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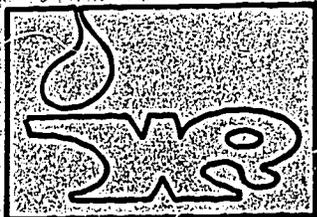
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ABSTRACT

The results of a 3-year study on the relationship between teacher emphases and student outcomes in mathematics and science at the secondary school level are presented in this report. Specifically, the study sought to determine the goals for mathematics and science which teachers of these subjects emphasize; the similarities and differences in attitudes toward and performance in mathematics and science by male and female, minority and nonminority students; and the possible link between teacher goals and student-level outcomes. Results showed that teachers in the study (N=133) often seemed unclear on how they could translate their overall goals into strategies that would prove effective for diverse students. The minority students in this study expressed favorable attitudes toward mathematics and science but performed more poorly in those subjects than did their nonminority counterparts. It is recommended that future research attend to the range of factors in the classroom and in settings beyond that context, that make the outcomes for minority students quite different from those that are obtained by other students. Research on goals is also advocated. Appendices include the instruments employed in the study. (ML)

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Teacher Goals and Race/Sex Equity in Mathematics and Science Education: Final Report

by Cora Bagley Marrett

December 1985

Wisconsin Center for Education Research



School of Education · University of Wisconsin-Madison
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TEACHER GOALS AND RACE/SEX EQUITY IN
MATHEMATICS AND SCIENCE EDUCATION: FINAL REPORT

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December 1985

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Abstract

This report summarizes the results of a three-year study on the relationship between teacher emphases and student outcomes in mathematics and science at the secondary school level. Specifically, the study sought to determine the goals for mathematics and science which teachers of these subjects emphasize; the similarities and differences in attitudes toward and performance in mathematics and science by male and female, minority and nonminority students; and the possible link between teacher goals and the student-level outcomes. The study gave particular attention to minority and female students, given the tendency for these groups to be underrepresented in mathematically-based careers.

The results suggest that the relationship of teacher goals and emphases to student outcomes is highly complex. Teachers who favor the same goal--having students develop cognitive skills, for example--do not always pursue the same teaching strategies. Moreover, the same strategy does not elicit identical responses across different students. The findings indicate a need for further inquiry on teacher objectives in mathematics and science instruction, for the teachers in this study often seemed unclear on how they could translate their overall goals into strategies that would prove effective for diverse students. The findings also suggest that an understanding of student attitudes need not enhance our understanding of influences on student performance. The minority students in this study expressed rather favorable attitudes toward mathematics and science but performed more poorly in those subjects than did their nonminority counterparts. Finally, the results

indicate that minority and female students should not be grouped together in studies of underperformance in mathematics and science. Minority students--both male and female--performed more poorly on standardized tests in these subjects than did nonminority females. It seems essential, then, for future research to give particular attention to the range of factors--in the classroom and in settings beyond that context--that make the outcomes for minority students quite different from those which are obtained for other students.

CHAPTER I
TEACHER GOALS AND STUDENT OUTCOMES

INTRODUCTION

As the decade of the 1980s unfolded, so did a spate of analyses on mathematics and science education in American society. One report after another described and decried our educational system, maintaining that it has rendered us a nation at risk, a nation whose economic strength and intellectual vitality are threatened.¹

What shadows the prospects for the future is the increased representation in our public schools of students who traditionally have stood on the fringes of mathematics and science education: females and minority students. The Commission on Precollege Education in Mathematics, Science, and Technology Education (1983) recommended as a basic goal for the society:

The improvement and support of elementary and secondary school systems throughout America so that...they... provide all the Nation's youth with a level of education in mathematics, science, and technology, as measured by achievement scores and participation levels (as well as other non-subjective criteria), that is not only the highest quality attained anywhere in the world but also reflects the particular and peculiar needs of our nation (p. 5).

It would be no mean accomplishment if the performance and participation of minority and female students matched that of their nonminority and male counterparts; it would be revolutionary indeed if the former groups reached the standards other nations have set.

Progress toward the goal demands the identification and assessment of the forces which shape the experiences of minority and female pupils. The study reported in this document addressed those needs. The study had as its fundamental concerns: to illuminate the teaching conditions

which promote minority and female achievement and involvement in pre-college mathematics and science education; and to highlight important influences on those conditions. The study centered on instruction in mathematics and science and the philosophy or goals of teachers which guide that instruction.

An analysis of teacher goals clearly warrants attention. The indictments of mathematics and science teaching often have pointed to teacher quality as a fundamental problem. Certain themes run through the studies: future teachers take too few courses in the subject matter and too many in the mechanics of teaching; significant numbers of teachers have emergency certificates only; college students who enter teaching score lower on standardized tests than do other college students. The criticisms overlook the part which differing philosophies about mathematics and science instruction might play. There is no consensus across the society as a whole on the outcomes one should find from precollege mathematics and science education.² Those who propose reforms often cannot agree on the goals of those reforms, let alone on strategies that would promote them. For some, mathematics and science education should be the lever for returning the United States to a place of scientific and technological prominence. According to this position, the United States, a country that gave birth to advanced technologies, finds itself lagging behind Japan and other countries in furthering technological development. Unless the educational system improves, U.S. technological leadership may be lost forever.

Other analysts contend that reforms should have as their objective: transforming and improving the ability of each individual to handle a world in constant change. For still others, mathematics and science

education should enhance the body civic, by providing a common knowledge base to all citizens. It should succor what Hannah Arendt once called "the sharing-of-the-world-with others."

Teachers must negotiate the different and potentially incompatible paths that lead to and from the several philosophies. We have little sense of how teachers traverse these paths, of the ideas and ideals which guide the choices they make, and of the consequences those choices have for the children whom they instruct. A better sense of mathematics and science education from the perspective of goals for instruction might offer insights on student outcomes--especially for minority and female students--that too often elude us.

A study of goals seems particularly appropriate in the context of equal opportunity in mathematics and science, for some have argued that the pursuit of certain objectives enhances minority and female student involvement. We review this theme in the next section. Given the possibility, then, that the emphasis chosen might make a difference for students who are underrepresented in elected mathematics and science courses, a study of goals seems timely.

TEACHER GOALS AND STUDENT OUTCOMES

On Goals in Mathematics and Science Education

Studies on goals in education cover three areas: what the public expects the schools to do (Reisler, 1981; Plisko, 1981), what various materials set forth as principles and priorities for education (Yager, 1978; Goodlad, 1983), and what teachers identify as the ends they seek; the research reported here fit in the third area. The model adopted for this study assumed that the goals for mathematics or science education

that a teacher endorses influences the teacher's classroom behavior which in turn affects the status and response of students in that class.

One can distinguish between information-based goals and student-based ones. Information-based goals or objectives have to do with the kinds of knowledge and skills the teacher wishes to foster in students. Student-based objectives are those centered on the kinds of students the teacher wants to affect.

Sources differ in the number and description of information-based objectives. The scientists and science educators who helped guide the first National Assessment of Educational Progress (NAEP) identified four major objectives for science education:

1. Knowledge of the fundamental facts and principles of science;
2. Possession of the abilities and skills needed to engage in the processes of science.
3. Understanding of the investigative nature of science.
4. Possession of positive attitudes about and appreciation of scientists, science, and the consequences of science.

(Science Objectives for the 1972-73 Assessment, 1972, p. 7)

For the 1972-73 Assessment, three major objectives were given, and each was divided into sub-objectives. Other changes in the statements preceded the 1976-77 Assessment (Science Report: Summary Volume, 1977).

In addition to NAEP, most state and local educational agencies have developed objectives for their science and mathematics teachers, and education textbooks provide lists as well. Considerable diversity exists across these sources, but there are some commonalities. Most of the inventories, whether for mathematics or science, give these five objectives:

1. The development of fundamental knowledge. This objective emphasizes the transmission of facts, rules, and formulas.
2. The development of skills. For mathematics these would be computational skills: the ability to calculate rapidly and accurately, the ability to take measurements. In science, the skills in laboratory experimentation would be emphasized.
3. The ability to apply knowledge and skills. The emphasis of this objective is on the translation of facts and proficiencies to contexts other than the one in which they were presented.
4. The development of an understanding of the personal and social relevance of the subject. This objective stresses the uses the society and the individual can make of scientific and mathematical information and skills.
5. The development of positive attitudes toward science and mathematics. Here, the emphasis is on affective rather than cognitive development.

An emphasis on attitude change pervades much of the literature in the 1970s on mathematics and science objectives (for a review, see Fraser, 1977). There is little evidence, however, that classroom teachers came to regard attitude change as a pre-eminent outcome for mathematics and science education. One analysis concludes: "While teachers may share the view that attitude objectives are important, they certainly (from their own reports) do not systematically teach towards attitudes. Rather, they teach toward students' acquisition of knowledge." (Schibeci, 1981: 72). The question--toward what ends should mathematics and science education aim?--must be addressed to teachers if

we seek an informed understanding of and change in pre-college education.

Teachers vary in the kinds of information they stress; they differ, too, in the types of students they favor. Several critics claim that secondary school teachers of mathematics and science prefer to teach upper-level courses in which more motivated--and often college-bound--students are likely to be enrolled. An extensive literature on gender and mathematics also suggests teacher preference for male students.

In a study of secondary school mathematics teachers Bean (1976) found that teachers initiated more contacts with male than with female students. According to a comprehensive review of the observational research (Brophy, 1985), it is generally the case that teacher-student interactions are gender-related: males elicit more negative responses from teachers, but they also receive greater praise and support for their work.³

Leacock (1969), Rist (1970, 1973), and several others have concluded that teachers often expect poor performance from minority and low-income students and as a result teach little to these students. Leacock reached this conclusion after she studied teaching in four elementary schools: two lower-income schools, one black and one white; and two middle-income schools, one black and one white. She discovered that the second- and fifth-grade teachers whom she observed in the lower income black school created and reinforced a defeatist attitude among the pupils.

Rist corroborated the Leacock findings in an observational study which he carried out in an all-black ghetto school. He demonstrated that the unfavorable images which the kindergarten teacher developed

about her students followed these pupils into the later grades as "objective" data. Washington (1978) observed ten integrated second grade classrooms and uncovered essentially the same results. Both black and white teachers viewed black students rather negatively, although this was somewhat less likely for the black teachers (also see Sayavedra, 1976, for a similar finding on Mexican-American students). Overall, the research suggests that teachers tend to treat black students, particularly low-income black students, in discriminatory ways (Gollub & Sloan, 1978). But the studies tell us relatively little about influences on the expectations. It might be that variations in teacher goals are associated with differences in expectations which, in turn, are connected with differentiated behavior toward students.

Teacher Goals in Mathematics and Science Education

Several studies have asked mathematics and science teachers their opinions on various teaching objectives and strategies. Welch and Walberg (1967), for example, polled 160 physics teachers for their views on the purpose of high school physics, the usefulness of different teaching methods, and the training needed for effective teaching. The researchers wanted to know if the attitudes and activities of physics teachers might help explain the continued decline in high school physics enrollment. They speculated that an emphasis on preparing students for college could put high school physics beyond the reach of many high school students. They found no evidence, however, of an emphasis solely on the college-bound. Eighty-seven percent of the teachers disagreed with the statement, "Only students who plan to go to college should take high school physics;" and 73 percent disagreed that "The major function

of the high school physics course should be to prepare students for college science courses." Nor did the teaching methods these teachers preferred seem likely to diminish enrollment. The teachers relied little on projects and workbooks but favored instead laboratory experiments, demonstrations, and discussion. The authors conclude that in the case of declining physics enrollment: "The physics teacher seems to be a victim of the trend, not the cause" (p. 442).

Not all studies have found the high level of consensus among teachers that typified the Welch-Walberg sample. Trowbridge (1965) surveyed two groups of high school physics teachers to determine the objectives they favored for physics instruction. The first group consisted of 85 teachers who were using a new course designed by the Physical Science Study Committee (PSSC); seventy-six teachers who were teaching the "traditional" courses comprised the second group. The two groups assessed several objectives quite differently. The traditional group tended far more than the PSSC group to agree that high school physics should "help the student become a more intelligent consumer of the products of modern technology," and should "teach the applications of physics principles to modern technology and to devices common in the life of the student" (p. 120). In contrast, the PSSC teachers were more likely to emphasize the intellectual and cultural aspects of physics and to stress in-depth coverage of a few major topics.

The Trowbridge study could not specify the connection between preferences of the teacher and preferences of the student. But there is other research which implies that the two are connected. Some evidence exists that minority and female students are not attracted to mathematics and science courses as those courses traditionally are

taught. The directors of the Study of Mathematically and Scientifically Precocious Youth at Johns Hopkins found that girls were most likely to remain involved if the program stressed the social outcomes of mathematics and if the classes were organized noncompetitively (Fox, 1975, 1977). Similarly, some scholars maintain that females avoid science because they have unfavorable images of scientists (Mead & Metraux, 1957; Mitias, 1970). A few sources point to a parallel pattern among black students. It would seem, then, that minority and female students need information on science and scientists in the social context. Instruction that aims primarily to impart knowledge about facts or research strategies is not likely to elicit substantial interest in science or mathematics among these students.

