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ABSTRACT

Developed to serve as a point of comparison for women and minority student participation in mathematics and science courses, this survey focused on secondary schools in Arkansas. Survey forms were sent to all Arkansas secondary schools (N=362) and 246 forms were returned (68 percent of the initial mailing). Findings include: (1) males are over-represented in general mathematics in smaller schools; (2) Caucasian females are over-represented in geometry and algebra II in smaller schools; (3) more than 40 percent of trigonometry/advanced mathematics, calculus, and computer science courses in medium-sized schools have an over-representation of Caucasian males or females; (4) black students in general are under-represented in mathematics classes after algebra I; (5) black male students are over-represented in physical science and general science courses in large schools; (6) Caucasian females are over-represented in chemistry in smaller schools and in advanced science courses in large schools; and (7) black students are under-represented in college preparatory science courses, such as chemistry, physics, and advanced science courses. An appendix contains the questionnaire. (ML)

Survey to Determine Women and Minority Participation In Mathematics and Science Programs In the Public Secondary Schools of Arkansas

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and

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I would like to thank Dr. Charles Watson, Mathematics Specialist of the Arkansas State Department of Education, who contacted me to conduct this survey. He was chiefly responsible for writing the grant and provided me with the support of his office in the design and conduct of the survey. I would also like to acknowledge the school districts which filled out and returned surveys. I know that with the many reports and other demands on their time this survey could very easily have been ignored. Additional thanks go to my secretary who helped with the tables and to my wife who was involved with most of the details of survey collection and report preparation.

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May, 1987

Survey to Determine Women and Minority Participation
In Mathematics and Science Programs
In Arkansas Public Secondary Schools

Introduction

The last 25 years have witnessed great changes in the way different segments of society relate to each other. Prior to this time United States society was mainly white male dominated. Today challenges from women and minorities have created a climate that calls for equality of opportunity. In order to ascertain how well society is doing in meeting this goal of equality of opportunity, periodic monitoring must be made to measure progress and/or establish a point of comparison. This survey strives to establish a point of comparison for women and minority student participation in secondary mathematics and science courses for the State of Arkansas.

National participation in mathematics and science courses is presented in Tables 1 (1), 2 (2), and 3 (3). Inspection of these tables gives some idea of the disparities that exist in the participation of blacks and females in secondary mathematics and science classes. With the exception of Algebra I females consistently enroll in mathematics courses in a smaller proportion than males. In addition, Table 3 shows higher percentage rates of males in secondary schools take four years or

Table 1

Percent of 17-year Olds Who Had Taken Various Mathematics Courses, by Sex 1977-78 (1)

	Alg. I	Geom.	Alg. II	Trig.	Precal. or Cal.	Comp. Prog.
Total		51.3	36.9	12.9	3.9	5.0
Males	70.7	52.1	37.8	14.7	4.7	5.9
Females	73.6	50.5	36.1	11.1	3.1	4.1

Alg. I = Algebra I

Geom. = Geometry

Alg. II = Algebra II

Trig. = Trigonometry

Precal. = Precalculus

Cal. = Calculus

Comp. Prog. = Computer Programming

Table 2

Percent of 17-year Olds Who Had Taken Various Mathematics Courses, by Race, 1977-78 (2)

	Algebra I	Geometry	Algebra II
Black	55	31	24
White	75	55	39

Table 3

Number of Years of Study by Subject of College-bound Seniors, by Sex, 1978-79 (3)

	Mathematics		Bio. Sciences		Phys. Sciences	
	Male	Female	Male	Female	Male	Female
	%	%	%	%	%	%
No Courses	.4	.5	5.9	4.5	6.6	12.1
One Year	1.7	3.0	60.9	60.4	26.8	38.8
Two Years	9.3	16.9	25.4	27.7	36.4	33.5
Three Years	24.1	34.2	5.2	5.2	23.7	12.9
Four Years	52.6	39.0	1.9	1.5	4.9	2.0
Five or More Years	11.9	6.4	.8	.6	1.7	.6
Mean Number Years	3.62	3.27	1.39	1.41	1.98	1.56

Bio. = Biological

Phys. = Physical

more of mathematics and three years or more of physical science courses. Both males and females take comparable amounts of biological science courses. Table 2 shows that black students take mathematics courses at much lower percentage rates than Caucasian students. Data was unavailable for comparisons by race for science classes. However, high drop-out rates, low rates of achievement of baccalaureate degrees in mathematics and science, and lower rates of achievement of masters and doctoral degrees in mathematics and science point to under-representation rates of participation of black students in mathematics and science courses at the secondary level. These rates are far lower than the percentage rates of blacks in the general population.

