. Students in rural schools and barrios of large urban cities are poorly informed about the various kinds of occupational roles and educational requirements for most of these work stations.

Generally, discussion about the probable factors causing underachievement of Hispanics in mathematics is usually speculative in nature. Discussion of likely causes is not grounded in empirical findings si[illegible] because there has been very little research conducted to uncover the variables producing this inequitable learning condition. However, while research is not available, the literature seems to be consistent in identifying the most likely factors and consensus even exists as to what intervention needs to be pursued if this underachievement is to be eliminated.

A review of the literature has identified five probable factors which could explain the underachievement status recorded by Hispanics in mathematics education. The five factors are language, cognitive learning styles, instructional methods, curricular material and teacher adequacy. While each of these factors will be discussed separately, in practice they are interrelated, and consequently it is difficult to determine which contributes and to what degree, to learning or lack of learning.

Language is a manifestation of culture; it both represents a group's society and creates present and future reality for the individual. With regard to learning, at minimum language is a mediator of concept development, and at most a determinatnt of concept formation. Concepts are categories of generalizable or related facts. Language is a coherent set of symbols used to label concepts and provide a quick reference and meaning to concepts. Concept learning at some stage involves word association between a concept and the concept name (Underwood, 1966). Discussion of concept development is relevant because as is obvious, Hipanics have a culture and language (Spanish) which is different from mainstream America. Also remember that of the 3.5 million Hispanic students approximately 2 million are limited-English-proficient. Consequently, it is crucial that mathematics concepts be presented to LEPs in the lan-

LEPs in the language they are most proficient in. It is well known that there are few bilingual teachers able to communicate with and instruct children proficient in a language other than English.

The phenomenon of culture connects the language instruction variable with the curriculum variable. While most educators agree that mathematics is the subject most culture-free, it is not devoid of representing cultural biases. For example, Bradley (1981) asks to what extent is mathematics culturally biased since logic is a major strand in mathematics, and (b) is not logic organized differently by cultural groups? Furthermore, according to Maria (1961:6), "mathematics is concerned with the study of relationships of ideas that man has abstracted from observation of the physical world and has generalized by rational reflection." Not all cultures interpret the physical world nor generalize about it in consistent ways. Differences between cultural groups have implications to the teaching of mathematics in two areas: curriculum materials and instruction. The way math concepts are presented in textbooks may be inconsistent with how immigrant Hispanic students have been introduced to certain concepts (Castellanos, 1981). This inconsistency may cause confusion in the student's mind and delay his/her understanding. Also, Tsang (1981) states that the curriculum should reinforce what has been learned previously and introduce new concepts based on previous knowledge. Immigrant students come from different cultures and are products of the educational system of their respective countries. The curriculum revision effort of the last two decades in the United States has led to significant differences between the mathematics curriculum of the United States and of those of many other countries. Finally, with regard to the teaching of mathematics, Lovett (1981) while indicating that mathematics is culture-free, states that the teaching of mathematics takes place in a cultural context. Moreover, he continues that good mathematics teachers have searched for the mathematics existing within the real world experiences of their students and have tried to incorporate such experiences in their teaching.

The amount of learning acquired by any student is most directly correlated to teacher quality. Castaneda (1981), along with others such as Gallegos (1981) and Serna (1981), argues that the teachers' attitudes toward mathematics and the teaching of mathematics need to be changed to be more positive and constructive. She also states that teacher training should include mathematics content, information about the learning characteristics of young children, and methods of mathematics teaching. Such training would help teachers to combine what they know about math with their knowledge of pupil's learning traits, and to acquire skills that would facilitate selection of math content and instruction that honor the young child's natural modes of learning.

Possibly, the most potent factor related to achievement and consequently having the greatest promise for program intervention and remediation is the cognitive styles of Hispanics. While Castaneda only argues for teachers to be prepared to match student learning characteristics with mathematics concepts and methodology, Ramirez and Castaneda (1974) propose a specific cognitive style which may map with Hispanics and therefore have significant pedagogical implications. As a result of their research, Ramirez and Castaneda suggest that children from certain cultural groups may be more field dependent, i.e., view their environment as unified and having an inherent order. In contrast, field independent persons appear to view situations in distinct parts and apply structure even when no order is readily apparent. Under this dichotomy, Hispanics tend to be more field dependent. Lovett (1981), in his writing about the mathematic teacher's role in bilingual education, points out that there are three aspects of field dependency which have direct bearing on the teaching of mathematics. One, field dependent students may learn mathematics more readily where the teacher provides a high degree of guidance, clearly states the outcomes, and structures the lesson. Two, presentation of materials or materials favoring social content seem to be more attractive to field dependent pupils. And three, working together and minimizing competition is a learning mode more conducive for field dependent youngsters. It appears that mathematics education has been organized to favor the field independent rather than the field dependent, i.e. open ended discovery rather than definite outcomes, individualization of instruction rather than group learning, and competition more so than cooperative activities.

Intervention Strategies: Uprooting the Problem

An effort to identify intervention programs attempting to remediate the banal learning of Hispanics in mathematics produced no results. While no reports were found in the literature, there have been and probably are a few experimental mathematics programs with focus on Hispanics. Most of these few programmatic efforts have been directed at curriculum development and have been school district initiated. It is safe to state that no prominent mathematics project has been designed and implemented with the primary purpose of testing teaching strategies applicable to Hispanics learning mathematics better. The search did, however, uncover a potpourri of studies and a few proposals.

Trevino (Note 2), in her 1968 dissertation study which assessed the effectiveness of a bilingual program in the teaching of mathematics in the primary grades in one south Texas school district, found that in all cases the scores of Spanish-speaking children taught bilingually were higher than the scores of Spanish-speaking children taught exclusively in English. This finding is supported by two studies, one conducted by Coggland and Cuevas (1979) and the other by DeAvila (1979). It is also the most consistent finding, viz., bilingual students do better in mathematics achievement than LEP and monolingual English-speaking students when taught in their mother-tongue and English. This finding even extends to the college-age pupil. Gerace and Mestre (Note 3) are examining college-age Spanish-speaking students majoring in technical subjects and report that their performance on mathematical skills is strongly related to language proficiency, more so than for monolinguals.

Research presently being funded by NIE provides educators and curriculum writers with insight about what researchers consider to be necessary knowledge in order to design instructional programs which will overcome the underachievement of Hispanics in mathematics. The team of Gerace and Mestre (Note 3) is investigating the cognitive processes of ten ninth-grade Hispanic bilingual students learning Algebra I. They anticipate that their findings will aid in the designing of mathematics curricula for bilingual students and in helping bilingual students become aware of successful strategies and common avoidable errors. In other research, Orvik (Note 4) is directing an interdisciplinary research effort into the nature or mathematics teaching and learning across cultures leading to the generation of hypotheses about the cognitive characteristics of learners and teachers; the nature of mathematical tasks; and teacher/learner social interaction in cross-cultural situations. Still another researcher, Saxe (Note 4) is examining monolingual and bilingual Spanish/-English and Chinese/English children ages 3-14 from middle and lower class families. Among many anticipated findings, he hopes to discover special competencies of inner city bilingual children and to illuminate early sources of differences in levels of preparedness of children to engage in mathematics learning. There are other studies directed at non-Hispanic poipulations but which have bearing on aspects pertinent to Hispanics. Such research will not be discussed here because of the lack of space.