One would expect to find high minority and female interest in mathematics and science where the pedagogical strategies downplay competition among individuals and where they stress the social and personal meaning of the course work. A study in New England schools reinforces the idea that some students need rather non-traditional instructional styles. In her study of 1500 students Brush (1980) found that they drew a distinction between their mathematics and their English teachers. They saw the English teachers as encouraging their ideas and originality and the mathematics teachers as rewarding right answers only. This was especially significant for the girls in these schools. According to Brush, the finding implies that greater teacher support for creativity is necessary for enlarging the pool of females in mathematics. Generally, then, the instructional emphases that attract majority males to science careers might be inappropriate for other categories of students. The topic deserves attention for, as we shall

demonstrate presently, there continued to be male-female, minority-nonminority contrasts in enrollment and performance in mathematics and science courses.

GENDER, PARTICIPATION AND PERFORMANCE IN MATHEMATICS AND SCIENCE

The research on both mathematics and science education consistently reports gender differences that favor males. The 1981-82 National Assessment in Science found higher scores for males than for females on items measuring knowledge of scientific methods, understanding on the application of science and technology, and science process skills. Significantly, the male-female gap varied across different content areas: it was smallest on biology items and greatest for physical science ones (Science Assessment and Research Project, 1983). The same tendency appears elsewhere, according to a recent analysis on gender and achievement in science (Steinkamp & Maehr, 1984). The authors discovered that in one study after another males outperformed females, although generally the sex differences were small. With respect to preference, boys felt more inclined toward the physical sciences than did the girls; girls preferred the biological sciences. The authors conclude that girls surpass boys in science subjects which are school-based, but boys excel where the subject can be learned "informally through extracurricular hobbies and contacts with knowledgeable males" (p. 49).

Several explanations prevail for the male-female differences. To assess these explanations, I review the research on gender and mathematics. I have chosen that literature rather than the material on

gender and science, for two reasons. First, a more extensive literature exists on the former topic. Second, because the pattern of gender differences is quite similar for science and mathematics, the theoretical argument for the findings should overlap.

The literature on gender and mathematics is rather sizeable (Fennema and Sherman, 1977, 1978; Fox and Cohn, 1980; Parsons, Kaczala and Meece, 1982; Pallas and Alexander, 1983). Generally, that literature shows that males surpass females on tests of higher level mathematics skills. On lower level skills--computation, for example--women equal or outperform men. The National Longitudinal Study of Mathematical Abilities (NLSMA), a survey conducted between 1962 and 1967 among eleventh grade students, found that girls did better than boys on the lower level tasks but not on the higher level ones (Wilson, 1972). The Women in Mathematics Survey, carried out in 1978, discovered that age and gender interacted to affect test performance. Among the thirteen-year olds, girls had slightly higher mean scores on the spatial visualization, algebra, and computation tests, and there were no gender differences on the problem solving test. For the twelfth-grade students, however, boys had higher mean scores on all of the tests, although the gender difference was significant statistically for only one test: problem solving (Armstrong, 1981). The 1978 National Assessment of Educational Progress (NAEP) included age groups quite similar to those in the Women in Mathematics Survey and uncovered findings paralleling those from the Survey. The thirteen-year old girls in the NAEP study surpassed boys on computation; but the latter were better at application or problem solving. Among the seventeen-year

olds, boys and girls were no different in computational skill, but boys did better on the application items (Armstrong, 1981).

Results from the quantitative segment of the Scholastic Aptitude Test (SAT-M) reinforce the conclusion that men and women perform unequally on tests of higher level cognitive skill. One analysis of approximately 6,000 twelfth grade students in 24 public high schools from across the United States found a higher mean score for boys--425.23--than for girls--388.45 (Pallas and Alexander, 1983). When the SAT-M has been administered to highly able young adolescents, sharp gender differences have stood out. That is a finding in a recent study by Benbow and Stanley (1983) on nearly 40,000 students thirteen-years of age and younger whose scores on the SAT-M made them eligible for the Study of Mathematically Precocious Youth (SMPY). Two patterns appear in these data, gathered between 1980 and 1982: boys had higher mean scores than did girls, and more boys than girls appeared among the very high scorers. The SMPY set contains data on over 800 thirteen-year olds with scores higher than 600; note that in 1981-82 the mean score for college-bound senior men was 493. There were, then, significant numbers of young adolescents whose performance in mathematics far exceeded the levels of the persons for whom the SAT-M was designed. But few females were counted in those numbers: girls comprised only 20 percent of the thirteen-years with scores higher than 600 and only seven percent of the group with scores at the level of 700 or above (for earlier data on SMPY see Fox and Cohn, 1980, and Benbow and Stanley, 1980).

Several reasons have been given for the gender differences in higher level cognitive skill. I review here three hypotheses others have offered and propose a fourth: the social orientation hypothesis.

The latter hypothesis suggests that women are more attentive than are men to the attitudes and behaviors of people around them, and that such attentiveness is consequential for the development of mathematical reasoning skills. My purpose is not to test the relationship between social orientation and performance in mathematics; instead, it is to offer a hypothesis that should help relate teacher orientation and behaviors to student outcomes.

Explanations for gender differences in mathematics performance can be judged on the basis of three criteria. First, the explanation must account for the fact that differences in cognitive skills appear most regularly after the ninth grade. Although Benbow and Stanley describe sharp contrasts before that grade level, other researchers have not found that pattern. The studies which Maccoby and Jacklin reviewed in 1974 reported few gender differences in mathematical skills during the pre-school and early school years but clear-cut differences on tests of cognitive skills among students in the junior high and high school years. There are exceptions, however. Fennema and Sherman (1978) administered the Romberg-Wearne Problem Solving Test--a three part test on comprehension, application, and problem-solving--to 1,320 middle school pupils in a midwestern city and found no consistent gender differences. The researchers divided the nine schools into four areas, according to geographic location, and compared the test results. They found differences for only one of the locales. Most of the research, however, departs from the Fennema-Sherman findings. Hence, a satisfactory explanation for gender differences must fit the age-related patterns that generally the research reports.

Second, the explanation should be consistent with the patterns found for subjects other than mathematics. Tests of reading skill usually show better performance among women than among men. An explanation for differences in mathematics should not conflict with the prediction one might make for reading, for example. In general, the explanation should not seem illogical in the context of a different content area.

Third, the explanation must fit with the existing empirical data. By now a substantial amount of information has been compiled on attitudes toward and instruction in mathematics. Explanations for gender differences in high level cognitive skills should flow from and lend insights on that information. These are the three criteria I use to evaluate the four hypotheses.

The Differential Coursework Hypothesis

As noted, the sharpest contrasts in performance appear during the secondary school years. Those are the years in which students begin to make choices about courses. One explanation for differential test performance highlights the differences between men and women in their course choices.

Until recently, most of the research on course participation uncovered significant differences between men and women. The Project Talent data, gathered in 1960 on over 400,000 high school students, found a higher percentage of men than of women in college-preparatory mathematics. A follow-up study in 1963, involving students who had been ninth-graders at the time of the original study, found that gender differences in course-taking had persisted (see Wise, Steel, and

MacDonald, 1979, on both the original and follow-up studies). Similar results emerged from the NLSMA. The coursework hypothesis maintains, then, that the differences seen among high school seniors--on achievement tests in general and on the SAT-M in particular--result from the limited enrollment in advanced courses by females. Females do not do well on tests of cognitive skills because they are not as likely as males to have taken the courses that build those skills.

The coursework hypothesis meets three criteria for an adequate hypothesis: it seeks to explain why differences appear in late but not early adolescence; it can be applied to any subject where differential course-taking and differential performance are found; and it has empirical support. Let us turn to the third matter.

A few of the analyses that have considered course-taking patterns have found rather narrow gaps in performance between men and women. When Fennema and Sherman (1977) compared high school men and women who had similar backgrounds in mathematics, they found only small differences in mathematics achievement. The Women in Mathematics Survey found no gender differences in problem solving performance among men and women who had taken calculus. Of those who had had pre-calculus, the problem-solving scores for men surpassed slightly the scores for women, but the difference was not significant statistically (Armstrong, 1981). The Pallas and Alexander study (1983) of high school seniors found a 36 point spread between the scores of men and women on the SAT-M. But when the researchers took account of courses taken, the spread shrank to 14 points.

The coursework hypothesis does not offer a totally satisfactory explanation for the differences in cognitive skills, however. First,

gender differences remain even among those who have taken the same courses. Using data from the Growth Study that the Educational Testing Service launched in 1961, Hilton and Berglund (1974) analyzed the progress in mathematics of male and female students. They examined results for the students as fifth graders and as seventh, ninth, and eleventh graders. Male and female students performed similarly when they were fifth graders, but at each successive grade level, the boys had higher test scores. The difference remained even after course histories were considered. The 1978 NAEP also found that the higher the level of the course taken, the wider the gap between the scores of men and women on application items. Among the 17-year olds who had stopped with geometry, the mean score for male students was four points higher than the mean for female students; among those who had continued to the second year of algebra, the mean score for men was six points higher; and for those who had continued beyond the second year algebra course, the difference was more than seven points (Armstrong, 1981).

Second, the coursework hypothesis is likely to diminish in importance, given the greater tendency for women to enroll in mathematics courses. Most of the research conducted over the last ten years shows a convergence in the course-taking patterns of men and women. In the Women in Mathematics survey, women were as likely as men to have had or to be enrolled in calculus, computer programming, and trigonometry. In fact, of the twelve courses that the survey covered, significant gender differences appeared for only three: probability/statistics, second year algebra, and accounting/business mathematics. The 1978 NAEP also found few differences in course taking. Of nine subject areas, significant gender-differences occurred for only two: precalculus/calculus,

and trigonometry (Armstrong, 1981; also see Fennema and Carpenter, 1981).

I am not recommending the dismissal of the coursework hypothesis, however. First, tests of the hypothesis show how important it is for studies of gender differences in achievement to take account of differences in coursework. Second, the gender difference might diminish even more if we had information on the content and not just the title of the course offered. Cross-sectional studies using different schools and different school systems cannot assure us that courses with the same name include identical material. Additional information on content, then, might reinforce the argument that coursework differences do indeed lead to divergences in achievement.

It seems unlikely, however, that female students are so distributed among schools that the content they are given departs noticeably from that taught to male students. Perhaps the mathematics programs in schools with large numbers of females in advanced courses are quite different from the programs that prevail where males predominate among the advanced-level enrollees. But this possibility can be questioned, given the fact that the gap between the scores of men and women appear even among students at the same level within the same school. Additional information about content would be useful, but it might not be the final answer to the question of differential performance.

The Differential Treatment Hypothesis

A second explanation hinges on differential treatment of males and females by their teachers. Much of the work is based on elementary school classrooms. Although this is not the level in which the most

stable differences in mathematical reasoning appear, the elementary experience deserves attention because of its implications for later test performance and because many of the interactional patterns seem to be repeated at the secondary school level.

Several studies on classroom interaction have shown that teachers interact more with boys than with girls, that teachers initiate more contact with boys, and that boys are more likely than girls to initiate contact with the teacher (see Brophy, 1985 for a review of this literature). A study by Dweck and others (1978) in three classrooms--two fourth grade and one fifth grade--found greater differences in the kinds of evaluations given to boys and girls than in the amount of contact the teachers had with them. The researchers inquired about the extent to which positive and negative evaluations were fed back to students. They found no differences in the frequency with which boys and girls received either positive or negative feedback, but they found noteworthy differences in the type of negative evaluations given. For the boys, only about one-third of the negative evaluations were related to the intellectual quality of their work; the rest referred to their conduct or to aspects having no direct bearing on academic performance. For the girls, over two-thirds of the negative evaluations were addressed specifically to academic performance. Dweck and her colleagues suggest that because the negative feedback occurred rather indiscriminately for the boys, these students did not necessarily see any link between the criticism given and their own intellectual performance and ability. For the girls, however, it was clear that the cues were directed to their academic and intellectual qualities. The

researchers propose that the difference in feedback might have prompted different self-assessments by boys and girls.

Studies at the secondary level have also identified differences in teacher responses to male and female students. In the ten high school geometry classes that Becker (1981) observed, teachers had more sustained interaction with the male students and gave more encouragement to them. Morse and Handley (1985) noted that the seventh grade science teacher whose class they studied initiated more interactions with the boys in the class, and that most of the interactions had to do with course content.

The differential treatment hypothesis might account for the age-related pattern in skill development in two ways. First, the conceptual nature of mathematics is emphasized more at the junior high school and high school levels than at the elementary school level. The tests administered for the early grades stress operational rather than conceptual skills (see Kaplan and Plake, 1981, on this point). Hence, the areas in which gender differences are most likely are not always the ones examined for pre-adolescents. Second, the effects of differential treatment might be cumulative. Differential treatment by a single teacher need not have any long-term consequences. But if the differential treatment recurs, then eventually it will matter. Not all elementary teachers treat males and females differently; thus, there is not likely to be enough experience with differential treatment during the first few years of schooling for its effects to be pronounced.

To explain the fact that men and women perform differently depending on the subject matter, the differential treatment hypothesis could call attention to the ways in which teacher behavior varies across

subjects. Leinhardt and her associates (1979) analyzed teacher behaviors in reading and mathematics instruction for 33 second grade classrooms. They found that for mathematics instruction, more of the contacts with the boys than with the girls were academic in nature. The pattern was reversed in reading instruction: for that subject, more of the academic contacts were with the girls.

On the third criterion--the extent to which the empirical literature supports the hypothesis--the verdict is mixed. I have cited studies upholding the thesis that male students and female students are treated differently by teachers. But there is also a body of research which shows that the frequency of contact does not always vary by student gender; that difference in amount of contact does not necessarily indicate inequality in academic treatment; and that students' interpretations of teacher behavior need not coincide with those of the researcher.