The concern for participation of blacks and women is born out of a concern for equal access to careers in management, engineering, science, mathematics, medicine, and other health professions. These careers have women and minority participation in far lower proportions than in the general population. Refer to Tables 4 (4) and 5 (5) for examples. Keep in mind that blacks constitute 10% of the labor force (6). Secondary mathematics and science courses act as one of the first filters to equal access. Four years of high school mathematics and three to four years of science including chemistry and/or physics provide individuals with a minimum start for career preparation in college for the above mentioned careers.

Table 4

Percent of Bachelors's, Master's, and Doctoral Degrees Awarded to Women in Selected Fields, 1982-83 (4)

Field	Bachelor	Master	Doctorate
All Disciplines	50.5	50	33.1
Business and Management	41.1	29.4	16.8
Computer and Information Sciences	36.3	28.3	12.9
Engineering	13.2	9.2	4.4
Life Sciences	46	43.5	32.1
Mathematics	43.8	34.5	16.6
Physical Sciences	27.3	21.4	14

Table 5

Percent of Degrees Awarded to Black Males and Black Females, 1980-81 (5)

	College Enrollment	Bachelor	Education	Engineering
Black Females	5.3	3.9	6.4	.5
Black Males	3.8	2.6	2.4	2.7

	Master	Education	Engineering
Black Females	3.7	6.7	.2
Black Males	2.1	2.1	1.4

	Doctorate	Education	Engineering
Black Females	1.7	4.1	.03
Black Males	2.1	3.7	.9

Survey Procedure

Mailing labels for all Arkansas secondary schools were provided by the State Department of Education. Three hundred sixty-two survey forms were mailed September 15, 1986, with a return date of October 1. The mailing contained a self-addressed and stamped return envelope, a survey form, and a letter from Dr. Charles Watson, State Department of Education Specialist in Mathematics, explaining the project and encouraging participation. (Copies of the survey and Dr. Watson's letter are included in the Appendix.) One hundred seventy or 47.0% completed surveys were returned by October 8, 1986. A second letter, survey form, self-addressed stamped envelope and a reminder letter from the principal investigator were sent to the non-respondees on October 15, 1986. This second mailing yielded an additional 76 completed surveys. The total number of completed surveys was 246 or 68.0% of the initial mailing. The distribution of these surveys both geographically and by students per grade level (Table 6) is representative of the distributions throughout Arkansas.

Results

Table 7 presents a comparison of class offerings by school size. As a result of inspection of this table, it was decided to consolidate these 10 groups into three groups that were similar