Besides the scant research mentioned, two proposed intervention programs were found. Hernandez (Note 5) expresses dissatisfaction with most research being conducted with regard to Hispanics and mathematics because such effort is aimed at identifying the primary cause of underachievement and diverts attention from designing programms to increase mathematics achievement for Hispanics. Instread, she proposes a model for change based on positive directions to improve instruction. Specifically, she argues for Bloom's Learning for Mastery model as an approach that can be implemented now to ensure increased mathematics achievement. Possibly having the same motivation as Hernandez, Ortiz-Franco (Note 6) makes some suggestions for inclusions when developing an intervention program for precollege minority students who are interested in pursuing mathematics /science careers. His suggestions are not based on research targeted at Hispanics, but based on intervention programs designed to increase the participation of white women in mathematics-related careers. In general, he discusses internal and external variables found to be important in intervention programs but comments correctly that specific implementation of such variables are dependent upon onsite circumstances, consequently offering none.

Consequently, a review of the scant research and literature reveals finding about how to improve the academic learning of Hispanics in mathematics are minimal and knowledge of remedial instructional programs suited to help Hispanics learn more mathematics is even less.

Research and Program Recommendations

It is recommended that a balanced and concurrent two-pronged approach be taken to bring about improved mathematics education forto Hispanic students. [illegible] prong, the major of the two, be re[illegible]arch and the second prong be experi[illegible] [illegible]jects. As the research com[illegible] b[illegible]is a substantial volume of knowledge, it should reduce in impor[illegible] [illegible] the second prong becomes the [illegible]jor effort, i.e., program implementation. The research focus should revolve around three dimensions: (a) the Hispanic child's cognitive and affective style, (b) methods of teaching mathematics to Hispanics and (c) scope, sequence and format of curriculum. Since all three of these dimensions of learning, met[illegible]dology and curriculum are interrelated, they should be treated as such. However, joint investigation should not be at the exclusion of examining one dimension unto itself.

Within each of the three research foci, studies should explore the following particular aspects. Of course, the questions are not all inclusive nor prioritiz[illegible] With regard to cognitive and affective learning styles of Hispanics, the following questions seem critical:

1. Is a bilingual's problem solving ability dependent upon first or second language proficiency?

2. What knowledge of mathematical concepts do Hispanic children have prior to entering school? What modes of motivation encourage Hispanics to pursue learning? Under what circumstances do Hispanics learn mathematics concepts at home?

3. How do Hispanics approach learning?

4. How does a Hispanic child's difficulties in mathematics depend on a particular concept rather than on a lack of general aptitude?

5. What are the psychological factors which influence Hispanic orientation to mathematics ? (This question would include the avoidance and persistance variables.)

6. What concepts, skills and predispositions are associated with success and pleasure in mathematics learning by Hispanics?

With regard to teaching methods, the following questions might be most fruitful:

1. How does the classroom environment influence Hispanic achievement?

2. What teacher behaviors promote positive interaction with Hispanic students?

3. What instruments and procedures can teachers use to identify cognitive learning styles of Hispanics?

4. How does the school climate and structure affect the Hispanic student's desire to participate and pursue a mathematics major?

Rather than research a series of questions when attending to curriculum, it is proposed that it would be more advantageous to undertake a developmental approach. The developmental thrust would be to generate curricula which incorporate the Hispanics's history, present environment and cultural values.

The second prong, project experimentation, could center around designing and implementing Bloom's model of mastery learning or incorporating Ramirez and Castaneda's constructs favoring field dependent learners. Such experimental projects would have to be well funded and participating staff as well as support staff would require extensive training. Of course, such experiemental projects would necessitate a systematic evaluation plan, both formative and summative.

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Language Minority Students *and Mathematics*

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THE PROBLEM

One of the basic problems we face as mathematics educators, deals with the ways in which we can be more effective in communicating mathematical ideas. This communication becomes critical when teaching students for whom English is a language not understood. In view of the learning difficulties which face language minority students, the lack of proficiency in English is found to be at the core of the problems. Language proficiency is also the focus of the various legislative and legal mandates which direct school systems to provide equal educational opportunities to linguistic minority groups. Both the Bilingual Education Act and the Lau vs. Nichols "Remedies" address the fact that " . . . students who do not understand English are effectively foreclosed from any meaningful education" (414 U.S. at 566, 1974). It is widely believed that the linguistic minority students' failure to achieve in school is caused by the "language problem." Research studies have also indicated that there appears to be a relationship between these children's degree of proficiency in English and academic functioning (Lewis, 1959; Cater, 1970; Anderson and Johnson, 1971; Campbell, 1973; De Avila, Cervantes and Duncan, 1978; Cummins, 1981). It may be assumed from these results that the more proficient in English these students are, the greater the opportunities available for them to achieve in school. Applying this assumption to the learning of mathematics two basic questions must be addressed before intervention programs are designed to assist these students. First, to what extent does the student's first and/or second language, effect learning and the assessment of achievement in mathematics? Second, what English language skills are necessary for successful achievement in the subject?

The above questions provide the foundation for the study of the problem-underachievement in mathematics as a result of lack of proficiency in English. In addition, the issues raised by the questions are relevant to all language minority students; the inability to use the English language in a school setting is a problem all language groups face.

ANALYSIS OF THE PROBLEM

The language factor in mathematics education may be analyzed in terms of its effect on the learning of mathematics and its role in the assessment of achievement. Also, an analysis of the language skills which are needed for successful mastery of mathematical concepts and skills may contribute to a further clarification of the problem and possible solutions.

The interest in the relationship between language and learning is not a new one. Some have suggested that language determines and defines thought. Others, such as Piaget (1956), have tended to accept only a limited effect of language on thought. However, his coworkers have expanded on this premise by suggesting that language development may be influenced by general cognitive development since some major changes in language mastery occur at times when major cognitive changes occur. From a further review of the literature, it may be assumed that language and learning are strongly related.

The relationship between language mastery and mathematics learning has long been accepted, although not always recognized as a factor in the learning of mathematical concepts and skills. There is sufficient evidence of this in the literature. Thorndike (1912) stated that " . . . our measurement in arithmetic is a measure of two things: sheer mathematical knowledge on the one hand; and acquaintance with language on the other." Aiken (1971) in a review of verbal factors and mathematics learning, reports that researchers have long recognized the role language plays in performance in mathematics. Studies indicate that there is also a positive correlation between reading ability and scores on tests of problem solving in arithmetic. More recent studies indicate that there is also a positive relationship between mathematics performance and second language ability (Cossio, 1977). In addition, there appears to be a relationship between instruction through the student's native language in curriculum content areas and high achievement in those areas (Granado, 1976; Tsang, 1976; Coffland and Cuevas, 1979; Cuevas and Llabre, 1981). In summary, the relationship between language factors and mathematics achievement is not clearly understood but it may be appropriate to assume that in order for a student to master the mathematics concepts, the language of the concepts must be mastered.