One examination (Good, Cooper, and Blakey, 1980) showed teacher-student relationships to be influenced by various factors, only one of which was student gender. Student achievement level, teacher expectations, and even the time of the year all made a difference for the quality and amount of contact between teacher and student. In fact, when the researchers took account of these other variables, they found rather small gender effects on interaction patterns (also see Brophy, 1985).

Counts of total amount of contact do not demonstrate conclusively that women are shortchanged academically. Much of the contact between the teacher and the male student--especially during the elementary

years--revolves around disciplinary problems. Boys are corrected for misbehavior more often than are girls (Serbin, et al., 1973).

Finally, it is not clear that students interpret contact with teacher in ways that coincide with some arguments in the literature. One study in particular challenges the generalization that students respond positively to praise and negatively to criticisms about their work. Eccles (1985) studied 17 mathematics classrooms serving grades 5, 6, 7, and 9 and the praise and criticisms meted out in them. She looked at the relationship between the amount of criticism or praise directed at a student and that student's perception of the teacher's expectation for him or her. She found no correlation between amount of praise and perception of expectations. She did find negative correlations between amount of criticism and perception, but the correlations tended to be rather low. Eccles suggests that the importance of praise or criticism will depend on the interpretation that the student gives to it. If the student believes that the praise--or criticism--conveys high expectations, then the response will differ from the instance in which the student believes that the teacher's reaction has little or nothing to do with expectations (also see Parsons, et al., 1982).

The Eccles study is only suggestive about the effects of teacher behavior, in that it is based on a cross-sectional design. Missing, too, is an analysis of the sources for the behavior, an analysis which builds from the perspective of the teacher.

The Differential Involvement Hypothesis

A gender difference with reference to interest in mathematics and engagement in mathematically-related activities has been used to explain the gender performance gap. Responses on several attitudinal surveys indicate that men are more involved psychologically with mathematics than are women. Dutton studied the attitudes of a group of junior high school students in 1956 and found fewer girls than boys agreeing with the statement: "I think about math problems outside of school and like to work them out." A replication of that study ten years later--again with junior high school students--produced an even wider discrepancy in male-female responses (both studies cited in Dutton, 1968).

The evidence is also clear that men are more likely to engage in mathematically related activities outside of the school context. Hilton and Berglund (1974) discovered that boys read more books on science and more scientific magazines than did girls. The 1978 NAEP science assessment found that far fewer girls than boys participated in extra-curricular science activities, such as reading science articles and books, watching television shows on scientific topics, and doing science projects and hobbies (for a review of the NAEP science results, see Matyas, 1985). Studies on mathematics specifically reveal the same trends. Fennema and Sherman (1977), for example, studied the mathematics activities of a group of secondary school students and discovered that the boys engaged in more such activities outside of the school than did the girls. For two of the four schools in their study the gender difference in mathematics activity was significant statistically.

The differential involvement hypothesis seems better suited for explaining differences in enrollment than in performance. It is not

clear that men and women in the same advanced level courses can be differentiated sharply on the basis of mathematics related activities. The evidence of a direct link between involvement and performance, then, is somewhat weak. Standing alone, the differential involvement hypothesis cannot serve as a complete explanation for performance differences. But it deserves attention, because it seems consistent with the age-related pattern, and it is applicable to subjects other than mathematics. It might be that in the subjects where girls excel, they spend more time than boys on subject-related activities outside of school. I regard the differential involvement hypothesis as complementary to the two hypotheses already reviewed and to the one introduced next. Perhaps women are no less inclined than men to think about mathematics outside of the classroom or to undertake mathematically related games and hobbies. But their sensitivity to others possibly leads women to accept gender stereotypes about appropriate roles, stereotypes that might direct them away from courses in mathematics during the high school years, stereotypes that could promote rather passive behavior in the classroom. Possibly, too, the decision to spend time with others reduces the amount of time left for the solitary activities that games and hobbies in mathematics and science might involve. Among the women who take the same courses as do men, differences in interests might lead to differential performance. Differences in interests produce differences in teacher responses as well. What might account for these differences in interests? I propose that a social orientation possibly diverts women from the type of involvement--psychological and behavioral--that might lead to high level mathematical skills.

The Social Orientation Hypothesis

I offer as a fourth explanation for gender differences the social orientation hypothesis. I mean by "social orientation," attentiveness to the attitudes and behaviors of other people. Various sources suggest that (1) women are more likely than men to be oriented to other people; and (2) a social orientation seems inconsistent with the development of high level cognitive skills, such as are required in mathematics.

The social orientation of women. There are several streams of research which show a greater tendency for women than men to be attentive to other people. Studies using interest or activity inventories report that more females than males evidence an interest in social service activities, for example. The gender difference appears among both adolescents and adults. Kuder (1964), the developer of widely used interest surveys, administered his General Interest Survey to two groups of students: one enrolled in grades 6-8 and the other in grades 9-12. He discovered that more of the girls than the boys in both groups expressed an interest in social service. The boys scored higher on the scales that covered outdoor, mechanical, computational, and scientific interests. Other studies report the same pattern for adolescents (Prediger, Roth, and Noeth, 1973; Campbell, 1974).

Analyses of adult populations show different interests between men and women that are rather constant across occupations. One recurring pattern is the preference women show for social activities (Campbell, 1974). Interestingly, a study of men and women engineers found no difference between them on a measure of self-expression, but it found clear differences on a people-orientation index: more of the women than the men scored high on that measure (David, 1974).

Gender differences in orientation to others has been cited to explain the underrepresentation of women in the physical sciences and engineering. Studies of engineers (David, 1974) and physical scientists (Eiduson, 1962; Helson, 1974) describe these professionals as individualistic and reserved. Indeed, two of the traits commonly ascribed to engineers and physical scientists, based on profiles of practitioners, are independence and aloofness. Supposedly, women stay away from the sciences, because those fields place little emphasis on the social context; when women enter the sciences, they choose those areas that give attention to the world of living things: the social, behavioral, and biological sciences.

Some of the research conducted in classrooms supports further the theme of gender differences in social orientation. Anderson (1970) cites several studies showing that close relationships in the classroom affect girls more than boys. Fox and Cohn (1980) report that mathematically precocious adolescent girls were much more concerned about the social context of mathematics learning than were the boys. Walberg (1967) administered the Reed Science Activity Inventory to a group of twelfth grade physics students to determine the types of science activities that attracted them. He found that the girls were inclined towards the animate aspects of science--nature study and applied life science, for example--while the boys preferred the inanimate aspects. He suggests that boys are more likely than girls to be attracted to activities involving the physical manipulation of objects.

Based on the Walberg results and the fact that many women choose to study the biological sciences, it might seem that the orientation I have in mind should be designated as "animate" rather than "social." But

such a designation would be too vague and too narrow. Defining an "animate orientation" outside of the science context would be difficult, and thus a hypothesis based on that orientation would not be applicable across a range of school subjects.

The designation "social" also has support from a wider array of research than has the designation "animate." In a study of both eleventh and twelfth grade physics students, Walberg (cited in Haertel, et al., 1981) discovered with a semantic differential scale that the girls scored higher than the boys on social, esthetic, and religious values. Male students had higher scores on economic, political, and theoretical values. Particularly relevant for our purposes is the finding that the female students had higher need for affiliation scores.

A study on student perceptions of classmates (Morine-Dersheimer, 1985) points to greater attention by women to social attributes. The researcher asked pupils in three fourth grade classrooms to indicate "what a new kid coming into your class [should] know about the other kids." The girls were more likely than the boys to mention interpersonal traits: who's friendly or unfriendly, nice or mean. But more boys than girls mentioned intellectual traits or hobbies and interests: who's smart or dumb, who collects baseball cards, who is musically talented. This study, then, suggests that even in the early school years, boys and girls who observe their peers see them from different angles.

Social orientation and cognitive skill development. A link between orientation to others and limited skill development in mathematics cannot be proven with the existing empirical data. But the literature is suggestive. A study of high school students, for example, found that

those who were very good in mathematics were less sociable than were those who did extremely well in English (Silverblank, 1972). Analyses on the personality profiles of scientists and mathematicians and on the childhoods of these professionals are also highly implicative.

As already mentioned, the profile drawn of the scientist revolves around non-social characteristics. Studies on the biographies of scientists suggest that such characteristics appear rather early. In particular, Roe (1951), Terman (1954), and Eiduson (1962) report that the scientists whom they studied were socially aloof and independent as children. But the presence of a correlation between discipline or occupation and independence during childhood does not prove that the latter contributed positively to the former. It could be that some scientists chose their fields because as children they were introverted and consequently wanted careers that would not tax their social skills. Possibly, too, the relationship between independence and entry into science is totally spurious. Finally, it might be that in recreating their pasts, scientists tend to recall most vividly their independent activities and forget or downplay the social ones.

What, then, is the basis for assuming a direct connection between independence and entry into science? Because my interest is in higher level cognitive skill development and not entry into scientific careers, let me examine the reasoning behind the argument that independence contributes to cognitive reasoning in mathematics.

The argument probably has been developed most fully by Fennema and Peterson (1985) in their analysis of what they term "autonomous learning behaviors." They treat these as activities (1) in which the individual engages independently of others and (2) for which that person does not

require continuous interaction with and feedback from other people as he or she develops a given skill. Fennema and Peterson suggest that the autonomous learner is likely to persist on difficult tasks, and that this persistence can produce the understanding of complex relationships that tests of higher level skills tend to measure.

One can turn to the literature on small groups to gain insights on the ways in which autonomy or interdependence might contribute to persistence on difficult tasks. Consider the following generalizations. First, the development of some skills, but not of others, requires interaction. Second, groups work best on clear-cut tasks. Third, groups develop expectations for behaviors and sanction those members who violate the expectations. Fourth, the norms or expectations that groups establish lie within the capabilities of most of the group members. Let us now consider the implications of these themes for the learning of higher level cognitive skills in mathematics.

Porter, Lawler, and Hackman (1975) point out that some tasks require interaction among people, but others depend on the knowledge and skills of the individual. We can extend the argument by noting that some skills can be developed only in the presence of others, while others can be honed independently. One cannot become a skilled basketball guard without the chance to practice against someone. Likewise, one becomes an effective communicator only by communicating with others. In both instances, there must be contact and feedback for the skill to emerge. But other skills do not demand the continued presence of others. One can become a skilled sprinter without having to compete with someone else; one's own time might be the standard to consider. Similarly, the development of cognitive reasoning does not require that

one practice against anyone; the development of cognitive reasoning is not inherently an interdependent task.

Because mathematical skill development is individually based, the presence of others is not essential. Indeed, that presence might hinder such development if, as Fiedler (1971) and others have shown, the group process works most smoothly when the task is clearly structured. The development of highly complex mathematical reasoning is not a well-understood process; i.e., we cannot indicate precisely the steps one must follow. Thus, the presence of others is not likely to enhance the extent or rate at which an individual develops complex reasoning skills. The third and fourth generalizations suggest that, when there is ambiguity about the task, the group norms that evolve are likely to be geared to the least common denominator. In other words, the group is unlikely to establish the highest possible standards of performance but instead is likely to find levels that are both acceptable to and attainable by the majority. The individual might be allowed to meet or surpass somewhat the group standards, but that individual is likely to be dissuaded from moving far beyond the group levels. Consequently, we might expect to find a greater tendency towards exploration among individuals who are not encumbered by the boundaries others would establish. In summary, I contend that independence and autonomy from others does in fact enhance the development of cognitive skills by allowing the individual to explore a wider realm than might occur were he or she influenced substantially by the views, concerns and rules of others.

How would the social orientation hypothesis account for the fact that stable gender differences in mathematical reasoning do not appear

during the elementary years? A study by Grant (1983) offers useful insights on this question. Grant found that the girls in the classrooms were teacher-oriented: they approached the teacher often, and the teacher encouraged the interaction (also see Grant, 1985). A review of the Grant research (Brophy, 1983:21) points out:

Grant's observations help explain why the "advantages" enjoyed by girls in the early grades do not seem to do them much good in the long run. These "advantages" are largely in personal and social relationships rather than in quantity or quality of academic instruction, and they may have the effect of inhibiting rather than stimulating the development of such attributes as intellectual curiosity, achievement striving, or intellectual risk taking."

The social contacts that are valuable early on do not have lasting positive effects.

MINORITY STATUS, PARTICIPATION AND PERFORMANCE

Studies on both participation in mathematics/science related activities and achievement in the subjects consistently report wide disparities between minority and nonminority students. Consider the results from NAEP which assessed samples of 9-, 13- and 17-year olds in 1973, 1978, and 1982. Between 1978 and 1982 performance in mathematics of 9- and 17-year olds remained stable and performance of 13 year olds increased. Students improved most on knowledge of fundamentals and computational skills, and least on measure of understanding and application of knowledge to particular problems. Black students registered greater gains between 1978 and 1982 than did white students;

Hispanic 13-year olds showed significant gains as well. Yet, in 1982, as in 1978, black, Hispanic and Native American children scored well below their nonminority counterparts.

The results from the science assessment parallel those for mathematics. Among 9-year olds, whites scored higher than blacks on measures of science content and science inquiry in 1982; the largest differential occurred on the inquiry component. Score differentials had narrowed from 1977, however. Among 13-year olds, whites scored higher than blacks, and there was little change since 1977. This same pattern occurred at age 17 but the gap was even wider. Scores for whites were higher than for blacks on the content, inquiry, and science-technology-society components.