TABLE 6

FREQUENCY OF RESPONDERS COMPARED TO STUDENT/GRADE LEVEL

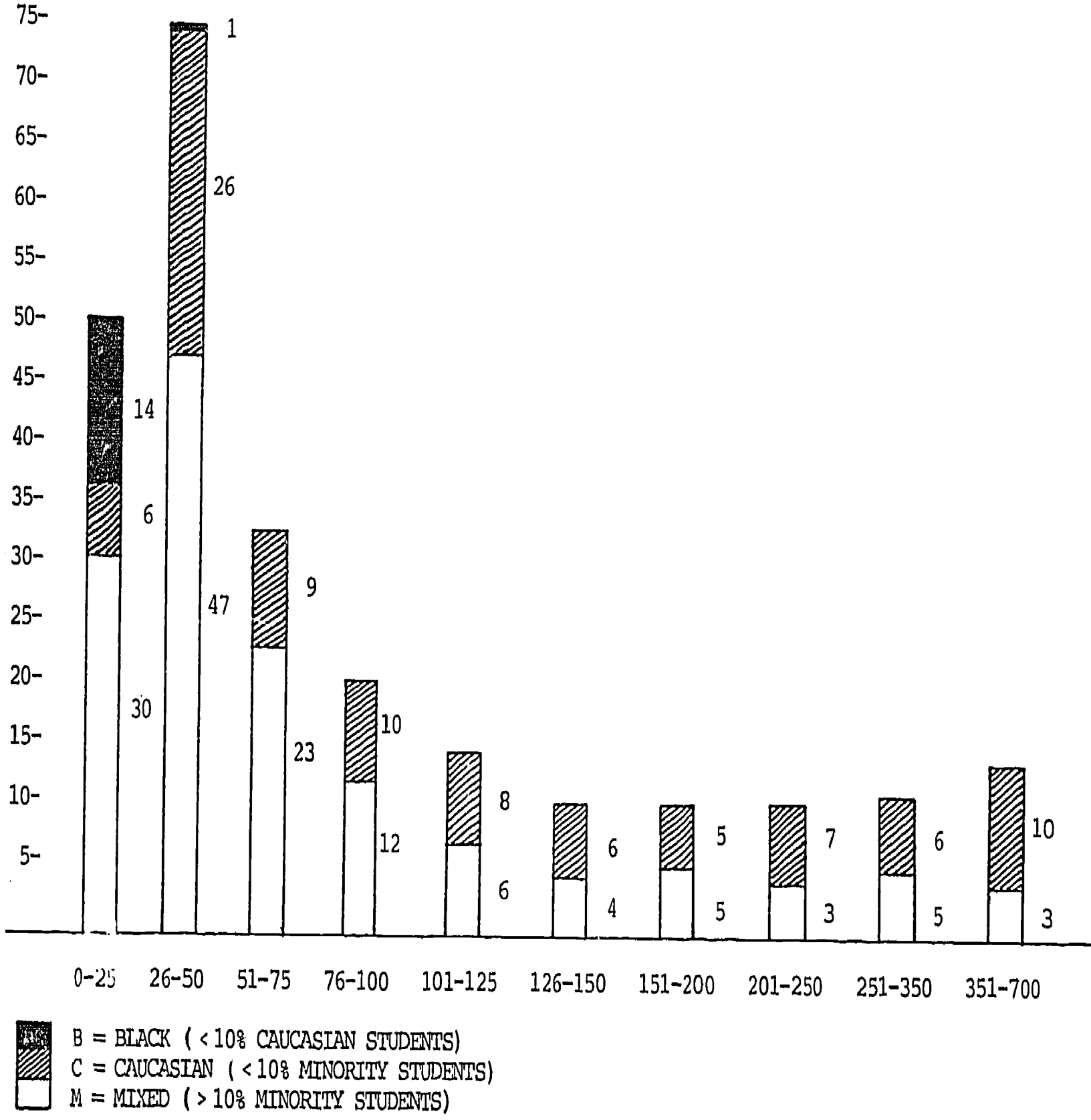

Table 7

Percent of Schools Reporting Offering Courses by School Size

Students/grade	0-25			26-50			51-75		76-100		101-125		126-150		151-200		201-250		251-350		351-700	
	C(n=30)	B(n= 6)	M(n=14)	C(n=47)	B(n= 1)	M(n=26)	C(n=23)	M(n= 9)	C(n=12)	M(n=10)	C(n= 6)	M(n= 8)	C(n= 4)	M(n=6)	C(n= 5)	M(n= 5)	C(n= 3)	M(n= 7)	C(n= 5)	M(n= 6)	C(n= 3)	M(n=10)
General Math	90.0	83.3	92.9	97.9	100.0	96.2	91.3	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	85.7	100.0	100.0	100.0	100.0
Algebra I	100.0	100.0	92.9	100.0	100.0	100.0	95.7	100.0	100.0	90.0	100.0	100.0	100.0	83.3	60.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Geometry	60.7	83.3	85.7	89.4	100.0	88.5	87.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Algebra II	93.3	50.0	100.0	80.9	100.0	88.5	91.3	100.0	100.0	90.0	100.0	100.0	100.0	100.0	80.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Trig./Adv. Math	60.0	33.3	42.9	83.0	100.0	50.0	95.7	88.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Calculus	10.0	0	7.1	6.4	0	7.7	17.4	22.2	8.3	10.0	16.7	37.5	50.0	33.3	40.0	60.0	0	57.1	80.0	83.3	100.0	90.0
Computer Science	73.3	50.0	64.3	93.6	0	65.4	95.7	77.8	83.3	80.0	83.3	75.0	100.0	100.0	100.0	80.0	100.0	85.7	100.0	83.3	100.0	80.0
Physical Science	86.7	83.3	78.6	89.4	100.0	53.2	100.0	88.9	83.3	100.0	100.0	79.2	75.0	33.3	60.0	60.0	33.3	85.7	40.0	83.3	33.3	60.0
Life Science	46.2	50.0	71.4	38.3	0	46.2	21.7	44.4	33.3	40.0	0	25.5	50.0	33.3	40.0	60.0	33.3	28.6	60.0	33.3	100.0	90.0
Biology	84.5	100.0	100.0	97.9	100.0	100.0	95.7	100.0	83.3	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	83.3	100.0	100.0
Chemistry	50.0	66.7	50.0	63.8	100.0	69.2	82.6	77.8	75.0	90.0	100.0	87.5	100.0	83.3	100.0	100.0	100.0	100.0	100.0	83.3	100.0	100.0
Physics	43.3	33.3	28.6	61.7	0	46.2	82.6	66.7	58.3	70.0	100.0	75.0	100.0	83.3	100.0	100.0	100.0	85.7	100.0	83.3	100.0	100.0
General Science	43.3	83.3	71.4	34.0	100.0	61.5	39.1	55.6	33.3	60.0	16.7	75.0	0	33.3	20.0	60.0	66.7	85.7	40.0	16.7	0	60.0
Advanced Placement	13.3	0	0	10.6	0	0	13.0	22.2	0	0	33.3	25.0	0	16.7	20.0	20.0	0	0	0	16.7	33.3	40.0
Advanced Science	23.3	16.7	35.7	36.2	0	7.7	43.5	55.6	33.3	50.0	33.3	50.0	75.0	66.7	100.0	60.0	100.0	71.4	100.0	66.7	100.0	80.0