In addition to the relationship between language and the learning of mathematics, the role language plays in the assessment of mathematics achievement must be discussed. The utilization of a language not understood by students is frequently given as one of the reasons for the inappropriateness of existing tests and testing situations when used with these students (Moreno, 1970; De Avila and Havassy, 1974; Ramirez and Gonzalez, 1972.) According to Chandler and Plakos (1969) vocabulary contained in the instrument is unfamiliar to them. Gearder (1975) provides an argument supporting the notion that the use of English as the language of the test is one reason for the obtained decreases in the achievement scores of Hispanic students. Although this claim is debatable, several studies have lent support to this hypothesis. Holland (1960), Mycue (1968), and Meeker and Meeker (1973) found that when tests were translated, Hispanic students tended to do better on the Spanish versions than on the English versions. But on the other hand, Anastasi and Cordova (1953) and Manuel and Wright (1929) found no significant differences in performance on the Spanish and English versions of achievement tests. Clearly a factor sometimes overlooked in these studies is the degree of native language proficiency possessed by the students as compared to their command of English.

Some researchers (Oller and Perkins, 1978) have even hypothesized that intelligence, achievement, and personality instruments basically test language proficiency. These authors have presented results of factor analytic studies in support of their claim. Given the inevitable dependence of achievement and intelligence tests on language, it seems logical that such tests would have decreased validity and reliability for less than proficient English speakers. Concerning the effects of language on the generalizability of mathematics achievement scores for bilingual students, Llabre and Cuevas (1981) found that scores from mathematics achievement tests (concepts and applications) for students whose first language is Spanish are less reliable than what is usually reported in the literature as acceptable. Given the results of their research Llabre and Cuevas (1981) also report that the primary language of instruction (English or Spanish), the level of reading proficiency in the language of instruction and the skill being measured should be taken into account when interpreting mathematic achievement test scores for linguistic minority students.

The previous discussion dealt with language in general as it relates to the learning and assessment of mathematics. Concerning specific language areas, reading related skills appear to play a significant part in certain types of mathematics achievement. A composite of results obtained by Banting (1923); Roling, Blume and Morehart (1924), and Stevenson (1925) includes the following reading related causes of failure in solving arithmetic word problems: (1) difficulties with word recognition; (2) lack of knowledge of vocabulary; (3) careless reading of the problem; and (4) lack of understanding of quantitative relationships. More recently, Hargis and Knight (1971) report that while reading materials have been developed which match the child's language, mathematics materials often present a mismatch between the vocabulary of the text and the student's vocabulary. It is Hargis and Knight's contention that more attention must be paid to reading related skills since all mathematics ideas are "embedded in definite language statements with clauses signaling relationships and nouns signaling ideas." In addition to reading skills, Cathcart (1974) reports that the student's listening ability in the classroom has a significant effect on his/her mathematics achievement.

The object of the preceding discussion was to place an emphasis on language as it relates to the learning of mathematics since proficiency in the language of instruction is so important. The child who comes from a home where English is the main language spoken will have heard many of the language constructions used in the mathematics classroom. One cannot make the same assumption for the child whose native language is not English. Research efforts must be directed towards the analysis of language skills and language-related teaching strategies which will facilitate the language minority student's learning of mathematics.

FUTURE DIRECTIONS

Throughout the search of the literature one glaring fact is evident—there is a dearth of research concerning the nature of the relationship between language (in general) and mathematics learning and the role language plays in the assessment of mathematical concepts and skills. When the focus is placed on language minority students, the absence of research studies is extremely apparent. Based on the premises that language does play an important part in mathematics learning and that language factors account, in part, for the language minority student's underachievement in mathematics, future research efforts should be directed toward multivariate studies of the relationships among selected aspects of mathematics and various language variables. Careful consideration must be taken in incorporating levels of student language proficiency, socioeconomic status, age and sex variables as factors in the research designs.

With respect to language effects on the assessment of mathematics achievement, studies need to be conducted which examine the relationship between the level of reading difficulty of the test and student's performance. As with all research conducted with limited English proficient students, the definition and assessment of language proficiency must be carefully thought and carried out.

More specifically, the following are some of the questions which are suggested from the above the two areas of concern:

1. What is the nature of the reading and language (general) difficulties present in selected areas of mathematics (concepts, problem solving, etc.)
2. Is there a language effect upon achievement in computation?
3. To what extent do mathematical skills transfer from one language to another?
4. What is the relationship of reading achievement in the student's home language and performance in problem solving in mathematics for bilingual and limited English proficient students?
5. To what extent do specialized language methodologies, such as English as a second language (ESL) in the content areas, facilitate learning in mathematics?

These, then, are just a few of the many challenging questions for study. Their answers will hopefully provide equity of educational opportunities in mathematics for the language minority students.

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Native Americans and Mathematics

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Today Native Americans are developing their communities and reservations to maintain their rights, lands, and people. In an attempt to gain equity in a world of computer and high technology industries, Indians need equal education, particularly in mathematics. Their communities and reservations are increasingly seeking to hire Indians trained in vocations and professions, which require competence in mathematics (Green, 1978, p. 13).

"Of all minority groups in the United States, Native Americans are the most poorly represented in the natural sciences, the health sciences, and mathematics; yet Native peoples are the most needful of any minority group of status improvement in the areas of health, education and social welfare. Indian health needs are generally well-known, as are the grim facts of Indian underachievement in education. Even though the necessity for more Indian professionals in all fields and for economic development throughout the Native world tie together the major areas of concern, other needs beyond basic health care delivery and education in plenty. Most land-based Native Americans are in a serious struggle for the retention and development of the land they own, and in that struggle lies a potential for economic development which can change health care and education\patterns for the good. Thus, Native engineers, geologists, agronomists, aquaculture specialists, chemists, geneticists, animal husbandry specialists, and botanists--are all needed for resource development, management, and planning on Indian lands. Additionally, Indian teachers and programs in these fields are needed to raise the general educational level of Native people, as well as to provide meaningful career options for all Indian--rural, urban, land-based and not." (Green, 1978, p. 1)

Achievement scores of Indian students fall below grade level as they progress through elementary and secondary schools. Indian students avoid high level mathematics courses in high school. Upon entering a college or university they are often unprepared for the calculus sequence, and select majors with little or no mathematics requirement. The result is very few Indians enter mathematics related careers.

About 70% of Native American students attend public schools in the United States. The remainder attend federal BIA supported schools, private, and parochial schools. The 1970 U.S. Census found 2,829 school districts with at least one Indian student. These districts averaged 3% Indian. Of those enrolled in public schools 70% live in five states: California, Arizona, New Mexico, Oklahoma, and Alaska (See Table 1). Montana, South Dakota, and the State of Washington each have more than 20 districts with over 10% Indian enrollment (Scherbeck, 1976).

New Mexico has 23,964 Indian students enrolled in public school allocated among 15 school districts. On tenth grade Proficiency Examination given to all students in New Mexico, Indian students had the lowest percentage scoring at or above 65% correct level when compared to Blacks, Hispanics, and Anglos (Southwest Resource Center for Science and Engineering, 1981, p. 7) (See Table 2).

The State of Washington has 18,114 Indian students enrolled in public schools, 4,407 Indian students are enrolled in districts of at least 10% Indian enrollment. These students are allocated in 25 school districts (Scherbeck, 1976). The Johnson O'Maley (JOM) programs compiled mathematics achievement test scores for Indian students in Washington (See Table 3).