Blacks and Native Americans regularly have scored lower than whites on both the verbal and mathematics components of the SAT. In 1982, blacks scored 117 points (366) lower on the mathematics component than whites; the gap in the verbal scores was 103 (341).

Blacks, Native Americans, and Hispanic students are underrepresented in mathematics and science courses at the secondary school level. A larger share of white than of nonwhite students enroll in an academic curriculum, the curriculum which generally includes an array of mathematics and science courses. Yet, even among those high school seniors in academic programs, higher proportion of whites than blacks take at least three years of mathematics and/or science coursework in high school.

None of the patterns described thus far depict the situation of Asian Americans. Asian students outperform all other groups. In 1982 Asians had an average mathematics score on the mathematics subtest of

the SAT of 513; whites averaged 483. Of the nearly 275,000 college-bound seniors who took an achievement test in mathematics and science in 1981, Asians scored higher than whites, blacks or Native Americans. Asian students are much more likely than others to take mathematics and science courses. Among 1980 seniors across the nation, 27 percent of whites, 17 percent of Native Americans, 15 percent of blacks and 50 percent of Asians had taken a trigonometry course. Almost three-fifths of the Asians, compared with about two-fifths of the whites and only about one-quarter of the blacks and native Americans, had taken a chemistry course in high school. Given, these patterns, in the discussion which follows Asian students have been excluded from the category of minority students.

The descriptive literature on minority-nonminority differences outstrips the theoretical literature. As a consequence we know more about the kinds of inequities that prevail than about the forces which produce them. This is not to suggest, however, that no systematic explanations exist for the patterns which recur. Indeed, two hypotheses prevail. The motivational hypothesis attributes the minority-non minority divergence to differences in level of student interest in or attraction to mathematics and science. A variation on the theme maintains that minority students move away from mathematics and science because they see few people like themselves--as teachers or professionals--in those subjects. The prior achievement hypothesis asserts that by the junior high school years, the academic problems that so many minority children experience have accumulated, and as a result, only a handful of children have records that could gain them admission to the more select and competitive subjects.

These explanations offer only partial vistas on the mathematics and science education of black, Hispanic and Native American students. The section which follows reviews each explanation and its limitations. It considers, too, a third perspective--termed here the "allocation perspective"--as a supplement to the other positions. I do not propose the perspective as an alternative theory; it is too underdeveloped to rate that designation. Rather, my intent is to expand the view on minority education by proposing that the characteristics of settings, not just those of students, must be acknowledged.

The Motivational Hypothesis

Studies on the achievement motivation of black and white students point to higher motivation levels for the latter than the former (Adkins, Payne, and Ballif, 1972; Mussen, 1953; Rosen, 1959). Achievement motivation, as used in these studies, denotes a drive to excel against an internal standard of performance. The research shows that black students have less of this need to achieve than do white students. A related body of work argues that racial differences in performance result from contrasting views on the causes of success. Persons who believe that internal, personal forces produce success are likely to pursue high standards; those who attribute outcomes to external forces put forth less effort. Blacks more than whites, analysts report, attribute outcomes to external, unstable causes (Battie and Rotter, 1963; Zytoskee and Strickland, 1971).

Most of the literature on minority-nonminority differences in mathematics and science does not ground the explanation in the general issue of achievement motivation, however. Instead, it contends that

features of mathematics and science make them unattractive subjects for minority youth. In other words, these youth may have high aspirations in other fields, but they do not find the study of mathematics and science motivating.

Two lines of inquiry address the issue of motivation for mathematics and science. One centers on the images of science and scientists which minority students hold; the other focuses on the role modeling.

Images of scientists. According to the first theme, minority students are not attracted to science, as they perceive the domain. Tibord found that many black students viewed scientists as aloof, asocial (1983). Dillon and James (1977) unearthed a similar view among the 500 black college students whom they studied. Not all of the students perceived scientists negatively, but those with negative perceptions generally rejected the idea of a career in science. Students who felt that "scientists have no social concerns or interests" and that "scientists have done more harm than good in this society" were unlikely to think of science as a suitable career.

On role models. Blacks who attend college are more likely than their college classmates to choose the social sciences and education over the biological and physical sciences. Sewell and Martin (1976) speculated that the contrast stemmed from exposure to role models. (Garrison (1985) set forth a similar thesis as he sought to account for the underrepresentation of minorities in biological and physical science careers. Essentially, the role model hypothesis asserts that minority students do not consider mathematics and science as suitable topics for

themselves, given that they know few if any minority mathematicians or scientists.

The motivational hypothesis proves intriguing but questionable. The arguments regarding negative images would lead one to expect hostile views of mathematics and science from minority students. Yet, the evidence belies that expectation: minority students usually report that mathematics and science are useful and enjoyable subjects. For the 1982 NAEP science assessment, 13-year old blacks had higher scores than did whites on items tapping attitude toward science. MacCorquodale (1983) surveyed high school girls of Mexican-American background to determine whether their attitudes toward mathematics might explain their limited enrollment in the subject. Significantly, the girls were likely to view mathematics as useful and worthwhile.

The motivational hypothesis is limited for another reason: it cannot account for the enrollment patterns of some who express positive attitudes toward mathematics and science. There is some indication that at the pre-college level, black females have higher aspirations than have black males. Thorpe (1969) found in a study of over 1,000 high school students that the black girls were more likely to aspire to a professional or technical occupation than were black boys or white girls. This finding coincides with a tendency others have uncovered for black girls to assign greater importance to academic values and to get better grades than do black boys (Patchen, Hoffman & Brown, 1980).

Based on these findings, one would anticipate greater involvement in the sciences by black females than by black males. But that is not the pattern: black males outnumber black females among professionals in the physical and biological sciences and in engineering. A study of

black college students which the Institute for Services to Education (Scott, 1977) directed might help explain the seeming inconsistency between interest and participation. The study found that among female science majors, the decision to take science was not necessarily related to the goal of entering a graduate/professional school or pursuing a career, as was the case with the male science majors. Rather, females took science simply because they enjoyed the discipline. The paradox perhaps could be accounted for as well by a finding from a study on the attitudes toward science of black fifth- and eleventh-graders. Nelson (1978) administered the Fennema-Sherman Attitude Scales and obtained achievement data for male and female students at both of these grade levels. She found few differences in attitudes, but by the eleventh grade, the males were higher achievers than were the females. It could be, then, that among blacks, forces other than attitudes, shape participation.

The role model thesis assumes that a student uses as a model an individual of his or her own ethnic heritage. Yet, that need not be the case. The participants in a conference on minority women in the sciences frequently credited their own successes to the help of others. "Each recalled at least one teacher who had inspired and encouraged her, and in most cases another who had openly discouraged her interest in science" (Malcom et al., 1976). Often, it was a nonminority teacher who provided the encouragement. That situation by no means is rare and if persons emulated only those with whom they shared a biological heritage or set of physical traits, never would new paths be trod.

Finally, an emphasis on motivation overlooks the complex relationship which may exist between attitudes and involvement.

Favorable attitudes may follow from rather than precede enrollment and achievement in mathematics and science.

Effects of Past Performance

A national study of achievement, published in 1966, reported that the higher the grade level, the greater the minority-nonminority gap (Coleman, 1966). Subsequent research replicates that finding.

To explain the fact that the gap widens the longer students remain in school, analysts have described the use and consequences of tracking or grouping. The practice of assigning students to an ability-based group permeates American education. Children are assigned to groups, often as early as the first grade, based primarily on test performance. Minority children, who generally perform poorly on the tests, find themselves in low ability groups.

Grouping should reduce differences by gearing instruction to varying learning styles. Grouping in fact appears to exacerbate differences, for students in high ability groups learn more than those in lower-ability groups (Barr and Dreeben, 1983; Good and Marshall, 1984). Little mobility takes place across different ability groups within a school year or from one year to the next (Hallinan and Sorenson, 1983). As a consequence, students who begin in lower ability groups remain near the bottom, learning less and less than their higher-grouped peers, as they move through their academia careers.

The hypothesis fits with a range of data on grouping and tracking practices. But it implies a far closer link between measured ability, placement, and learning than may exist. As the next section will argue, the same test score can result in quite different placements, depending

on such conditions in school as the distribution of test scores, the size of groups, and the number of staff members available for instruction. Past performance makes a difference, but the difference it makes depends on the setting in which the student finds himself or herself.

The Allocation Perspective

The explanations discussed thus far associate enrollment and achievement in mathematics and science with characteristics or dispositions of students. An alternative perspective focuses on allocation policies and practices. According to this position, the number of different courses a school can provide--in mathematics, for example--depends on such factors as the size of the mathematics teaching staff, staff qualifications, and the course requirements the district sets. Where a large, specialized staff exists and requirements are minimal, considerable diversification--of courses as well as of levels or tracks for courses--is likely. The highest level courses may be filled with students who, in a less diversified school, would be assigned to lower level courses. The distinction between the two settings, lies, not in the traits of the students, but in the numbers and types of classes the school has to fill. The attitudes and achievement levels students in a given school, and not in the student population at large, determine how students will be arrayed among courses. Student characteristics matter only in a relative sense. Where there is an abundance of relatively motivated and high-achieving students, the elective and top level courses will be filled with them.

Indeed, many of these students may end up in other courses, merely because no more space exists in the "selective" ones.

The hypothesis has not been used to account for minority enrollment patterns. Yet, it seems consistent with those patterns. In an earlier study I found higher black female enrollment in elective mathematics courses in predominantly black than predominantly white schools. The difference stemmed from the nature of the available pool for those courses, not from the attitudes and absolute test scores of the students.

The matter of allocation deserves analysis in a study on teacher goals, for it treats teachers, not as passive actors who only respond to the qualities students bring to the classroom, but as active intervenors who must decide the meaning and importance of those qualities. The teacher must weigh those qualities as he or she reflects on the ends to be accomplished in mathematics and science education.

ORGANIZATION OF REPORT

This report contains five chapters. Following this introductory chapter, chapter 2 describes the research design, data collection strategies, measures, and techniques of analysis. The third chapter summarizes the results on teachers: their goals and classroom emphases. The data on students--student attitudes and achievement--form chapter four. The final chapter ties together the results for teachers and students and considers their implication for research, policy, and practice.

FOOTNOTES

1. The 1983 report of the National Commission on Excellence in Education, entitled A Nation at Risk: The Imperative for Educational Reform, did not focus exclusively on mathematics and science. That task was left to the Commission on Precollege Education in Mathematics, Science, and Technology which also issued its report in 1983: Educating Americans for the 21st Century.

2. The Council of Chief State School Officers has embarked on a project to set content goals for elementary and secondary mathematics and science education. The project proposal declared ". . . we do not have explicit goals for mathematics and science education. Our national debate has extended to the need for such goals, but we have not taken advantage of the wealth of thought and talent applied to these problems at the state and local levels." Project proposal, 1985, p. 5

3. For other research on gender and interaction see Louise C. Wilkinson and Cora B. Marrett, 1985.

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CHAPTER II

THE RESEARCH DESIGN

OVERVIEW

Data collection for the study took place in four parts during the 1982-83 academic year. In part I, 133 teachers completed questionnaires; one version covered goals in mathematics education, the other, science education goals. Part II centered on observations in the classrooms of 43 teachers, a subset of the group from part I. In the third part, questionnaires were collected from the students enrolled in the observed classrooms. For the final part, achievement test scores for these students were drawn from school records. Parts I and II involved teachers primarily; parts III and IV focused on students.

THE DATA ON TEACHERS

Measuring Teacher Goals

The questionnaire on goals was developed, pretested, and revised during the 1981-82 academic year. Based on statements in the literature on mathematics and science objectives and items in existing instruments, I devised a form to assess (1) the objectives the respondents endorsed and (2) respondent views on the characteristics of strong pre-college mathematics and science programs. With reference to objectives, the items sought to distinguish between an emphasis on skill--in computation, for example--and one on conceptual understanding. There were items as well which asked about the importance of equity as an outcome of mathematics and science education at the pre-college level. The last set of items in the questionnaire covered the background of the

respondent: educational level, years of teaching experience, gender, and race/ethnicity. A group of 20 teachers served as respondents in the pilot test of the instrument.

Of the 133 teachers who completed the final instrument, 73 taught mathematics and 60 taught science. They represented 14 schools in five different districts: 3 middle schools, 6 junior high schools, and 5 senior high schools. In terms of background characteristics, women outnumbered men: 65 percent of the 133 respondents were female. More whites--68 percent--than blacks served as respondents.

The data from the goals questionnaire were handled in several ways. First, all of the data from the mathematics teachers--and separately, from the science teachers--were aggregated and reviewed for the patterns they might contain. Chapter 3 describes those patterns. Second, the information on the teachers whose classrooms were observed was extracted from the larger body of material. I compared the extracted responses with those for the entire group, and I looked at the former responses in connection with the observational and student data.

Analyzing Classroom Practices

Part II--the classroom observations--and the other two parts concentrated on eleven of the fourteen schools from which the respondents to the goals questionnaire had come. The eleven schools--two middle schools, five junior high schools and four senior high schools--covered four separate school districts (see Table IIA). One of the districts, located in a metropolitan area in the Southcentral United States, contained two of the senior high schools and one of the junior high schools. Another district, covering both a suburban and

TABLE IIA
TEACHERS IN STUDY

Participation	Mathematics Teachers	Science Teachers	Total
Completed Goals			
Questionnaire Only	50	40	90
Completed Questionnaire			
Participated in Observation Study	23	20	43
TOTAL	73	60	133

rural populace in the Southeast, had two of the junior high schools. An urban district, also in the Southeast, was the site for one of the senior high schools and two junior high schools. The fourth senior high school and both of the middle schools were found in a medium-sized Midwestern city. The schools differed in size and racial composition (see Table IIB).