C (< 10% minority students)

B (< 10% Caucasian students)

M (> 10% minority students)

according to courses offered and students per grade. The groups that resulted from this reorganization of the data are small (0-50 students per grade), medium (51-250), and large (251-700) schools. Table 8 represents these consolidated categories. This table shows a number of trends. In general, the larger the school the more likely that it will offer upper level mathematics and science courses, since there will be sufficient numbers of students enrolled in the these classes, and smaller schools, by the very nature of their size, have difficulty offering a wide variety of upper level mathematics and science courses. Physical science is offered less frequently in larger schools than in smaller schools, probably because many of the smaller schools are K-12 or 7-12 schools in which this course would be taught. In larger school systems this course would be offered in a junior high/middle school and not at the high school level. Advanced placement science, which is taken to receive college credit by examination, is offered at very few schools of any size with the exception of mixed race schools where almost 1/3 of these schools have this option. The difficulty of offering advanced placement rests in having a qualified teacher to teach a college level course. Smaller schools offer the basic mathematics and science courses but not enough of the higher level courses required for passage through the first filter into college career paths in mathematics, science, medicine, and business management. This discussion is relevant to the participation of minorities and

Table 8

Percent of Schools Reporting Offering Classes by Size

Collapsed Categories

School Size	S (0-50 students/grade)			M(51-250)		L(251-700)	
	C(n=77)	B(n= 7)	M(n=40)	C(n=53)	M(n=45)	C(n= 8)	M(n=16)
Gen. Math	94.8	85.7	95.0	96.2	97.8	100.0	100.0
Algebra I	96.1	100.0	95.0	98.1	95.6	100.0	100.0
Geometry	80.5	85.7	90.0	94.3	100.0	100.0	100.0
Alg. II	85.7	57.1	92.5	94.3	97.8	100.0	100.0
Trig./Adv.	74.0	42.9	47.5	98.1	97.8	100.0	100.0
Calculus	9.1	0	7.5	18.9	33.3	87.5	87.5
Comp. Sci.	85.7	42.9	65.0	92.5	82.2	100.0	81.3
Phys. Sci.	88.3	100.0	90.0	86.7	75.6	37.5	68.8
Life Sci.	39.0	100.0	90.0	26.4	37.8	75.0	68.8
Biology	88.3	100.0	100.0	94.3	100.0	100.0	93.8
Chemistry	58.4	71.4	87.5	86.8	88.9	100.0	93.8
Physics	54.5	28.6	40.0	83.0	77.8	100.0	93.8
Gen. Sci.	37.7	85.7	65.0	32.1	62.2	25.0	43.8
Adv. Pla.	11.7	0	0	11.3	13.3	12.5	31.3
Adv. Sci.	31.2	14.3	17.5	50.9	57.8	100.0	75.0

females in mathematics and science at the secondary level in that approximately 14% of all students attend small schools, 45% attend medium-sized schools, and the remaining 41% are in the large schools. Fifty-nine per cent of all students, regardless of race or gender, have limited opportunities to take upper level mathematics and science courses that act to keep doors open to the previously mentioned prestige careers. With this in mind the question is how do females and minorities pass through this first of many filters?