Choctaw Indian students in Mississippi scored below grade level in mathematics on the Califnornia Achievement tests. The gap between the mean test scores and the grade continues to widen as the students progress from second to twelfth grade. By twelfth grade Choctaw Indian students' mean is at eighth grade level in mathematics (Brod, 1979, p. 13) (See Table 4).

Sells (1973) disclosed high school mathematics is a critical filter for anyone entering the job market or seeking higher education. Students who have not taken Algebra and Geometry in high school are ineligible for admissions to some colleges upon graduation (Office of Provost, 1976). Students without a background in trigonometry are not prepared for the freshman calculus sequence in college and must limit their choice of undergraduate major to education, social sciences, arts and humanities, if they plan to continue to avoid mathematics courses. Students who choose to enter vocations such as surveyors, auto mechanics, machinists, carpenters, roofers, electronics workers and technicians in scientific and industrial laboratories, are not required to earn college degrees, but are required to study high school mathematics beyond algebra (Krienberg, 1976, p. 2).

The evidence shows Native Americans are not obtaining sufficient competence in mathematics to study the higher level mathematics courses in high school, to take the calculus sequence, and to enter mathematics related careers. All the recruitment efforts of Indian communities and reservations together with high technology industries to employ Indian people in careers requiring mathematics or statistics will be unsatisfactory. As long as Indian students avoid mathematics and limit their choices in the job market, there is little hope to raise the overall relative family incomes of Indian people to any significant degree.

If mathematics educators of Indian students are to resolve this dilemma, we must investigate the contributing factors. For any school setting the student's education is effected by teachers, curriculum, administration and community. Indian students have the added dimension of living in two worlds--home and school--which are products of two cultures--Indian and White. The questions are: How do these cultures contribute to Indian students avoidance of mathematics and lack of competence with mathematics? And what other factors in the school setting contribute to the avoidance and lack of competence?

Dr. Rodney Brod (1976) compared Indian students with their classmates and found the differences to be that Indian students had more resident changes, were more rural, lived further from school, rode the school bus, had older siblings and more sisters, had large families and no phone listed in school files (Brod, 1976). To consider these factors, no phone, changing residence, and living far from school, teachers and school administrator would not have an easy time contacting parents when they needed. Likewise, having large families, living far from school and no phone, parents would not have an easy time visiting or contacting the school.

Indian students struggle to survive in two cultures. Generally teachers and school administrators are not Indian and have the cultural values of mainstream society. Indian students attend school six hours a day and bring the attitudes, values, and beliefs from their home environment and Indian communities into the classroom.

Charles G. Moore (1981) and Lehi Smith (1981) have written about mathematics learning of Navajo students in relation to the Navajo Language. They concur that the language has styles of thought and communication, which influence students in their approach to solving problems and learning mathematical concepts. Their papers indicate that research is needed to fully understand the effect of Indian language on mathematics learning of Indian students.

Jack Easley (1980) in <u>On Understanding the Mechanism of Under-representation of Minorities in Mathematics</u>, says children of other cultures have different personal insights about behavior patterns (p. 6). Some decide to tell their feelings, others attempt to keep their feelings. Elementary teachers of Indians remark about Indian children's silence in the classroom. This factor makes 'discovery' based teaching methods inappropriate in traditional Indian communities according to Green (1978, p. 5). However, Indian students' behavior of silence should only discount discovery based learning when verbal responses are expected. Discovery is an intimate part of everyone's learning. The expression of that learning does not have to be a verbal response, but can be non-verbal. Especially, since traditional Indian communities/tribes had highly sophisticated forms of non-verbal communication.

Reporting on the conference in Mathematics in American Indian Education, Rayna Green (1978) writes, "conferees agreed many mathematics teachers and counselors perpetuated the mystique of math as hard and inaccessible to all, but the brightest students" p. 4). This may occur from their own feelings about mathematics, for they suffer from painful experiences with math (Mitzman, 1976, p. 11).

Conferees on Mathematics in American Indian Education agreed Indian students are both unprepared and dissatisfied with mathematics (Green, 1978, p. 4). Indian teenagers are more verbal than those in elementary school. Teenagers rebel against the "stringent discipline practiced by federal and parachial schools" and choose not to study the mot "disciplined, visible Western forms of education," which they believe to be math and science courses (Green, 1978). In high school Indian students select social science and humanities, for they appear more relevant to their lives.

Teachers and counselors believe Indian students are incompetent in mathematics. They encourage only the most promising students to take higher mathematics courses in high school. Dr. Brod, University of Montana, found teachers will give white studetns the benefit of the doubt when grading, but seldom extend this practice to Indian students (Brod, 1976).

Parents influence teenagers, especially mothers. In Choctaw student assessment of vocational needs the question was asked: "In choosing your job or career, whose ideas are most important?" The major respsnses were 'My ideas' (81.9%) and 'mother's ideas' (46.9%). The major career choices of Choctaw student's were Professional (40.6%), and Craft/foreman (15.6%) (Brod and Brod, 1979). In Colville student assessment of vocational needs the same question was asked. The major responses were "my ideas" (90.3%), and "mother's ideas" (52.2%). The major career choices of Colville student's were professional (32.1%), operative (11.2%), clerical (10.4%) and service worker (10.4%) (Brod and Brod, 1981).

Two types of students appear to be good candidates for mathematics based careers. The first has an excellent memory for algorithm and definitions, plus has successfully practiced their application on classroom assigned problems. The second is the individual who reconstructs mathematics ideas, creates problems to test ideas, completes all classwork and seeks to learn more about mathematics by him/herself (Easley, 1980). Traditional Indians had a highly developed memory needed to pass on the culture (Moore, 1981). This ability to memorize has not been employed in the mathematics classroom. But as Easley writes, students who memorize definitions and algorithms do not survive in higher mathematics courses as well as the "self-taught problem solvers who easily create ways to solve new mathematics problems" (1980, p. 3). In any case neither of these two types of math students is being encourged among Indian student by their teachers.

The question to address at this point is how teachers contribute to the lack of mathematic competence among Indian students? In elementary schools teachers teach many subjects. They suffer from math anxieties developed in their own schools days (Sells, 1973, p. 2). Generally elementary school teachers are not trained nor enthused about mathematics. High school teachers are trained in the subject but lack special training and commitment for Indian students (Green, 1978). Most teachers believe in equal education for all, but they do not have the resources to meet the responsibility. Teachers criticize their studies at college and universities. None of their courses provided the understanding of problems they dealth with in the classroom (Easley, 1980).

Lucy Sells (1973) wrote "the traditional classroom forces people into proving other people wrong." Jack Easley (1980) wrote "Mathematics classes are 'extremely dull' in all grades K-12 in all kinds of schools for all kinds of students." When students simply memorize facts, they do not learn how to apply them in the real world. When they rely on formulas, they do not learn to think (Heltzel, 1976). The two forms of problem solving are: application of algorithms to written problems and the creative exploration of a problem situation. The first is considered problem solving by elementary school teachers. The second is needed in advanced amthematics courses and in real life situations (Easley, 1980). Elementary school teachers are afraid of students who demonstrate creativity in mathematics. They overlook the curiosity of students and prefer to focus on the economic pay-off in later life. Green (1978) concurs that Indian students are encouraged to study mathematics only to fulfill a college requirement or vocational program.

Mathematics materials for Indian students needs more attention (Green, 1978). Many textbooks used by Indian students do not address their cultural and intellectual interests. The quality tends to be less than satisfactory (Gore, 1980).