The design called for participation by two mathematics teachers and two science teachers in each school. Observations would be carried out in two different classes taught by each teacher, and all of the students in those classes would complete the attitude/perception questionnaire. Forty-three teachers--23 in mathematics and 20 in science--participated in all phases of the study. Sixty-two different classes taught by these teachers were observed three times during a semester; another 15 were observed twice.

The classes covered an array of subjects in mathematics and science. Because course titles did not always cover the same content from one school to the next, we grouped classes into one of three levels, depending on the prerequisites or intended student population. Level I courses are those designed for students performing near or at grade level. Level II consists of courses for students somewhat above grade level. Level III refers to advanced courses. In this system, algebra I would represent a level II course if taught to ninth grade students but a level III when seventh graders were enrolled.

The observations took place in October, November, and December. Prior to each visit to the classroom, the observer held brief discussions with the teacher on the course, the students, and any other

SCHOOLS AND STUDENTS IN STUDY

Participating Schools	School		Students					
			Questionnaires			Achievement Data		
	Total Enroll- ment	Percent Minority	Math Students	Science Students	Total	Math Students	Science Students	Total
<u>Senior High Schools</u>								
Alpha High School	2067	24.2	175	116	291	173	115	288
Beta High School	1898	57.5	101	94	195	95	90	185
Gamma High School	1161	100.0	109	26	135	106	26	132
Delta High School	651	23.6	77	64	141	76	63	139
<u>Junior High Schools</u>								
Epsilon Junior High	1489	63.9	61	85	146	71 ¹	70	141
Zeta Junior High	568	4.6	47	79	126	46	78	124
Eta Junior High	539	21.7	66	55	121	44	68 ¹	112
Theta Junior High	647	43.4	73	71	144	61	81 ¹	142
Iota Junior High	731	8.6	262	84	346	261	82	343
<u>Middle School</u>								
Kappa Middle School	572	35.1	141	41	182	136	40	176
Lambda Middle	576	22.4	43	56	99	42	56	98
TOTAL			1155	771	1926	1111	769	1880

¹The number of students with achievement test scores exceeds the number completing questionnaires because some students in the classrooms failed to fill out the questionnaire.

information the teacher deemed pertinent. The observers followed this schedule:

October: Observer contacts each teacher to find out about classes and students.

Observer visits teacher's classes to conduct trial observations.

Observer visits classes to conduct final observations.

November: Observer contacts teacher to find out about progress of classes and to arrange observation visit.

Observer conducts observations.

December: Observer contacts teacher to find out about progress of the classes, to arrange observation visit and to arrange brief interview.

Observer conducts observations and a formal interview with the teacher.

The classroom observations centered on the teacher's instructional and interpersonal behavior. To be explicit, the observational instrument that was developed for the project required the observer to record the level of the information given to the class (product or "what" information versus process or "why" information); the target of the information presented by the teacher; the nature and tone of the teacher's response to student questions; and the teacher's observations about the usefulness and difficulty of the subject. The observer recorded as well information on assignments given, sources used, and methods employed.

Six observers worked with the project. One, a substitute mathematics teacher in one of the selected districts, carried out the

observations in the three participating schools in that district. A second substitute teacher covered one of the junior high schools. Three of the observers held college faculty posts; two taught at the same institution. One of them, a professor of science, observed the science classes in the three schools drawn from his district. The other, a mathematics professor, attended the mathematics classes in the same schools. The third college teacher had responsibility for the mathematics and science classes in a senior high school. Finally, the research assistant for the study, Michele Trepanier, collected the classroom data in two of the junior high schools.

The instruction to the observer emphasized teacher communication: the content or type of material communicated; the method or methods used for communicating it; and the style of the communication. The observer was instructed to attend to subject-related communication, not matters centered primarily on classroom management or non-subject related interaction. The observer had to begin by determining in which of four categories the communication fell: giving information, asking questions, responding to student questions or directing student behavior. If the behavior fell outside of these categories it was to be coded as "other."

Once the category was chosen, the observer had to note certain things about the behavior. If the teacher was giving information, then the following needed to be established: (1) the target for that information (the entire class, some part of the class, or a single student); (2) the method used--lecture, discussion, demonstration, other; and (3) the level of the information. The last differentiated between "product" or descriptive information, and "process" or

conceptually-based information. Similar details were provided for the other three categories. The observers were asked to remain alert to all classroom encounters and to collect any materials the teacher distributed.

Although all of the observers had received the same instructions and I kept in contact with them throughout the observational phase, I realized that the reports possibly would vary from one observer to the next. Thus, I began the analysis by aggregating the data by observer; no noteworthy differences stood out. There was little reason, then, to question the reliability of the data. In the next step I looked at the data points for each teacher to see if a profile or pattern emerged. I then compared profiles for a subject area--all mathematics teachers were compared against one another, for example--and for a school. Finally, I related these profiles to the information from the goals questionnaire and the student data.

THE DATA ON STUDENTS

The third and fourth parts of the project centered on students. Concretely, I gathered information on student attitudes and achievement.

Student Attitudes and Perceptions

The data on student perceptions come from responses to a questionnaire, one given to mathematics students, and a related version to science students. The questionnaire covered attitudes to the subject in general and perspectives on the class in which it was distributed. It contained a set of fixed-choice items and two open-ended questions.

The two open-ended questions asked: "What do you like most about this class?" and "What do you like least?"

Eight of the participating teachers, seven of whom taught mathematics, allowed us to distribute questionnaires in their non-observed classes as well as in the ones we observed. Consequently, the number of students who filled in the questionnaire (1,926) exceeds the number who were in the observed classrooms (1,556).

Nearly six of every ten who completed the questionnaire was enrolled in a mathematics class. Females comprised 52 percent of the mathematics students and 53 percent of the science students. Almost seventy percent of the students in mathematics and nearly 73 percent of the students in science were white; most of the other students were black.

I drew on the research of Brush (1980), Armstrong (1982), Fennema and Sherman (1977), and Hilton and Berglund (1974) in creating the student questionnaire. Paralleling that research I developed six scales from the fixed-choice items: enjoyment of the subject, usefulness of the subject, easiness of the subject, and support for the study of the subject from teachers, parents, and peers.

Each scale contained at least two items: the scales and their content appear below. One of five responses could be given for each item: agree strongly (score: 5), agree somewhat (4), uncertain (3), disagree somewhat (2), disagree strongly (1). I averaged the responses to obtain a mean scale score; on each scale, then, scores could range from 1.00 to 5.00. In addition, I reversed the scoring on negatively worded items to make high scores reflect positive views. The six scales tapping attitudes to the subject follow.

Enjoyment of subject

Mathematics [science] is fascinating and fun.

Mathematics [science] lessons bore me. (This item was reversed for scoring).

I enjoy working on mathematics [science] problems.

I do not enjoy working on mathematics [science] problems. (This item was reversed for scoring).

Usefulness of subject

I expect to have little use for mathematics [science] after I finish high school. (This item was reversed for scoring.)

Knowing mathematics [science] will help me get a good job.

Mathematics [science] is a worthwhile and necessary subject.

Taking mathematics [science] is a waste of time for me.

Easiness of subject

Mathematics [science] has been my worst subject. (This item was reversed for scoring.)

I am sure that I can learn mathematics [science].

I'm not the type to do well in mathematics [science]. (This item was reversed for scoring.)

Anyone can learn mathematics [science].

Teacher support

My teachers have encouraged me to take all of the mathematics [science] I can.

My teachers do not expect me to get good grades in mathematics [science]. (This item was reversed for scoring.)

Parent support

My parents do not encourage me in my study of mathematics

[science]. (This item was reversed for scoring.)

My parents do not think of me as being good in mathematics

[science]. (This item was reversed for scoring.)

My parents expect me to do well in mathematics [science].

My parents think that I am smart in mathematics [science].

Peer support

My friends think mathematics [science] is an important subject.

My friends look down on people who get good grades in
mathematics [science]. (This item was reversed for scoring.)

The questionnaire asked students to reflect on themselves and on the classroom. The classroom measures reproduced ones other researchers had tested. Walberg and others (Walberg and Anderson, 1968; Walberg, 1969; Anderson, 1970) have developed the Learning Environment Inventory (LEI), a series of scales which assess views on the attitudes and behaviors of one's classmates. The apathy scale measures perceptions of student concern for the class as a whole. An illustrative item from that scale: "Members of the class do not care what the class does." The friction scale has to do with divisiveness in the classroom, as illustrated by this item: "Certain students are responsible for petty quarrels." Haladyna and his associates (1983) have examined three aspects of the classroom environment: the social-psychological climate, teacher quality--as the students perceive it, and classroom management/organization.

My questionnaire included items that fit within two broad categories: perception of classmates, and perceptions of teachers.

Perceptions of classmates

Most of the students in this class enjoy it.

Most of the students in this class pay close attention while the teacher is talking.

Students in this class don't do much work. (This item was reversed for scoring.)

Perceptions of teacher

The teacher takes a personal interest in each student.

The teacher encourages students to present their own ideas.

I did not create scales for these items but looked instead at response patterns for each one.

The data analysis for the questionnaire responses followed two strategies. In the first, I pooled the data for all respondents from one of the subject areas--mathematics, for example--and analyzed the responses on the basis of student gender, ethnicity, and grade level. The second strategy produced results at the classroom level. To relate teacher goals and classroom communication to student perceptions, it was necessary to have measures at the level of the classroom for each of these components.

To supplement the quantitative data, I reviewed responses to the two open-ended questions: "What do you like most about this class?" and "What do you like least?" We looked especially at the extent and nature of comments about the teacher and classmates. Although these questions were optional, most students answered them. Of the 1,155 mathematics students who completed questionnaires, 1,103--over 95 percent--indicated at least one aspect of the class that they liked; the number responding to the dislike question was only slightly smaller: 1,022. The response rates were even higher among the science students: 96 percent of the science respondents answered the first question and 92 percent, the

second. The high response rate suggests that the patterns evident are generalizable to the entire sample.

Multiple responses were possible but infrequent. Consequently, the total number of items identified as "like" responses among mathematics students (1,567 responses) was not substantially higher than the number of respondents (1,103). For science students the number of responses on the first question (1,150) was about one and one-half times the number of respondents.

We coded up to three responses per person, organizing the responses first into very detailed codes, and then grouping them into larger categories. For the present analysis, we used eight of these larger categories; the labels and representative items are as follows:

(1) Responses having to do with the teacher

Aspects liked:

"The way she [the teacher shows us and gives us the chance to ask questions." (mathematics student)

"The teacher explains the answers well." (mathematics student)

"[The teacher] takes time to explain and helps you when you need it." (mathematics students)

"My teacher is real up front." (mathematics student)

Aspects disliked:

"When the teacher calls me sweetheart." (science student)

"The teacher." (science student)

"The teacher does not discuss much of what is in the chapters." (science student)

"The teaching in here is very poor." (science student)

(2) Responses having to do with the subject or content of the class

Aspects liked:

"I like working with variables." (mathematics student)

"I like math in general."

"The chapter on the reproductive system."

Aspects disliked:

"Fractions."

"Doing word problems."

"The chapter on minerals."

"The math part of chemistry."

(3) Responses pertaining to the work requirements for the class

Aspects liked:

"I usually don't have much homework." (science student)
 "The tests." (science student)

Aspects disliked:

"I don't like the really long assignments." (mathematics student)
 "Homework is what I like the least." (mathematics student)
 "Taking end of the chapter tests." (science student)

- (4) Responses pertaining to the students in the class

Aspects liked:

"I like the way everyone pays attention so that we can get through." (mathematics student)
 "[The class] is nice and friendly all the time." (mathematics student)
 "I like being in class with all my friends." (science student)

Aspects disliked:

"Some of the students don't belong here it seems." (mathematics student)
 "The way just a few people disturb the class. I think they should be put out of the class." (mathematics student)
 "Some of the students don't take science seriously."

- (5) Responses having to do with the materials, equipment or resources for the class

Aspects liked:

"The book." (mathematics student)
 "Reading the book." (science student)

Aspects disliked:

"I would change the lack of supplies." (mathematics student)
 "The books. They're too thick and too long." (science teacher)
 "The films. They were boring and outdated." (science student)

- (6) Responses having to do with laboratory or discussion periods

Aspects liked:

"I like it when we have open class discussion because I learn better." (science student)
 "The labs we do."
 "The interesting experiments we have done." (science student)

Aspects disliked:

"Not talking about the assignments enough." (science student)
 "We don't get to do experiments."
 "I hate experiments."

- (7) Undifferentiated responses

Aspects liked:

"There isn't anything I can think of that I don't like about this class." (mathematics student)
 "In this class everything for me is okay." (mathematics student)
 "I like everything about this class no matter what we do." (science student)

Aspects disliked:

"I really don't like anything about this class."

(mathematics student)

"I hate everything about science."

(8) Other responses

Aspects liked:

"I like the way everything fits in. There's a place for everything we learn." (mathematics student)

"I am learning something useful." (science student)

Aspects disliked:

"Having to learn about things I'll never benefit from."

(mathematics student)

"I don't like science this early in the morning."

"When we have to leave at the end of the period."

(mathematics student)

Student Performance

For student performance we obtained achievement test scores, and first and second semester grades for the given mathematics or science class through which the student was included in the sample.