Summaries of the results of this survey for rates of minority and gender participation in secondary mathematics and science classes are presented in Table 9, which compares representation by gender and race by school size, and Table 10, which compares deviation from expected representation by gender and race by school size. In Table 8 the category Caucasian is applied to schools that have less than 5% total minority population, mixed race schools refer to schools with greater than 5% minority population, and race is a category used for comparison of the proportion of black students in mathematics and sciences courses. Also, the representation data for the Caucasian and mixed race categories were reported for males since the data for females contains the same information. For example, in general mathematics classes for small Caucasian schools males were over-represented 21 times, within + or -10% of the expected percentage 44 times and under-represented three times. The

Table 9

Comparison of Representation in Mathematics and Science Clases by

Race and Gender by School Size

	S									M									L								
	Caucasian (Male)			Mixed (Male)			Race (Black)			Caucasian (Male)			Mixed (Male)			Race (Black)			Caucasian (Male)			Mixed (Male)			Race (Black)		
	+	0	-	+	0	-	+	0	-	+	0	-	+	0	-	+	0	-	+	0	-	+	0	-	+	0	-
General Math	21	44	3	12	20	2	7	24	3	12	38	1	7	35	1	15	27	1	1	7	0	4	12	0	9	7	0
Algebra I	9	47	17	1	25	7	2	19	12	0	46	4	4	35	3	3	29	9	1	7	0	0	16	0	6	9	1
Geometry	10	21	13	3	14	9	0	14	12	4	28	17	3	25	3	3	24	10	1	7	0	0	14	2	1	9	5
Algebra II	5	18	17	1	8	10	2	9	8	4	33	9	3	25	15	3	20	17	0	8	0	0	16	0	0	6	10
Trig./Adv. Math	2	6	1	0	3	1	0	2	2	12	18	7	0	28	12	0	11	20	2	6	0	2	13	1	0	3	13
Calculus	*	*	*	*	*	*	*	*	*	1	2	0	8	16	7	1	1	9	3	4	0	5	7	1	1	1	11
Computer Sci.	12	11	8	2	10	3	3	7	5	7	30	6	2	6	3	3	17	15	3	5	0	4	5	2	0	2	9
Physical Sci.	14	47	8	6	23	4	8	22	3	1	40	1	2	31	0	6	25	2	0	3	0	3	8	0	5	5	1
Life Science	6	19	2	6	8	3	3	11	3	5	7	3	9	6	1	8	8	0	1	5	0	5	7	0	5	6	1
Biology	7	59	6	6	26	3	3	24	8	2	47	1	2	35	6	4	33	6	0	8	0	1	14	0	0	13	2
Chemistry	7	14	7	1	12	5	1	8	9	7	25	11	2	29	8	1	17	20	2	5	1	2	11	2	0	3	12
Physics	5	8	1	0	4	2	0	3	3	2	12	0	9	8	3	0	6	14	5	2	0	7	7	1	0	2	13
General Sci.	6	16	1	4	16	2	7	13	2	10	15	3	6	18	3	11	16	0	0	2	0	4	4	0	4	3	1
Advanced Pla.	1	2	0	*	*	*	*	*	*	0	3	0	0	3	0	0	1	2	1	0	0	0	3	1	1	0	3
Advanced Sci.	5	3	7	0	3	1	*	*	*	2	9	11	4	12	6	2	7	13	1	6	0	1	5	5	1	3	0

\+ proportion is higher than .10 above expected

0 proportion is within +/-.10 of expected

\- proportion is lower than .10 below expected

* not included, if less than 10 students in the class

Table 10

Deviation of Representation in Mathematics and Sciences Classes

by Race and Gender by School Size

	S						M						L					
	Caucasian		Mixed Race				Caucasian		Mixed Race				Caucasian		Mixed Race			
	D	G	D	G	D	R	D	G	D	G	D	R	D	G	D	G	D	R
General Math	.62	M	.71	M	.41	B	.47	M	.33	X	.70	B	.22	X	.50	X	1.13	B
Algebra I	.47	F	.33	X	.73	W	.16	X	.19	X	.44	X	.22	X	0	X	.75	B
Geometry	.59	F	.69	F	.92	W	.69	F	.70	F	.74	W	.22	X	.25	X	.67	W
Algebra II	.85	F	1.05	F	.84	W	.39	X	.60	F	.85	W	0	X	0	X	1.25	W
Trig./Adv. Math	.40	X	*		*		.65	M	.52	a	1.29	W	.50	a	.25	X	1.63	W
Calculus	*		*		*		*		.55	a	1.64	W	.86	M	.77	M	1.69	W
Computer Science	.77	M	.40	X	.67	W	.33	X	.53	a	.86	W	.75	M	.73	M	1.64	W
Physical Science	.41	M	.36	X	.48	B	.05	X	.12	X	.36	X	*		.54	M	.91	B
Life Science	.44	M	.63	M	.35	X	.67	M	.63	M	1.00	B	*		.83	M	.83	B
Biology	.19	X	.34	X	.46	B	.08	X	.28	X	.28	X	0	X	.13	X	.26	X
Chemistry	.50	a	.56	F	1.0	W	.51	F	.41	F	1.05	W	.50	a	.26	X	1.60	W
Physics	.71	M	*		*		1.12	M	.90	M	1.40	W	1.43	M	.93	M	1.73	W
General Science	.52	M	.36	X	.64	B	.29	X	.44	M	.81	W	*		1.00	M	1.00	B
Advanced Placement	*		*		*		*		*		*		*		*		1.50	W
Advanced Science	.93	F	*		*		1.00	F	.54	F	*		*		.91	F	1.27	W