Herbert Their, of Science Curriculum Improvement Study at the University of California at Berkeley, warns educators against the "remediation syndrome" and "identity accomplishment confusion." The "remediation syndrome" is the belief the child is the problem and needs more time at the same thing. By spending more hours the child suffers longer and develops a poor self-image and dislike of the subject. The "identity accomplishment confusions" is teaching the child his own culture with the curriculum. Such efforts in the past resulted in changing illutrations or stories. Children spent too much time on traditions, songs and games, which would be okay if the school didn't side-step teaching the skills needed to survive in today's world. Attempts to teach a culture by teachers without direct experience in that culture either programmed the child or caused him to respond passively. Dr. Their suggests the school should focus on the child's learning process and develop curriculum with the advise and cooperation of community members. The community should encourage children to obtain school related skills and relate their importance to their culture and community. Dr. Their feels an experience-based curriculum which integrates the Indian students' school, home and other life experiences is the most promising approach in the mathematics classroom. The experienced based curriculum should be planned with the cooperation of school and Indian community.

Answers to why Indian students are not gaining mathematical competence are many. Solutions vary depending on the culture and environment of specific Indian students. However, mathematics educators should find the following programs and ideas significant for Indian mathematics education.

Cardell (1978) described the peer learning experience used by mathematics teachers of Mascalero-Appache children. The teacher presented the mathematics lesson in the traditional fashion. Learning stations were set up around the classroom with a peer learning leader at each station. Students were free to choose their leader and to rotate among the stations. The leader reviewed the lesson, allowed students to ask questions, and checked their work. To wind up the lesson the learning leader gave up the lesson the learning leader gave graded check-up reviews which were spot-checked by the teacher. When compared with the control group the students in the peer learner experience gained more in mathematical concepts and skills, developed positive attitudes toward the experience and demonstrated growth toward positive attitudes toward mathematics.

In an education via radio program among the Guatemalan Highland Maya, thirty-four teachers converted their homes into classrooms three evenings a week. Core lessons were broadcasted each evening in the Tzutujil language. The teachers turned off the radio for review questions and for checking students work. Once a week the teacher returned to the broadcast office to discuss their classes and the lesson for the coming week. This program reached 906 students over four years. The students were friends and relatives of the teachers, but they had relatively no formal schooling. "In comparison with other eductional and development projects in the Highland Maya area, . . . the results have been outstanding" (Early, 1973, p. 228).

Native American loom beadwork has properties which illustrate mathematical concepts in Geometry, Coordinate Geometry, Number Theory, and Measurement. Claudette Bradley (1976) has used loom woven beadwork to develop culture based mathematic curriculum for Indian students. After students master the task of making loom beaded items the students were to develop their beadwork designs on computers using Logo. Seymour Papert (1980) has developed Turtle Geometry using Logo computers. His theory is that students learn mathematics by using mathematics to write computer program that draw shapes, designs, or animated pictures on the Logo TV-screen. Native American loom beadwork designs are ideal subjects for Logo computers in technicolor.

Project SEED designed by William Johntz (1980) is for minority school age children. Trained scientists and mathematicians teach abstract conceptually oriented mathematics with the discovery method. The staff loves mathematics and communicates well with students. They have observed creative answers and questions in their students to responses that are generally considered "wrong" answers by traditional mathematics teachers. Project SEED has been successful in Berkeley, California with fourth and fifth grades for over 17 years.

Oregon Mathematics Learning Center Salem, Oregon has designed creative ways for teaching mathematics. One way is the lab approach (Mitzman, 1976, p. 11). The mathematics lab provides opportunities for students to explore mathematics through game and hands-on materials. The center offers workshops for teachers, provide a place for materials for learning mathematics. About a third of the teachers have been Indian. The written responses of teachers who attended the workshops were very positive. Many teachers became math enthusiasts (Mitzman, 1976; Heltzel, 1976).

In summary, to address the question of what factors may improve the mathematical competence of Indian students the analysis of this paper places the findings in three categories: the cognitive domain, the affective domain, and the social domain. In the cognitive domain Indian students must be encouraged to reconstruct mathematical ideas, create problems, test ideas, complete classwork, and seek to learn more mathematics on their own. As in the SEED project, Indian students need to develop spatial relationships, which can be accomplished through creative uses of hands-on materials, as well as, calculators and computers. In the affective domain Indian students need support and counseling from Indian community members and mathematics related professionals. In the social domain Indian students may need briefing on mathematical language, test-taking strategies, and/or appropriate problem solving techniques prior to studying higher math courses. Culture based mathematics should not push aside the main focus of learning mathematics, but would be most effective if Indian community members took primary responsibility of developing culture based mathematics both in and out of school and worked cooperatively with mathematics teachers of the school.

Mathematics educators should be aware of research in culturally approprite communication styles, especially in reservation areas. Of particular interest should be the issue of silence in elementary schools of Indian student and the traditional sophisticated non-verbal forms of communication. There are other forms of expressing learning than talk. The use of hands-on materials and computers would be appropriate for quiet students. Discovery methods would work and teachers would learn to recognize learning.

At the high school level particularly, Indian educators should research the job market within Indian communities as well as the greater non-Indian community. They should familiarize themselves with the role of mathematics in these vocations and professions, relating the information to students, and creating opportunity for students to meet Indians in those fields.

To make any lasting effective change in mathematics education parents, tribal leaders, counselors, teachers, and administrators must be educated about the necessary changes. Mathematics has been taught the same way in elementary and secondary schools for over a hundred years. Educators learned from the intervention of "New Math" in the 1960's that when teachers and parents become frustrated over the changes in mathematics curriculum, the new program gets pushed aside in favor of "back to basics" (Cheek and Castle, 1981).

An evaluation process is essential for determing the effectiveness of mathematics curriculum for Indian students. Observation and interviewing techniques should be investigated. The issue of evaluation is important for it is intimately tied with the goals and objectives of school, community and students. It should not lose sight of the fact the Indian students must be prepared to survive in two worlds, and that achievement tests are not sufficient indicators of a successful mathematics program for Indian students.

Indian people need a Teacher Center for research and education of teachers. A Teacher Center would serve Indian mathematics educators from federal, public, and non-public schools; conduct research projects and training workshops. It would develop a research pool of mathematics educators working in Indian settings (Green, 1978). Such a Teacher Center could be established within a college or as an independent agency. The center could employ Indian people in mathematics-related careers and Indian graduate students in mathematics related studies. The center would maintain a library; organize research teams to assess Indian mathematics education, programs, curriculum, and classes: research Indian learning styles, publish research findings, and train teachers to design their own mathematics curriculum based on culture and environment.

Indian students face all the problems of other minority students with traditional mathematics classrooms, incompetent teachers and biased counselors. In addition, Indian students face cultural conflicts imposed on them by language, communication and learning style differences between school and home. Consequently mathematics teachers cannot afford to be complacent and rely on published textbooks for curriculum design.

Parents, counselors, teachers and tribal leaders must come together in cooperation with mathematics education researchers to determine goals, design new programs and evaluation processes. Solutions will evolve out of cooperation between Indian and school communities and vary among Indian culture and environments.