Achievement test data. The eleven schools used versions of four standardized achievement tests: the Comprehensive Test of Basic Skills (CTBS), the California Achievement Test (CAT), the Stanford Achievement Test (SAT), and the Stanford Test of Academic Skills (TASK). Not all of the tests covered the same components. The information we collected and the relevant tests follow:

Reading vocabulary - CTBS, CAT, SAT

Reading comprehension - CTBS, CAT, SAT

Reading total - CTBS, CAT, TASK

Spelling - CAT, SAT

Mathematics computation - CTBS, CAT, SAT

Mathematics concepts - CTBS, SAT

Mathematics application - CTBS, SAT

Mathematics total - CTBS, CAT, SAT, TASK

Science - SAT

Chapter IV summarizes the achievement results, emphasizing in particular those for mathematics. Three facts should borne in mind. First, the analyses are based on national percentile rank, not on raw score; percentiles were the most commonly used measure across the various schools and tests. Second, when the results are reported for subtests--mathematics computation, for example--the sample size drops, for fewer students had a subtest score than had a total score. Third, comparisons have been drawn across tests. Yet, the items from one test to another need not be strictly comparable. Hence, the findings may be suggestive only.

The achievement data came from school records. We obtained information for 1,880 students from the classes in which questionnaires were distributed (see Table IIB). In a few instances, the achievement data could not be matched to a respondent because the individual had not filled out a questionnaire. In still other instances, a respondent had no test score. But there were fewer than 100 cases in which one piece of the data--the questionnaire or the achievement information--was missing for an individual.

During the 1983-84 academic year, we summarized the attitudinal data--based on the enjoyment, easiness, and support scales--and the achievement data for each of the participating teachers and schools. The report to each teacher contained three parts: a brief overview of the study and the procedures that yielded the results; a summary of the overall results--first, for all participating schools and then for the

teacher's school; and a summary for the given teacher's classes. The principal received a report containing only the first two parts.

The report to each mathematics teacher provided three pieces of information on student attitudes: the mean score on each of the six scales for all 1,155 mathematics students in the study; the mean score for the mathematics students who participated from the teacher's school; and the mean score for each of the teacher's classes included in the study. Parallel procedures were followed for science teachers and in the provision of information on achievement test performance.

Course grades. At the end of the first half of the school year, each of the 22 teachers represented in the study was asked to submit student grades. The request was repeated at the end of the second half. All grades were converted to a six-point scale, with a failing grade valued at one point and the highest, at six points. There were then, two grades included in the analyses.

As with the data on attitudes, I analyzed the achievement data at the level of the full sample, paying attention to race, gender and other characteristics, and at the level of the classroom. Chapter IV summarizes the results at the first level; Chapter V covers the second.

OTHER SOURCES OF INFORMATION

My information on the classrooms, students, teachers, and schools extends beyond the details contained in the questionnaires, the observer reports, and the performance data. I visited each school at least twice; in my initial visit I discussed with the teachers, principals, counselors and others my plans and identified possible participants.

The visits and discussions helped me understand the academic program, the clientele of the school, and the nature of the teaching staff.

We obtained descriptive information--on the size of the district, the test scores for all district schools, and the course offerings--from district administrator's offices. Teachers provided their lesson plans, tests and handouts.

The observers spent time outside of the classrooms talking with the participating teachers and with other school personnel. Their impressions have contributed to the interpretations on teacher goals that this report offers.

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Chapter III

MATHEMATICS AND SCIENCE TEACHERS AND THEIR INSTRUCTIONAL GOALS

THE IMPORTANCE OF CONCEPTUAL LEARNING

The teachers in the study shared certain teaching objectives. They agreed with one another that education in mathematics and science should emphasize the development of reasoning ability; that it should not focus merely on skill development or rote memorization. This trend appears in the responses to several of the items in the teacher goals questionnaire. One of the items asked teachers to rank different objectives for mathematics and science instruction. Most of the mathematics teachers placed in the first or second rank: "teaching students to understand basic mathematical concepts" (see Table IIIA). Those who wrote in additional responses often stressed conceptual and reasoning development. One teacher indicated that she emphasized: "Having students learn to reason and think critically."

An item which asked teachers to weigh different objectives indicated further the interest in reasoning and conceptual understanding. Mathematics teachers were asked: "Which is more important: (1) having students learn to reason and think critically, or (2) having them learn basic terminology and rules?" Although one-quarter of the respondents answered "both," the largest proportion (66 percent) chose the first option (see Table IIIB).

The other area of substantial consensus had to do with the kinds of students on which instruction should focus. The mathematics teachers concurred that pre-college education should provide students the skills

TABLE IIIA
RANKING OF VARIOUS EDUCATIONAL OBJECTIVES¹

OBJECTIVE	HIGHEST RANK			LOWEST RANK		
	1	2	3	4	5	(N)
<u>Mathematics teachers</u>						
Proving students a foundation for studying higher mathematics	13%	13%	16%	15%	42%	(67)
Instilling a positive attitude toward mathematics	32	7	25	30	7	(73)
Having students perform mathematical operations accurately	30	32	18	15	5	(73)
Teaching students an understanding of basic mathematics concepts	41	26	18	7	8	(73)
Having each student see the personal relevance of mathematics	14	16	16	23	30	(73)
<u>Science teachers</u>						
Providing students a foundation for studying advanced science courses	12%	20%	13%	35%	20%	(60)
Instilling a positive attitude toward science	33	23	22	17	5	(60)
Having students carry out laboratory experiments successfully	3	5	17	25	50	(60)
Teaching students an understanding of basic concepts and principles in science	33	23	32	10	2	(60)
Having each student see the personal relevance of scientific knowledge and skills	32	28	13	12	15	(60)

¹The results are for all of the teachers in the study: those who were observed as well as the ones who only completed the questionnaire.

TABLE IIIB

DISTRIBUTION OF RESPONSES TO SELECTED GOALS QUESTIONS

PERCENT FOR EACH RESPONSE

	<u>Option 1</u>	<u>Option 2</u>	<u>Both</u>	(N)		
Which is more important to you: (1) having students learn to reason and think critically, or (2) having them learn basic terminology and rules? ¹	66%	8%	26%	(73)		
Which is more important to you: (1) having students understand the social relevance of science, or (2) having them recall fundamental principles in science? ²	39	30	31	(61)		
	<u>Disagree strongly</u>	<u>Disagree somewhat</u>	<u>Undecided</u>	<u>Agree somewhat</u>	<u>Agree strongly</u>	(N)
The major function of advanced math courses should be to prepare students for college mathematics. ¹	3	18	9	30	41	(73)
The major function of advanced science courses should be to prepare students for college science. ²	8	10	13	48	21	(61)
Mathematics consists more of ideas and principles than of formulas and procedures. ¹	7	31	19	26	17	(73)
Science consists more of ideas and principles than of formulas and procedures. ²	3	12	17	40	28	(60)
One of the most important reasons for studying mathe- matics is that it helps students think according to strict rules and procedures. ¹	6	26	11	43	14	(72)
I give greater attention to noncollege bound than to college-bound students						
Mathematics teachers	-	23	5	51	20	(73)
Science teachers	34	22	17	14	14	(59)

¹Mathematics teachers²Science teachers

for further study in mathematics. Nearly three-quarters endorsed the statement "The major function of advanced mathematics courses should be to prepare students for college mathematics." Over half reported that in their classes they gave greater attention to college-bound than to non-college bound students. This pattern existed even among those teachers assigned to level one courses.

The science teachers also chose responses which stressed conceptual skill. For more than half of the respondents, the goal--"having students understand basic concepts and principles in science"--ranked first or second (see Table IIIA). The percentage of science teachers who answered that science courses should prepare students for college science fell only slightly below the proportion of mathematics teachers who had given a similar response for their subject area (see Table IIIB).

DISSENSUS AMONG MATHEMATICS AND SCIENCE TEACHERS

I uncovered little variation in the reports teachers gave on the importance of conceptual skills and their emphasis on those skills. But there were other items on which disagreements appeared. One of these had to do with the stress that should be placed on fostering positive attitudes towards mathematics and science. A significant proportion of the mathematics teachers ranked first among the five goals: "Instilling in students a positive attitude toward mathematics." These teachers were likely to rank as second most important: "Having each student see the personal relevance of mathematics learning." The same trend prevailed for the science teachers.

Mathematics teachers differed on the importance of an emphasis on procedures. Teachers were given the statement: "Mathematics consists more of ideas and principles than of formulas and procedures." About 40 percent disagreed with the statement while a similar fraction (43 percent) accepted it; the remainder were undecided. One-third disagreed and over half agreed that "one of the most important reasons for studying mathematics is that it helps the student learn to think according to strict rules and procedures" (see Table IIIB). Persons who accepted the position that mathematics instruction should emphasize ideas more than procedures, tended to reject the statement that the study of mathematics promotes thinking according to rules and procedures.

Among science teachers, the issue of the relevance of science for the student drew varying reactions. Teachers were asked: "In the science classes you teach, which is more important to you: (1) having students understand the social relevance of science, or (2) having them recognize and recall fundamental principles in science?" One-third answered "both are equally important;" the others split between the alternatives. Individuals who chose the first alternative were less likely than others to rank highly the idea that precollege science education should provide students the foundation for advanced study in science.

The responses from the full set of teachers indicated that two different orientations existed: an emphasis on student attitudes, and an emphasis on knowledge of facts and procedures in the subject area. The emphasis on the former included the view that the attitudes of students needed to be nurtured; information on the uses of the subject

should be transmitted. The results for the teachers in the observational phase of the study corroborated those for the entire sample. Among the 23 mathematics teachers whose classes we observed, one-quarter ranked the development of favorable attitude first in importance while one-third placed it in fourth place among the five possibilities. The teachers were asked: "Which is more important: (1) having students become proficient in performing calculations, or (2) having students see the relationship to mathematics to their other courses?" Six of the twenty-three respondents could not distinguish between the two, nine chose the first response, and eight chose the second. On the matter of whether mathematics consists primarily of ideas and principles or of formulas and procedures, nine opted for the emphasis on principles while an equivalent number made the other choice. The related question to science teachers--science as ideas versus science as procedures and formulas--resulted in nearly equal choices on each side.

It was possible to place teachers into one of two categories: teachers who emphasized student attitudes, and teachers who gave greater emphasis to skill development. I shall explore these dimensions at greater length later in this chapter; but at this point, let me turn to the findings from the classroom observations.

THE TEACHING OF MATHEMATICS AND SCIENCE

Observers recorded three categories of teaching activity in the classroom: giving information--through lectures, demonstrations, or discussions--asking questions, and responding to student inquiries. For the first category, the observer determined the target of the activity--

the entire class, a segment of the class, or an individual students; for each category the observer recorded the level of the communication--whether it centered on correct answers or on the reasoning underlying answers or procedures. Observers kept track, too, of the completeness with which teachers answered student questions and the tone in which answers were given to students.

With reference to the three categories, teachers spent more time giving information to students or asking them questions than in reacting to student inquiries. This applied in both mathematics and science classes, and appears in the higher mean scores for those two categories (see Table IIIC). In transmitting information, teachers directed their attention to the entire class; whole-class instruction prevailed. The observer for an eighth grade mathematics class described it as teacher centered: the teacher assigned students to seats and conducted the dialogue which took place. A seventh grade science class had a similar evaluation; according to the observer, the teacher generated questions or discussion topics. Yet, the group of teachers as a whole seemed sensitive to student interests, if we take into account willingness to accept volunteered responses and to give considered reaction to student questions. Although teachers often directed their questions on course material to a specific student, they also allowed students to raise their hands and be recognized or to call-out the answer.

In several respects, the teaching approaches showed remarkable consistency. Teachers gave assignments--for completion in class or at home--collected and reviewed homework, prepared student for tests, and discussed test results. The series of events from one day in a first year algebra class describes other classes as well:

TABLE IIIC

MEANS FOR TEACHING ACTIVITIES AND EMPHASES
ACROSS OBSERVED CLASSROOMS

CATEGORY	MEAN SCORE ¹	
	Mathematics Classrooms	Science Classrooms
<u>Activity</u>		
Giving information:		
Entire class as target	3.56	3.59
Segment of class as target		
Individual student as target		
Asking questions:		
Individual student selected to respond	2.96	2.96
Volunteer selected to respond	3.50	1.98
Call-out response accepted	2.51	2.89
Answering questions:		
Detailed answer given	2.23	2.33
Non-detailed answer given	1.09	1.72
<u>Emphasis</u>		
Information given:		
Primarily at product level	2.02	2.36
Primarily at process level	1.01	1.44
Questions asked:		
Primarily at product level	5.81	6.52
Primarily at process level	.74	1.22

¹These scores indicate the average number of times, across the observations, that the observer witnessed the given activity or emphasis.

1. When the students entered the class their initials were around the board with a page and a problem for them to solve.
2. The teacher explained each solution and gave the class the opportunity to ask questions.
3. Students were called on to give the steps in the solution of several problems in the textbook. The teacher would call out the problem number and have students raise their hands when they had completed the problem. A student was then asked to place the problem on the board.
4. Another assignment was placed on the board, and students worked on the problems in that assignment to the end of the period.

In a seventh grade mathematics class where students were covering prime factors, the teacher demonstrated the procedure on the board, sent some students to the board to carry out some exercises, and then assigned problems to be done later on.