a D is large but does not favor any subgroup

* D not calculated if less than 7 cases

X D is not great enough to favor any subgroup

female data for the same category would be the complement, that is females were over-represented three times, within the expected value 44 times, and under-represented 44 times. The same procedure was used for the race comparison with black student data being chosen as the representative data. The Caucasian student data would be the complement of the black student data. Black schools (less than 5% minority enrollment) were not included in these tables because there were so few schools and the enrollments in many of the mathematics and science classes were less than 10, which limited severely the meaning of statistics derived from such data.

In Table 10 a statistic called deviation was calculated for each category. This statistic has a model of equal representation in a class. Equal representation is defined as the percentage of each group represented in a mathematics or science class being within + or -10 % of the school population as a whole. The + or -10% was chosen because schools that are reasonably trying to achieve equal accesss to classes will be able to stay within such a target figure. Theoretically, there should be no cases falling in the over-representation (+) and the under-representation (-) subcategories. In doing statistical analysis some room for error has to be allowed. The deviation is calculated by subtracting the expected from the actual values for the subcategories for the +, 0, and -. The values (signs ignored) for the + and - subcategories are subtracted from each other.

This difference plus the difference from the 0 subcategory (both signs ignored) are added together. This number is divided by the total cases in the three subcategories. The resulting number is the deviation (D) which can range from zero (no deviation from equal representation) to 2.00 (all cases in the + or - subcategory). A D of higher than .40 is considered evidence of too great a deviation from 0. This value (.40) represents 20% of the cases in both the + and - subcategories. If a value is greater than .40 but the + and - are equal within +1 or -1, this is marked M=F. At least seven cases were needed to calculate a D for a category, since the value of D is more meaningful for larger numbers.

Analysis of Data

There are a number of notable patterns discernible in Table 9. Gender differences with males being over-represented appear in general mathematics classes in small schools for Caucasian and mixed race and for males in medium-sized Caucasian schools. Gender differences with females over-represented appear in geometry in Caucasian and mixed race small and medium-sized schools, in Algebra II for small schools both Caucasian and mixed race, for mixed race medium-sized schools, and in Algebra I for small Caucasian schools. Males are over-represented in calculus and computer science courses for large-sized schools and for small Caucasian schools. Males also are over-represented in

trigonometry/advanced mathematics courses in medium-sized Caucasian schools. Finally, in medium-sized mixed race and large Caucasion schools there is great variability in which gender is over-represented in the trigonometry/advanced algebra, calculus, and computer science courses.

The science classes present a mixed picture of patterns of representation by gender. First, males are over-represented in life science and physics courses in all categories except for life science in large Caucasian schools and small schools of mixed race. These classes did not have enough schools represented to calculate a meaningful statistic. Second, males also were over-represented in physical science and general science courses in small Caucasian schools and in large mixed race schools. In addition, males are over-represented in general science in medium-sized mixed race schools. Third, females are over-represented in advanced placement science classes except in small mixed race schools and in large Caucasian schools, where samples were not large enough to calculate a meaningful statistic. Fourth, in small and large-sized Caucasian schools the variability in over-representation between male and female was so high that other local factors than school size could account for this. Fifth, females are over-represented in chemistry classes in small and medium-sized mixed race schools.

The race representation in mathematics courses presents a

fairly simple picture. Black students are over-represented in general mathematics classes no matter what the school size. Black students also are over-represented in algebra classes in large schools. In all other mathematics courses, regardless of the size of the school, Causacians are over-represented in mathematics classes.

The race representation in science courses presents a more complex pattern. Black students are over-represented in physical science and general science classes in small and large schools and over-represented in life science classes in medium and large-sized schools. Black students also are over-represented in small school biology classes. Caucasians are over-represented in chemistry and physics classes in all school sizes with the exception of small school physics classes in which there were not enough cases to calculate a meaningful statistic. Also, Caucasians are over-represented in advanced placement science and advanced science classes in large schools and in medium-sized general science courses.