Table 1

Seventy Percent Indian Students Attend Public School

State	Districts with more than 10% Indians enrolled	Students in districts over 10%	Students in districts of less than 10%	Total
Alaska	20	14,172	2,756	16,928
Arizona	55	20,014	11,455	31,469
California	29	2,835	27,959	30,794
New Mexico	15	20,945	3,019	23,964
Oklahoma	339	69,517	17,171	86,688
Other States & District of Columbia	202	49,631	95,021	144,652
Total	660	177,114	157,381	334,495

(Scherbeck, 1976)

Table 2

New Mexico Proficiency Exam (Tenth Grade) Success Levels at 65% Correct for Several Content Areas by Ethnic Group (1977)

Test Content/Skill Area	Indian	Blacks	Hispanics	Anglos
Computation	21%	27%	41%	72%
Problem Solving	57%	58%	79%	94%

(Southwest Resource Center for Science and Engineering, 1981, p. 7)

Table 3

1980 Mean Normal Curve Mathematics Achievement Equivalents and Percentiles

	Mean	Percentile
Washington State JOM students	41	33
Colville Reservation students	40	30
National Average	50	50

(Brod and Brod, 1981, p. 11)

Table 4

Spring Math Grade Equivalents on California Achievement Tests, Choctaw Agency Schools, 1977--1979

Grade Level	1977	1978	1979
3	2.3	2.5	2.9
4	3.4	3.6	3.8
5	3.7	4.2	4.0
6	4.9	4.6	4.9
7	5.5	5.7	5.5
8	5.9	7.2	7.0
9	6.4	7.4	7.5
10	7.0	7.9	8.1
11	7.7	8.2	8.5
12	8.1	8.0	8.1

(Brod, 1979, p. 13)

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Brod, Rodney L, Rodney L., Choctaw Education, LPS & Associates, Rocky Boy's Route, Box Elder, Montana, December 1979.

Brod, Rodney L., and Brod, Mary Jane, Educational Needs of Colville Confederated Tribes, LPS & Associates, Rocky Boy's Route, Box Older, Montana, August 1981.

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Early, John D. "Education Via Radio Among Guatemalan Highland Maya," Human Organization, Volume 32, Number 3, p. 221-229, February 1973.

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Finnell, Robert, A High School Intervention Strategy to Improve the Mathematics Performance of Minority, Mathematics Engineering Science Achievement, University of California, Berkeley, 1980.

Gore, Pat L., Courses--Books--Comments, Box 28, Bacone College, Muskogee Oklahoma, 74401, 1980.

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Green, Rayna, Math Avoidance: A Barrier to American Indian Science Education and Science Careers. Sept. 8, 1978, BIA Education Research Bulletin, Volume 6, Number 3, p. 1-8.

Heltzel, Ellen Emry, "Math Gains New Dimensions with Aid of Teacher "Enthusiasts'", The Oregonian, Section C, Friday, October 15, 1976

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Jordan, Janie, An In-depth Look at Selected Strategies to Improve the Mathematics Performance of Minorities, Norfolk State University, Norfolk, Virginia, July 1980.

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Papert, Seymour, Mind storms: Children, computers, and powerful ideas, Basic Books: New York, 1980.

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Sells, Lucy W., Mathematics as a Critical Filter, Problems and Solutions, American Sociological Associatin, Washington, D.C., 1973.

Smith, Lehi, Mathematics Education in an American Indian Culture, Arizona State University, Tempe, Arizona, 1981.

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Their, Herbert D. "Some Thoughts in Educational Experiences and Pueblo Indian Children," Science Curriculum Improvement Study, Lawrence Hall of Science, University of California, Berkeley

Office of the Provost. The Third College, University of California, San Diego, La Jolla, California, November 1976.

Appendix B

Resource List

Of Publications, Materials & Organization

EQUITY IN MATHEMATICS PROJECT

RESOURCE LIST

PUBLICATIONS (Books and Journal Articles):

Unless otherwise noted the publication listed provides information on the nature of the problem of obtaining equity in mathematics for the specific target group. General recommendations for action are included 'n many of these publications.

A. Anick, C. M., Carpenter, T. M., and Smith, C. "Minorities and Mathematics: Results from the National Assessment of Educational Progress." Mathematics Teacher, 1982, 74, pp. 560-568.

B. Anton, S. and Humphreys, S. Handbook of S rategies for Evaluating Science Education Programs.

C. Becker, J. R. and Jacobs, J. E. "Sex: Is It an Issue in Mathematics?" Educational Horizons, Winter 1983, 61 (2), pp. 60-67.

D. Beckwith, J. and Durkin, J. "Girls, Boys, and Math." Science for the People, September/October 1981, pp. 6-8, pp. 32-34.

E. Blum, L. and Givant, S. "Increasing the Participation of Women in Fields that Use Mathematics." American Mathematical Monthly. December 1980, pp. 785-792.

F. Brush, Lorelei R. Encouraging Girls in Mathematics: The Problem and the Solution. Cambridge, MA: Abt Books, 1980.

G. Erlick, A. C. and LeBold, W. K. Factors Influencing the Science Career Plans of Women and Minorities - supplementary. West Lafayette, IN: Purdue Research Institute, 1977.

H. Fauth, G. C. and Jacobs, J. E. "Equity in Mathematics Education: The Educational Leader's Role." Educational Leadership. March 1980, pp. 485-490. Provides specific suggestions for supervisors on how they can promote sex equity for both students and women faculty.

I. Fennema, E. "The Sex Factor" and Burton, Grace M. "Response to 'The Sex Factor'." In Fennema, E. (eds.) Mathematics Education Research: Implications for the 80's. Alexandria, VA: Association for Supervision and Curriculum Development, 1981.

J. Fox, L. H., Brody, L., and Tobin, D. (eds.) Women and the Mathematical Mystique. Baltimore, MD: The Johns Hopkins University Press, 1980.

K. Fox, L. H., Fennema, E., and Sherman, J. Women and Mathematics: Research Perspectives for Change. Washington, DC: U.S. Department of HEW, 1977.

L. George, Y. C. The Status of Minority Women in Science (Report No. UCAR-10032). Livermore, CA: Lawrence Livermore Laboratory, 1979.

M. Green, R. "Math Avoidance: A Barrier to American Indian Science Education and Science Careers." BIA Education Research Bulletin, 6(3), Sept. 1978, pp. 1-8. (ERIC # 170 084.)

N. Hedges, L. V., and Majer, K. Female and Minority Representation in College Majors as a Function of Mathematics Requirements. San Diego, CA: University of California, 1976. (ERIC Document Reproduction Service No. ED 007 781.)

O. Humphreys, S. (ed.) Women and Minorities in Science: Strategies for Increasing Participation. Boulder, CO: Westview Press, 1982.

P. Johnson, W. N. Teaching Mathematics in a Multicultural Setting: Some Considerations When Teachers and Students are of Differing Cultural Backgrounds. Murray State University, Murray, KY. (ERIC # 183 414.)

Q. Kansky, B. and Olson, M. Mathematical Preparation versus Career Aspirations: A Study of Wyoming's 1978 High School Seniors. (ERIC # ED 168 263.)

R. Kenschaft, P. "Black Women in Mathematics." American Mathematical Monthly, 1981, Vol. 88, pp. 592-604.

S. Llabre, Maria M. and Cuevas, Gilberto J. "The Generalizability of Mathematics Achievement Scores for Bilingual Students." The Journal for Research in Mathematics Education, (forthcoming).