The Emphasis on Results

When the teachers described their own emphases, they placed the development of reasoning ability high on their lists. Yet the observers saw little emphasis on reasoning or developing a conceptual understanding. Indeed, there was consensus across the observers that the teachers tended to stress routines and rote memorization. Teachers asked questions and gave information that, in our scheme, fell within the classification: product-oriented. In both the information they transmitted and the kinds of questions they raised, teachers gave greater weight to right answers than to the processes through which solutions could be sought (see Table IIIC). Significantly, mathematics and science teachers alike displayed the tendency.

Some teachers stressed memorization of facts; others wanted the facts recorded, whether or not the student committed them to memory.

1. Define element.
2. Discuss arrangement of periodic table.
3. What does atomic number tell?
4. List 4 facts about metals.
5. List 4 facts about nonmetals.
6. Define chemically active.
7. List members of alkali metals.
8. List 5 facts of alkali metals.
9. Purpose of flame test.
10. List members of alkali earth metals.
11. List 4 facts about alkali earth metals.
12. List substances that contain alkali earth metals.

Name _____ Date _____

CHAPTER H Heat

A. Understanding Ideas

Circle the letter in front of the best answer to complete each statement.

1. In a home steam radiator, heat is given off into the room as _____.
 - a. water forms steam
 - b. water forms ice
 - c. steam forms ice
 - d. steam forms water
2. Heat conduction in solids is high because molecules _____.
 - a. are close together
 - b. are far apart
 - c. are not present
 - d. are too dense
3. Heat transfer from our sun through space occurs by _____.
 - a. conduction
 - b. convection
 - c. radiation
 - d. all of these
4. If it takes 1000 calories to change the temperature of 1 kg of water 1°C, how many calories are needed to change 2 kg of water 1°C?
 - a. 2
 - b. 2000
 - c. 200
 - d. 1
5. Heat energy moves through solids by _____.
 - a. conduction
 - b. convection
 - c. radiation
 - d. none of these
6. Heat energy produced by foods that are eaten comes from _____.
 - a. fossil fuels
 - b. a physical change
 - c. a chemical change
 - d. none of these
7. Heat is produced by _____.
 - a. temperature
 - b. molecular motion
 - c. calories
 - d. convection
8. Temperature is a measure of _____.
 - a. molecular kinetic energy
 - b. temperature change
 - c. heat loss or gain
 - d. all of these
9. During convection, heat is transferred by _____.
 - a. solids
 - b. insulators
 - c. movement of heated matter
 - d. temperature
10. Insulation is effective in _____.
 - a. moving heat quickly from an area
 - b. reducing the heat
 - c. blocking heat transfer
 - d. increasing the heat
11. When heat is removed from water _____.
 - a. ice is formed
 - b. water evaporates
 - c. conduction occurs
 - d. radiation occurs
12. Heat of _____ is required to change a liquid to a gas.
 - a. fusion
 - b. vaporization
 - c. convection
 - d. conduction

Name _____ Date _____

B. Interpreting Ideas

Match each of the following statements with the letter of the correct choice. Write the correct letter on the line to the right of each statement.

A. Conduction B. Convection C. Radiation

- 1. Means of heat transfer through metals. 1. _____
- 2. Transfer of heat because of changes in density of heated material. 2. _____
- 3. Transfer of heat through a vacuum. 3. _____
- 4. Transfer of heat through liquids and gases. 4. _____
- 5. Molecules move from a heated area to a cooler area. 5. _____
- 6. Heat from the sun. 6. _____
- 7. Transfer of heat through air, glass, water, and a vacuum. 7. _____
- 8. Transfer of heat from molecule to molecule. 8. _____
- 9. Transfer of heat in the atmosphere. 9. _____
- 10. The emission of heat from a hot metal bar to its surroundings. 10. _____

Determine whether each of the following statements is true or false. Write the word true or false on the line to the right of each statement.

- 11. All substances in the universe are in motion. 11. _____
- 12. Heat always travels one way, toward cold areas. 12. _____
- 13. Temperature measures the heat in a body. 13. _____
- 14. The specific heat of a substance can be expressed in calories. 14. _____
- 15. Matter with a lower specific heat will heat slower than matter with a higher specific heat. 15. _____
- 16. If enough heat of fusion is added to an ice cube, it melts. 16. _____
- 17. Heat of fusion is required to change a liquid to a gas. 17. _____
- 18. Plastic foam is a very good conductor of heat. 18. _____
- 19. Our atmosphere serves as an efficient insulator. 19. _____



Name _____ Date _____

D. Completing Ideas

Fill in the blanks correctly. Do not use any word more than once.

- | | | | |
|------------|------------|-----------|---------------|
| calories | fusion | mass | specific heat |
| cold | heat | molecule | temperature |
| conduction | insulation | radiation | vaporization |
| convection | kinetic | rises | warm |
| cooler | liquids | solids | |

(1) _____ is a form of energy which warms the world. It comes from molecular energy. Molecules move and their (2) _____ energy is heat. Scientists use (3) _____ to measure the amount of heat in a substance. Heat moves in one direction, from (4) _____ areas to (5) _____ areas.

Transfer of heat takes place in three ways. (6) _____ is transfer of heat by waves. (7) _____ is the movement of heat through solids, liquids, and gases. It is due to heat passing from molecule to (8) _____. Heat conduction is greatest in (9) _____ and very poor in liquids and gases. These transfer heat by (10) _____ currents which are created in the hot areas of (11) _____ and gases with movement toward the colder regions. This movement is due to warm air or gas being less dense and so it (12) _____ (13) _____, denser areas move downward. These movements create convection currents. (14) _____ reduces heat transfer by blocking, or trapping, convection currents.

Heat is measured in (15) _____. The heat required to raise the temperature of 1 g of a substance 1°C is called (16) _____. The amount of heat required to melt 1 g of a solid is known as the heat of (17) _____. The amount of heat needed to change 1 g of a liquid to a gas is called heat of (18) _____. Heat lost or gained depends on a substance's specific heat, (19) _____, and the temperature change involved.



Consider the assignments that figures I and II represent. The handouts were given in an eighth grade science course in two different schools as homework assignments. To fulfill the assignment the student needed merely to copy the answer from the textbook. The observations covered a class in which during a test the teacher allowed students to exchange information about the page on which specific answers could be found.

Any number of reasons might account for the discontinuity between teacher reports about their emphasis on conceptual development and the results from the observations. First, teaching is a two-way process: the responses of students may steer classroom encounters towards ends the teacher would not consider ideal. Often, students who report liking mathematics give as their reason: the certainty of the subject. In their view, mathematics--and sometimes science--consists of right and wrong answers; there is no shadowy territory to negotiate. It may be difficult for a teacher at the middle or later school levels to overcome an image that earlier school as well as out-of-school experiences support. Second, the respondents might have given socially acceptable answers. They need not have been committed to conceptual learning but thought that they should be. Third, teachers possibly found little support and few resources for encouraging reasoning ability. Textbooks stressed the memorization of facts; the competency-based tests which some of the systems had instituted did not assess reasoning; indeed most evaluation strategies assessed factual knowledge. Finally, there is no consensus among specialists on the nature or teachability of cognitive or conceptual skill. If cognitive scientists and educators find the terrain muddy, teachers likewise find it difficult to traverse.

Variations among Teachers

Some important differences emerged among the teachers, however. There were teachers who sought deliberately to reach all students and to emphasize the importance of the subject for personal development. In an algebra 2 class, for example, the teacher made a point of relating the topic taught to "college and life in general;" the teacher maintained to the students that the topic was within everyone's reach and was in fact not at all difficult. A ninth grade science teacher expressed concern about and interest in each of her students, indicating to them the value of the material being covered, its usefulness for other school subjects, and the ease with which it could be learned. That class differed significantly from another ninth grade science class in the same school, taught by another teacher. In the second class, only a handful of students tended to participate; the teacher made little effort to include all of the students in the discussions.

Teachers sometimes varied their approaches according to the course being taught or the number of enrollees. But overall, each teacher retained certain emphases across class periods and across courses. A junior high school teacher emphasized class participation in her seventh grade mathematics class and in her ninth grade geometry course. A high school chemistry teacher taught both of the chemistry one courses with a rather remote manner. He asked questions and then proceeded with his lecture whether or not the students responded.

Importantly, the two orientations which appeared from the questionnaire responses emerged from the observations as well. There were teachers who gave attention to student attitudes. The observer for the ninth grade science class, mentioned earlier, described

the teacher as "very caring" and helpful to all students on an equal basis. The teacher expressed concern for everybody. A high school biology class had a teacher who fostered group work. The observer wrote of one class period: "Students were directed to work in small groups. During the lecture students took notes without being told so. Students' group work was observed by the teacher working around the room."

Other teachers emphasized the inculcation of information. A seventh grade science teacher usually directed her questions--centered on factual information--to a given student. Students rarely raised questions in one of the pre-algebra classes. Often, the teachers who highlighted factual knowledge sought to relate that knowledge to college requirements. This occurred most frequently among high school teachers, but there were instances as well in which teachers below that level discussed the material in the context of the college years.

The teachers who displayed an interest in student attitudes through their questionnaire responses showed the same orientation in their classroom activities and emphases. The same pattern obtained for inculcation of information. There was, then, a convergence between the questionnaire and the observations on the theme that some teachers emphasized student orientations while others stressed student knowledge.

CHAPTER IV
THE ATTITUDES AND ACHIEVEMENT OF MATHEMATICS
AND SCIENCE STUDENTS

ATTITUDES TOWARDS MATHEMATICS AND SCIENCE

The six attitude scales used in this study--enjoyment of the subject, perceived usefulness of the subject, perceived usefulness of the subject, and support from others--had appeared on several earlier inquiries. Some of those studies had found male-female differences on these dimensions. Consider the findings on support from parents, teachers, and peers. The MacCorquodale (1983) survey of Mexican American children and their parents determined that parents of girls were less likely to encourage actively the work in mathematics of their offspring than were parents of boys. The girls were likely to view mathematics as worthwhile and useful, but they also responded that boys do not like girls who outperform them in mathematics and science. Significantly, the boys were even more inclined than the girls to believe that a man would be uninterested in marrying a woman who wanted to become a scientist or mathematician. Gender differences appear as well in the research on perceived utility, difficulty, and attractiveness of mathematics and science (see Brush, 1980; Armstrong, 1981; Fennema and Sherman, 1977).

But there were no systematic differences between males and females in my sample. Nor were there racial differences or differences related to age. Indeed, responses to all of the scales rather uniformly were positive. Students tended to perceive mathematics and science as

enjoyable, useful, and relatively easy. The respondents--regardless of gender, ethnicity, age, or grade--saw their teachers, parents and peers as quite supportive (see Table IVA). The scores from science students fell slightly below those for mathematics students. Yet the gap was not wide. Generally, responses to science were not greatly different from responses to mathematics for this sample.

Interestingly, others have also uncovered quite favorable views of these subjects among pre-college students (Matthews, 1981; Anick, et al., 1981). Moreover, there are some indications that students have become increasingly positive about mathematics and science (Dutton, 1968).

The findings might seem to imply that the attitudes and perceptions were neither problematic nor pivotal in the mathematics and science education of our subjects. That conclusion may overstate the case, for two reasons. First, the fact that the students consistently ranked peer support lower than support from parents and teachers suggested that there might have been peer-centered problems for several of the students. Second, the items on support were rather abstract. I realized that if the questions were related to a specific context--the classroom in which the questionnaire was distributed--the responses on teacher and peers might differ from the ones given for the more general questions.

Perceptions: The Classroom Context

To determine whether responses varied when the context was specified, I looked at five items that asked about peers and teacher in the target classroom. The first of these was: classmates' enjoyment of

TABLE IVA
 PERCEPTIONS OF SUBJECT AND OF SUPPORT FROM OTHERS, ALL RESPONDENTS

SCALE ¹	STUDENTS BY SUBJECT AREA			
	<u>Mathematics Students</u>		<u>Science Students</u>	
	Mean	Standard Deviation	Mean	Standard Deviation
Personal enjoyment of subject	3.52	1.00	3.60	.83
Perceived usefulness of subject	4.28	.63	3.38	.77
Perceived easiness of subject	4.02	.76	3.85	.76
Perceived teacher support	4.13	.79	3.83	.83
Perceived parent support	4.06	.69	3.75	.74
Perceived peer support	3.67	.80	3.43	.81
Number of respondents	1,155		771	

¹

Scale scores could range from 1.00 to 5.00. The higher the score, the greater the agreement with the scale. Thus, a 5.00 would represent the highest level of enjoyment of the subject--mathematics or science--perceived usefulness of the subject, perceived ease of the subject, and perceived support for the study of the subject from teachers, parents, and peers.

the class. There were more students in both mathematics (mean: 3.49) and science (mean: 3.36) who agreed that their classmates enjoyed the class than disagreed (see Table IVB). But the responses to this item varied more from student to student than did responses to the items in the enjoyment, usefulness, easiness, and support scales.

I entertained the possibility that the negative responses were not randomly distributed. To explore this, I looked at classroom means for the measure: classmates' enjoyment. Four of the mathematics classes had means on this variable that were lower than the grand mean. The mean for one of those classes, designated here as class B, was less than 2.00; this indicates that class members generally disagreed with the statement that most of them enjoyed the class experience.

Six science classes emerged as somewhat distinctive. In two instances--class E (mean: 3.19) and class G (mean: 3.13)--the means were not substantially below the overall science mean (3.36) on the enjoyment item. But because negative scores were so rarely clustered at the classroom level, both E and G stood out within the larger sample.