A final look at the data shows that certain cross categories of race and gender are over-represented in some courses. Black males are over-represented in small school general mathematics, large school physical science, medium and large school life science, and in large school general science courses. Caucasian females are over-represented in small and medium-sized school

geometry, Algebra II, and chemistry, and large school advanced science courses. Caucasian males are over-represented in large school calculus and computer science, medium and large school physics, and medium-sized school general science courses. Caucasian males and females were over-represented an equal number of times with a high degree of deviation from equal representation in trigonometry/advanced mathematics, calculus, and computer science classes in medium-sized schools. These results contradict one of the general findings of previous studies reported in Lockheed, et al, (7). These authors show that there were ethnic, but not gender differences, in participation in mathematics courses, and they support the findings of ethnic and gender differences in participation in science and computer courses.

Conclusions

The picture for mathematics supports the following generalized conclusions. First, males are over-represented in general mathematics in smaller (small and medium-sized) schools and black males, in particular, are over-represented in general mathematics in small mixed race schools. Second, Caucasian males are over-represented in calculus classes in large schools. Third, Caucasian females are over-represented in geometry and Algebra II in smaller schools. Fourth, the more than 40% of trigonometry/advanced mathematics, calculus, and computer science

courses in medium-sized schools have an over-representation of Caucasian males or females. Whether the overrepresentation is Caucasian male or Caucasian female is dependent on local factors. Fifth, black students in general are under-represented in mathematics classes after Algebra I and under-represented in computer science courses.

The picture for science supports the following conclusions. Black male students are over-represented in physical science and general science courses in large schools and in life science classes in larger (medium and large) schools. Caucasian females are over-represented in chemistry in smaller schools and in advanced science courses in large schools, while Caucasian males are over-represented in physics in larger schools and in general science in medium-sized schools. Finally, black students are under-represented in college preparatory science courses, such as chemistry, physics, advanced placement science, and advanced science courses.

Recommendations

All students should be challenged to take courses in mathematics and science to the level that their abilities allow so that the doors to a great variety of career opportunities remain open to them. The small number of students in the upper level secondary mathematics and science courses indicates that many children of each gender and all races are having these doors

closed prematurely. Some groups, particularly Caucasian females in upper level mathematics and science courses and black students in courses from geometry through calculus, computer science, and upper level science classes are not represented in numbers equal to their proportion of the general population. What can be done to keep equal access available to these groups?

First, many students in under-represented groups are opting out of mathematics and science classes at the first opportunity. To counteract this, it is imperative that at-risk students have early and success-oriented experiences with mathematics and science courses at the elementary level. Kahle and Lakes (8) summarize an article by writing, "The data show that by age nine, girls, although expressing interest in many science activities, do not experience as many as do boys." The same is true of black students who also develop a negative view of science, science classes, and science careers. A number of programs have been developed for early intervention, such as Math for Girls (Berkeley, California, 1974) for girls 6 to 14 and Solving Problems of Access to Careers in Engineering and Science (SPACES, Berkeley, California, 1982) for grades 3 to 10, which are described by Becker (9).

Role models are important for students so that it is possible for black students and females to be successful in mathematics and science classes in preparation for careers which

require such courses. The National Science Foundation and the Mathematics Association of America have sponsored programs since 1975 to bring women scientists and mathematicians into schools. Similar programs for minority scientists and mathematicians can be created and made available to schools. This program should reach into the elementary schools as well as into the secondary schools.

Teachers are a critical component of the equal access question. As Kahle (10) reports, the studies show that "good teachers make a difference." Secondary mathematics and science teachers should take the initiative by persuading women and minorities to take more and advanced courses in mathematics and science. Teachers should look for signs of potential academic ability other than just good grades. Look for students who have a curiosity about themselves and their environment, invent games, and/or play with numbers. Teachers need to be aware of possible cultural differences with respect to taking mathematics and science courses, such as "its not cool to be smart or take smart courses" or "you can't be feminine if you compete with boys in mathematics and science." Be aware that average or below average grades in lower level courses do not mean that a student cannot compete in advanced courses. Pamphlets, books, and audiovisual materials demonstrating that women and minorities can and do succeed in careers requiring mathematics and science should be available and used in elementary and secondary classrooms. Many

of the previous suggestions are included in an article by Atwater (11).

Counselors at all levels of public school education can help by career counseling that emphasizes equal access to careers requiring mathematics and science courses. Hittner and Jacobs (12) cite studies which "document the non-support and sometimes actual discouragement (by counselors) of young women in their pursuit of mathematical study and interest in mathematical and scientific careers", but did not find such a bias in their own study. Counselors also could help teachers set up "shadowing" programs for students in which the students would spend part or all of a school day with a minority or female professional whose work requires mathematics and/or science. This type of "shadowing" before high school can be a very important factor in helping students to understand the requirements for passing through the various filters into those careers previously mentioned.