T. Luchins, H. "Women and Mathematics: Fact and Fiction." American Mathematical Monthly, 1981, Vol. 88, pp. 413-419.

U. Malcom, S. M. "Women/Minorities in Science and Technology." Science, 1981, Vol. 214, p. 137.

V. Matthews, W. Adding Up Race and Sex: A Study of Enrollment in High School Mathematics Classes. Occasional Paper, Program on Women, Northwestern University, December 1980. (Available from the Program on Women.)

W. Matthews, W. "Coloring the Equation: Minorities and Mathematics." Journal for Research in Mathematics Education, 14 (1), January 1983, pp. 70-72.

X. Matthews, W. Issues in Research on Minorities and Mathematics. Paper presented at the annual meeting of the National Council of Teachers of Mathematics Presession, St. Louis, April 1981. (Available from the author at the University of Wisconsin-Madison.)

Y. Newton, D. Women in Mathematics. Portland, ME: J. Weston Walch Publisher, 1978. (A series of posters.)

Z. Perl, T. Math Equals: Biographies of Women Mathematicians and Related Activities. Menlo Park, CA: Addison-Wesley Publishing Company, 1978. In addition to providing biographies of women mathematicians, specific activities on the mathematics discussed in their biographies are given.

AA. Schonberger, Ann. Sex-Related Issues in Mathematics Education. In Lindquist, Mary Montgomery. Selected Issues in Mathematics Education. Chicago, IL: National Society for the Study of Education, 1981.

BB. Sells, L. W. "High School Mathematics Enrollment by Race and Sex." In The Mathematics Filter: A New Look At An Old Problem, 1978. (Available from Overcoming Math Anxiety, c/o S. Hamer Associates, 15 Lewis Street, Hartford, CT)

CC. Skolnick, J., Langbort, C., and Day, L. How to Encourage Girls in Math & Science: Strategies for Parents and Educators. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1982. Contains many activities that parents and teachers can use to encourage children to study mathematics.

DD. Taylor, B. Ross. "Equity in Mathematics: A Case Study." Mathematics Teacher, January 1983, pp. 12-17

EE. Tobias, Sheila. Overcoming Math Anxiety. New York, NY: W. W. Norton 1978. Includes descriptions of appropriate activities for a Math Anxiety Clinic.

PUBLICATIONS AND MATERIALS AVAILABLE FROM ORGANIZATIONS AND ASSOCIATIONS:

Items preceded by * are those materials which are for use with students. The others provide information for educators.

A. American Association for the Advancement of Science, 1776 Massachusetts Ave. S. W., Washington, DC 20036

1. Aldrich, M. L. and Hall, P. Q. Programs in Science, Mathematics and Engineering for Women in the United States, 1966-1978.

2. Green, F. [illegible]port and Recommendations: Conference on Mathematics in Amer[illegible] Indian Education, 1978.

3. Hall, P. Q. and Swartz, A.

    a. Associations of/for Scientists of Racial and Ethnic Minority Groups, 1978.

    b. Associations of/for Women Scientists, 1978.

    c. Committees of/for Women of Associations of Scientists, 1978. Listings of contact persons and organizations.

4. Hall, P. Q. Problems and Solutions in the Education, Employment and Personal Choices of Minority Women in Science, 1981.

5. Malcom, S. M., Hall, P. Q., and Brown, J. W. The Double Bind: The Price of Being a Minority Woman in Science. (Report No. 76-R-3), 1979.

6. MESHwork NEWS. A newsletter on Opportunities in Science.

B. Clarke Irwin & Co. Ltd., 791 St. Clair Avenue, W., Toronto, Ontario, Canada M6C 1B8

Posters:

* 1. Dropping Math? Say Goodbye to 82 Jobs
* 2. Mathophobia

(1 to 5 posters - $2.00 each; next 25 posters - $1.50 each; any over 30 posters - $1.00 each.)

C. College Board, New York, New York

1. Casserly, P. L. Helping Able Young Women Take Math and Science Seriously in School, 1979. Identifies key factors in school systems that have been successful in enrolling young women in advance placement courses in mathematics and sciences.

D. Education Commission of the States, 1860 Lincoln Street, Suite 700, Denver, CO 80295.

1. Armstrong, Jane M. Women in Mathematics - Achievement and Participation of Women in Mathematics: An Overview, 1980.

E. Education Development Center, 55 Chapel Street, Newton, MA 02160 (toll free # 800/225-3088).

* 1. The Math-Science Connection: Education Young Women for Today (film or videocassette for teachers, parents, and community leaders; rental also).
* 2. Sandra, Zella, Dee, and Claire: Four Women in Science (film or videocassette, 7-12; rental also).
3. Expanding Your Horizons in Science and Mathematics (a handbook for conference planners, $2.50).
* 4. Sex Stereotyping in Math Doesn't Add Up (audio cassette and guide for teachers, $4.50).
* 5. Equality in Science: Formula for Changing Sex Bias (audio cassette and guide, $4.50).
* 6. Count Me In: Educating Women for Science and Math (videotape for high school, college students, and faculty; rental also).
* 7. How High the Sky? How Far the Moon? (curriculum resource for K-12 with four audiotape cassettes, $14.50).
8. Science, Sex, and Society (collection of readings, post-secondary, $15.75).

F. Ford Foundation, Office of Reports, 320 East 43 St., New York, NY 10017.

1. Fox, L. H. The Problem of Women and Mathematics, 1981.

2. Minorities and Mathematics, 1981.

G. Humboldt State University, Arcata, CA 95521.

1. Women in Science and Mathematics Bibliography, Phyllis Chinn, 1980 ($3.00).

H. Tobias, Sheila, Institute for the Study of Anxiety in Learning, Washington School of Psychiatry, 1610 New Hampshire Avenue, N.W., Washington, DC 20009 (202/667-6380).

1. Paths to Programs for Intervention ($16.00).

2. Resource Catalogue for Practitioners ($13.00).

3. Resource Manual for Counselors/Math Instructors ($12.00).

* 4. Self-Help Kit for Students ($12.00).

(Or order all for $40.00 prepaid.)

I. Lawrence Hall of Science, University of California, Berkeley, CA 94720.

1. Expanding Your Horizons in Science and Mathematics: Conferences for Young Women Interested in New Career Options: A Handbook for Planners. Koltnow, Joanne (limited supply available from Lawrence Hall of Science for $3.00; also available from WEEA Distribution Center at EDC).

* 2. Use EQUALS to Promote the Participation of Women in Mathematics. Kaseberg, Alice, Kreinberg, Nancy, and Downie, Diane (from Lawrence Hall of Science for $7.50).

* 3. Math for Girls and Other Problem Solvers. Downie, Diane, Slesnick, Twila, and Stenmark, Jean Kerr (from Lawrence Hall of Science for $7.50).

4. Women Moving Up: A Resource Directory Focusing on Careers in Science, Engineering, and Technology. Cremer, Christine (from Lawrence Hall of Science for $5.00).

5. Math/Science Network Broadcast, newsletter describing recent activities of the Math/Science Network, free from Math/Science Resource Center (address below.)