School administrators can play an important role by monitoring patterns of participation in mathematics and science courses. If patterns of under-representation or unusually low enrollments occur in mathematics and/or science courses, notice can be given to the teachers involved so action can be taken to encourage any under-represented group to participate. Elementary and middle/junior high school principals can actively encourage

and support the teaching of mathematics and science. Many teachers at these levels need this encouragement and support to present mathematics and science classes in interesting and effective ways, as has been recognized by Mechling and Oliver (13).

Parents have a great influence on their children's attitudes toward mathematics and science. The schools need to seek positive support from parents where it exists and to teach parents where there is resistance or the presence of stereotypical behavior against students, whether female or minority, taking as much mathematics and science as their children are capable.

It is hoped these survey results will foster the philosophy that the purpose of public school education is to open as many doors to all students as is possible given only the limitations of the talents of the students themselves. Closed doors mean dreams unfulfilled. In the end closed doors hurt more than the students; they effect all Arkansans.

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Appendix

MATHEMATICS-SCIENCE ENROLLMENT QUESTIONNAIRE

NAME OF SCHOOL _____ NAME OF PRINCIPAL _____

SCHOOL ADDRESS _____ GRADES INCLUDED _____

INSTRUCTIONS: Please supply the following information as it applies to your school. That may mean that sections of this questionnaire will not be appropriate for you to fill in. The numbers asked for in each section will be the actual number of students in each category.

ENROLLMENT DATA

TOTAL SCHOOL ENROLLMENT

	CAUCASIAN	BLACK	ASIAN	OTHER	TOTAL
MALE					
FEMALE					

MATHEMATICS ENROLLMENTS

COURSE		CAUCASIAN	BLACK	ASIAN	OTHER	TOTAL
GENERAL MATH (to include all units of basic skills, consumer math and business math)	MALE					
	FEMALE					
ALGEBRA I (first year algebra even if given in more than two semesters)	MALE					
	FEMALE					
GEOMETRY	MALE					
	FEMALE					
ALGEBRA II (second year algebra with or without trigonometry)	MALE					
	FEMALE					
TRIGONOMETRY/ADVANCED MATH (analytical geometry, pre-calculus and other advanced math)	MALE					
	FEMALE					
CALCULUS	MALE					
	FEMALE					
COMPUTER SCIENCE (any computer course including literacy or programming)	MALE					
	FEMALE					

SCIENCE ENROLLMENTS (in grades 9 - 12 only)

COURSE		CAUCASIAN	BLACK	ASIAN	OTHER	TOTAL
PHYSICAL SCIENCE	MALE					
	FEMALE					
LIFE SCIENCE	MALE					
	FEMALE					
BIOLOGY	MALE					
	FEMALE					
CHEMISTRY	MALE					
	FEMALE					
PHYSICS	MALE					
	FEMALE					
GENERAL SCIENCE	MALE					
	FEMALE					
ADVANCED PLACEMENT (courses in preparation for college board exams to include biology, chemistry or physics)	MALE					
	FEMALE					
ADVANCED SCIENCE COURSES (ie. chemistry II, advanced biology, physiology, not advanced placement or college board courses)	MALE					
	FEMALE					

PLEASE RETURN BY OCTOBER 24, 1986

RETURN TO: DR. MICHAEL J. WAVERING
314 GRADUATE EDUCATION BUILDING
UNIVERSITY OF ARKANSAS
FAYETTEVILLE, AR 72701

Arkansas
DEPARTMENT OF EDUCATION
4 STATE CAPITOL MALL • LITTLE ROCK, ARKANSAS 72201-1021 • (501) 371-1461
TOMMY R. VENTERS, Director, General Education Division

September 3, 1986

MEMO TO: Secondary Principals

FROM: Charles D. Watson, Specialist in Mathematics

SUBJECT: Mathematics-Science Survey

Data collection is an intergal part of planning for program expansion and development. For a number of years we have heard that certain groups from the student population in our schools are not electing courses from the areas of mathematics and science. The enclosed survey is being conducted through the University of Arkansas at Fayetteville in an effort to determine the extent to which that observation is valid. If in fact enrollments of minority students or women are not representative in our upper level science and mathematics courses, we need to explore ways to increase their participation in these courses.

As you are collecting data for the Annual Secondary School Report and the other reports that you make at this time of the year, I hope that you or department chairs from your school will complete this one-page form and return it to Dr. Wavering at the UAF.

A detailed summary of the results will be available in February 1987.

Thank you for your help!