* 6. Poster Series from the Network: one set of three for $5.00; ten sets for $30.00; twenty sets for $50.00 (from Lawrence Hall of

* 7. SPACES (Solving Problems for Access to Careers in Engineering and Science). Fraser, Sherry (ed.) (from Lawrence Hall of Science for $10.00).

Checks to "Regents, University of California," sent to Careers, Lawrence Hall of Science, University of California, Berkeley, CA 94720.

J. Mathematical Association of America, 1529 18th Street, N.W., Washington, DC 20036.

* 1. The Math in High School . . . You'll Need for College (February 1978) (one copy free).

* 2. Careers in Mathematics (one copy of each free)

* 3. Mathematics at Work in Society, a mathematics and career awareness package for students in grades 8 and above (4 videotapes--available free of charge).

4. Blacks and Mathematics (BAM) and Women and Mathematics (WAM). Visiting lecturer program to interest Black students or women to pursue mathematics-based careers. Aimed at high school students.

K. Mathematics Department, Minneapolis Public Schools, 807 Broadway, Northeast, Minneapolis, MN 55413.

* 1. A series of six brochures (cost $1.00). Don't Knock It Unlock It With Math. One each in Algebra, Geometry, Trigonometry, Advanced Algebra, Probability and Statistics, Math Analysis.

L. Modern Talking Picture Service, 5000 Park Street North, St. Petersburg, FL 33709.

* 1. Science: Woman's Work, film (free loan print).

M. National Action Council Minorities in Engineering, Inc., 3 West 35th Street, New York, NY 10001

* 1. A Piece of the Action, film. Encourages high school students to pursue an engineering career.

* 2. Hi There, I'm Your Exciting Future. A guide describing course requirments for careers in science and engineering. For junior high and senior high school students.

Send for the NACME publications list.

N. National Council of Teachers of Mathematics, 1906 Association Drive, Reston, VA 22091.

2. Mathematics Education of Girls and Young Women, information resource (September 1980).

3. Guidance/Counseling for Both Counselors and Mathematics Teachers at the Secondary School Level, position statement (January 1976).

* 4. Resource Guide For Careers in Mathematics, information resource (September 1982).

* 5. Mathematics Teaching As A Career - brochure.

* 6. Mathematics and Careers - Engineer, Police Officer (posters and brochures available).

7. Report on Task Force on Problems in Mathematics Education of Girls and Young Women, (February 1980, cost $2.50).

* 8. Multiplying Options and Subtracting Bias. An Intervention Program developed by Fennema, Elizabeth, et al. (4 videotapes, one each for teachers, students, guidance counselors, and parents--for purchase only). ($125.00 each videotape and guide; $375.00 for all four videotapes and guide.) (Available for rental from Women and Mathematics Education.)

9. Handbook for Conducting Equity Activities in Mathematics Education. Provides descriptions of workshops and conferences for educators. Includes resource lists, workshop handouts, action research projects, and state-of-the-art papers on underrepresented groups (Blacks, Girls, Hispanics, Language Minority, and Native Americans) in mathematics.

* 10. Multicultural Mathematics Materials. Krause, Marina C. Games and activities from around the world to enhance individual students' ethnic identity and enhance the mathematics lesson as well. Introduces children to the ethnic heritage of others. Large-size reproducible activity pages; grades 1-8 (1983, 80 pp., #327E1, cost $5.00).

O. National Research Council, Committee on Minorities in Engineering, 2101 Constitution Avenue, N.W., Washington, DC 20418.

1. Building the Multiplier Effect, Summary of a National Symposium, 14-16 September 1978.

P. National Science Foundation, Washington, DC

1. Ideas for Developing and Conducting a Women in Science Career Workshop. Kreinberg, Nancy (from National Science Foundation, #SE-81-16, free).

Q. National Science Teachers Association, 1742 Connecticut Avenue, N.W., Washington, DC 20009

2. Career Oriented Modules to Explore Topics in Science.

Two sets of materials:
COMETS -- Science. 24 modules on science.
COMETS -- Profiles. 24 profiles and activities of women who use math and science.

COMETS -- Science are ideal material to help presenters at career conferences find activities that are appropriate for junior and senior high school students.

R. Ohoyo Resource Center, 2301 Midwestern Parkway, Suite 214, Witchita Falls, TX 76308

1. OHOYO IKHANA: A Bibliography of American Indian--Alaska Native Curriculum Material.

S. ERIC/SMEAC Information Center, Ohio State University, 1200 Chambers Road, Columbus, Ohio 43212.

1. Jacobs, J. E. (ed.) Perspectives on Women and Mathematics, 1978. (Also available from NCTM, $6.75)

2. Lovett, C. James and Snyder, Ted. Resources for Teachers of Mathematics in Bilingual Classrooms, 1979. (Also available from NCTM)

3. Suydam, M. and Kirschner, V. Selected References on Mathematical Anxiety, Attitude, and Sex Differences in Achievement and Participation, 1980. ($2.50)

4. Schildkaump-Kundiger, Erika. An International Review on Gender and Mathematics, 1982.

T. Society for Applied Linguistics

1. Holm, Wayne and Rossier, Paul. The Rock Point Experience, 1980.

U. UNESCO

1. UNESCO, Interactions Between Linguistics and Mathematical Education: Final Report of the Symposium, Nairobi, Kenya, 1974.

V. Washington State Mathematics Council, Attn: Wayne Peterson, Marshall Bldg., 520 N.E. Ravenna Boulevard, Seattle, WA 98115.

* 1. Multicultural Mathematics Posters and Teachers Guide ($5.00 per set). (Make check payable to: W.S.M.C.)

W. Women in Science, B322 School of Dentistry, The University of Michigan, Ann Arbor, MI 48109.

1. A series of 8 videotapes designed to encourage young women to take

Science, Geology, Biomedical Science, and Physics/Astronomy. The eighth tape presents the dilemma of a young woman interested in science and mathematics.

X. Women and Mathematics Education, c/o Education Department, George Mason University, 4400 University Drive, Fairfax, VA 22030.

1. Resource packet on the Stanly-Benbow Controversy ($2.00).

2. Rental of Fennema tapes: Multiplying Options: Subtracting Bias (see NCTM).

3. A Resource list - updated annually.

III. RELEVANT ASSOCIATIONS

A. Minorities and Mathematics, Chicago Community Trust, 208 S. LaSalle St., Suite 850, Chicago, IL 60604.

B. National Association For Equal Opportunity in Higher Education, 2243 Wisconsin Ave., N.W., Washington, DC 20007 (202/333-3855).

C. National Association for the Advancement of Colored People, New York, NY.

D. National Council of Teachers of Mathematics, 1906 Association Drive, Reston, VA 22091.

E. United Negro College Fund, Inc., New York, NY.

F. Women and Mathematics Education, c/o Education Department, George Mason University, 4400 University Drive, Fairfax, VA 22030.

Please send items for inclusion in future editions of this list to Dr. Judith E. Jacobs, c/o Women and Mathematics Education.

Originally prepared for distribution by Women and Mathematics Education. Expanded to include other underrepresented groups and for use by the National Council of Teachers of Mathematics Equity in Mathematics Project. Permission to reproduce this resource is granted, provided acknowledgement is given to WME and NCTM.

0171/2299 August 1983

Appendix C

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Attending NCTM Equity Conferences

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1982 - 1983

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