The next review centered on trends of the classroom level for two other measures related to perceptions of peers: classmates' attentiveness, and classmates' effort. The means for one of the mathematics classes--class C--surpassed the overall mean on both measures. It seemed, then, that class C was not a setting in which negative views of classmates generally prevailed. In the other three classes, however--and especially in class B--students were not convinced that their classmates paid attention and worked hard.

The results for the science classes were consistent across all three measures of classmates' dispositions: the means for the science

TABLE IVB
PERCEPTIONS OF CLASSMATES AND TEACHER, SELECTED CLASSROOMS

CLASSROOMS	ITEM ¹				
	Classmates' enjoyment of class	Classmates' attentiveness	Classmates' effort	Teacher's interest in students	Teacher's encouragement of ideas
Mathematics					
Class A-1 (N=18) ²	2.35	2.39	3.55	1.93	2.88
Class A-2 (N=16)	2.19	2.62	2.86	2.41	2.92
Class B (N=20)	1.95	1.85	2.85	3.30	2.90
Class C (N=23)	2.74	4.18	4.30	4.22	3.39
All mathematics students	3.49	3.68	4.07	3.72	3.64
Science					
Class D-1 (N=27)	2.41	1.89	2.52	2.84	3.33
Class D-2 (N=15)	2.53	2.07	3.13	3.53	3.33
Class D-3 (N=20)	2.79	2.16	2.31	2.95	3.30
Class E (N=21)	3.19	2.29	3.24	3.81	4.13
Class F (N=19)	2.84	2.21	2.84	3.61	3.89
Class G (N=23)	3.13	2.81	2.61	3.29	3.91
All science students	3.36	3.12	3.48	3.45	3.73

¹Each of the categories is based on a single item. The score given represents the mean for that item. Scores could range from 1.00 to 5.00. The higher the score, the stronger the perception that classmates enjoy the class, are attentive to the teacher and work hard. In addition, the higher the score, the stronger the view that the teacher expressed interest in each student and encourages students to present their own ideas.

²This indicates number of respondents in the given class.

³Classes with the same letter but different numbers were taught by the same teacher.

sample as a whole were higher than the ones for these particular classes. Science classes were more likely than mathematics classes to require student interaction--laboratory work generally was done with groups; hence, the science students perhaps had greater opportunity than had the mathematics students to observe the behaviors and infer the attitudes of one another.

Two of the items referred to the teacher: the teacher's interest in the students, and the teacher's encouragement of student ideas. Most of mathematics and science students in the sample believed that the teacher expressed interest in them and readily accepted their questions and ideas; the overall means for mathematics (3.72) and for science (3.45) were high and not very different from each other.

The three mathematics classes that were somewhat negative on the classmate items also were less positive than most students on the teacher items. One of those classes (class A-1) had a mean of 1.93 on the teacher interest item; this indicates that the students in that class rated the teacher as relatively uninterested in them. They were more positive on the teacher encouragement measure, although the mean there for class A-1 (2.88) was lower than the mean for all mathematics students (3.64).

The results were somewhat mixed for the six science classes. Two of the class means on the measure "teacher interest" fell below the overall science mean, but the other four means surpassed it. Similarly, the results on the other teacher-related items were close to the mean for the science students as a whole. Two conclusions seem evident. First, classmates dispositions were viewed more negatively by these students than was teacher responsiveness. That pattern seems consistent

with the results reported earlier for the teacher support and peer support scales. Second, the students did not seem to attribute classmate inattentiveness or lack of effort to teacher disinterest or discouragement of ideas. The students were the source of concern.

It was possible that the three mathematics classes and the six science classes with relatively low scores on the classmate measures might have been unrepresentative of the larger set of classrooms. To evaluate this possibility, I scanned at the courses they covered, the schools in which they were located, the teacher who was involved, and the academic performance of the students who were enrolled. In general, the classrooms did not stand out as dissimilar to the others in the study.

The mathematics classrooms. The three mathematics classrooms included a pre-algebra class (class A-1), a class in general mathematics (A-2), and a class in first year algebra (B). Obviously, the classes were not of a common course type. Indeed, I had data on eight other pre-algebra classes, nineteen other general mathematics classes, and nine additional algebra I classes and--except in one instance (class C-1, a general mathematics class)--the responses were more positive than was typical for the three focal classrooms.

Two of the classes were within a single school. It might have been that in the given school negative perceptions of classmates prevailed. That was not the case, however; the school means for the items on classmates did not diverge from the means on those measures for the other schools. Two of the classes--A-1 and A-2--were taught by the same teacher. This implied that the results on classmates were in some way associated with teaching style. There was some evidence to support that

view. The study included two other classes taught by the same teacher, and although their means on the attentiveness items exceeded the means for classes A-1 and A-2, they were not as high as the overall student mean. Some of the comments from the students illustrate more directly the link that students from A-1 and A-2 made between classmate and teacher behavior. It was the case, too, that the students from a second class taught by the teacher of class B were somewhat negative about their classmates. But they were not as negative as were the students in her class B.

Finally, I reviewed course grades to determine if the three classrooms tended to be populated with poor performers. Recall that the study used a five point scale for grades, with A=5, B=4, C=3, D=2, and F=1. The mean for final course grade across all of the mathematics students was 3.07. The means for the three mathematics classes were not significantly different from that overall mean: Class A-1, 2.83; A-2, 2.95; and B, 3.00. The analysis of student scores in reading, based on standardized test results, indicated further that these students were similar in ability and performance to others in the sample.

The science classrooms. The science classes included three chemistry classes (chemistry 1-2: classes D-1, D-2, and D-3), a physical science class at the junior high school level for advanced students (Introductory Physical Science: class E), an elective course in biology for seventh grade students (class F), and a general science course (class G). As this should illustrate, the courses varied across grade level and field within science.

The three chemistry classes were taught by a single teacher. But the means from another chemistry 1-2 class that this teacher offered

exceeded those for the three classes listed in Table IVB. Similarly, an analysis of the responses for the teacher of class E revealed that the reactions in her second class were not as negative as those in class E. It would appear that different classes had different climates or social environments, and the teacher was not the only force producing that environment.

The mean grade, based on final grade in course, was higher across the science classes (4.01) than across the mathematics students (3.07). Consistent with that pattern, I found relatively high grade averages for four of the science classes: class D-1: 4.00; class D-3: 3.27; class E: 3.57; and class F: 3.89. The average was lower for class D-2--2.87--and quite low for class C--1.13. In the last case, over half of the students received a final grade of F. Interestingly, the students from that class were no less positive about the teacher's interest and encouragement than were students from classes with high grade averages. Again, this seems to indicate that the classes with relatively low scores on the classmate items were not settings in which poor teacher-student relations prevailed.

Results from the Open-ended Items

Responses to the open-ended items that asked about features of the classroom that the student liked and disliked help us understand the results reported so far. Let us review first the trends for the full sample and then turn to the findings for the selected classrooms.

Several of the students did not differentiate among features of the class. Some reported that they liked everything about it, while others found nothing that they liked. There were more responses that were

completely positive (10 percent of the mathematics students and 5 percent of the science students reported that they liked everything about the class) than were completely negative (4 percent of the mathematics students and 3 percent of the science students indicated that they disliked everything). A large proportion of the more remaining responses had to do with the teacher. But more students were likely to include the teacher on the list of praise-worthy features than on the disfavored list.

About one-quarter of the positive responses about the teacher given by the mathematics students were non-specific; i.e., they did not indicate what it was about the teacher that was favorable. I was able, however, to code three-quarters of the responses according to whether they referred to the instructional behavior of the teacher or to the teacher's relationship with students. Very few of the responses (10 percent of all of the responses on the teacher) referred to the latter. It appears, then, that when students reported that they liked the teacher, they had in mind the teaching strategies rather than the personableness or sociability of the teacher.

Relatively few of the mathematics students mentioned their classmates when they identified features liked, and frequently the responses were non-specific. Comments about classmates were more likely to show up on the question about dislikes, and nearly all of those responses were specific: they referred either to academic aspects or to interpersonal ones. Most of the responses (67 percent) that criticized classmates had to do primarily with academic matters: student inattention, lack of interest, poor performance. The female respondents

were significantly more likely than the males ones to criticize their classmates for academically-related reasons.

The responses of the science students usually paralleled those of the mathematics students. For the former a sizeable fraction of the favorable responses referred to the teacher; more of the responses from females (26 percent) than from males (20 percent) fell into that category. Second, the largest proportion of unfavorable responses had to do with the work requirements; no gender differences appeared for this category.

But most of the positive responses from the science students had to do with laboratory work: students tended to report favorably on the laboratory experience. As with the mathematics respondents, science students were more likely to mention their classmates when they listed their dislikes than when they cited things they liked.

Patterns in the selected classroom. The patterns of comments from the nine targeted classrooms coincide with the overall ones: comments about the teacher predominated when students noted features they liked; comments about the teacher rarely appeared among the set of dislikes; and remarks about classmates more often were negative than positive.

Consider some of the statements from class A-1, a pre-algebra class. One student indicated: "I like how the class is organized and quiet; it is easy to work in." Another reported liking the teacher because "she explains how to do the problems on the homework." Not all of the students were so positive, however. One criticized the teacher "because she doesn't let us present our own ideas and is much too strict." Others were concerned as well about the number of rules that the teacher imposed, but there was just as frequent concern about

classmates, e.g.: "[I dislike] the class interruptions, the people yelling." Complaints against classmates recurred in the general mathematics class that this same teacher offered. One student disliked "how loud everyone gets and the horse-play that goes on when we are supposed to study or do our work;" another, the fact that "everybody talks when the teacher is talking. To me that is very rude." But there were fewer complaints from another class that the teacher offered, and the comments that were made did not tend to center on classmate behavior or attitudes.

Students in the algebra I class, designated here as class B, had some negative views of the teacher; but they had even more negative comments about the students. A student disliked the fact that "some students don't pay attention, and they talk too much and always get smart with [the teacher]." Another corroborated that report, noting that "the students always talk and interrupt the teacher while she is trying to explain a problem or a question." Still a third student reported disliking "the attitudes other students have and their rudeness." Yet, students from the same teacher's algebra III course reported liking "being able to work with other students," and "the challenge that each student is trying to do his/her best."

It might seem that difference in the level of the course would explain the greater concentration of negative comments for class B than for the other class handled by the same teacher. The results from the science classes do not confirm that assumption, however. Chemistry was an advanced course, and the students in the chemistry classes tended to be drawn from the high end of the achievement spectrum. Yet, respondents from classes D-1, D-2, and D-3 had sharp criticisms of their

classmates. One disliked "the lack of seriousness on the part of other students;" another, "the students who disrupt the class." Still a different student contended that "the goof-offs distract me."

But the number of critical comments directed at the chemistry teacher and his performance cannot be overlooked. I found in the comments a litany of complaints about class organization and of the teacher's ability to explain the material. The following sums up many of those complaints: "Being truthful, I don't feel my teacher is able to communciate and to help students understand the difficult parts of this class." Apparently, the students in this class felt that their classmates were not highly attentive, but they attributed the inattentiveness more to teacher than to student shortcomings. Yet, the respondents from a fourth chemistry class, under the same teacher, found several positive aspects of the teacher's behavior. Admittedly, some of the comments offer rather backhanded compliments: "[I like the teacher because] he lets us get by a lot; my teacher is pretty funny." But several others listed "the teacher" as a feature of the class that they liked. It would appear from the differences between the fourth class and the classes D-1, D-2, and D-3 that the same teacher need not elicit the same reactions from different classes of students.

The results from science class F and from a second class with the same teacher illustrate the same point. Although several students in class F remarked favorably on the teacher--"the teacher is nice to the students--and unfavorably on the students--"[I dislike] the confusion and the non-organization among the students"--there were more positive comments about the teacher and the students from the second class.

I was especially interested in the responses from class G, given the high number of failures among its students. Students stated that they liked: "how friendly the teacher is;" the fact that "the teacher is a nice person" and that "she explains every question." They disliked "all the talking going on around the room;" "the way the students treat [the teacher];" and "the student behaviors." There were complaints about student behavior in a second class that the same teacher taught, e.g., "[I dislike] the students acting like they have no manners or training." but the comments about the teacher were quite similar to those from class G. Even though grades were quite low in class G, students were no more likely there than in the comparison classroom to direct their criticisms at the teacher rather than at the students.

The results from the classroom level analyses suggest that the global measures of attitudes for the sample as a whole obscure finer distinctions within schools. Chapter five builds on this theme and its links at the level of the classroom teacher goals, and teaching patterns.

Gender comparisons on perceptions of classrooms. It was clear from the open-ended items that males and females often evaluated the classroom experience differently. More of the favorable reactions from girls than from boys had to do with the teacher (see Table IVC). But there was no difference between the two in their tendency to mention their classmates. In addition, a larger fraction of the favorable responses about the teacher from the girls (65 percent) than from the boys (57 percent) had to do with instructional matters (see Table IVD).

Relatively few students mentioned their classmates when they identified features liked, and frequently the responses were

TABLE IVC
ASPECTS OF THE CLASS LIKED AND DISLIKED BY
MATHEMATICS STUDENTS: GENDER COMPARISONS

ASPECT	ASPECT LIKED			ASPECT DISLIKED		
	Boys (N=713) ¹	Girls (N=854)	Difference	Boys (N=469)	Girls (N=510)	Difference
The teacher	38.0%	45.4%	-7.4%**	10.7%	9.8%	.9%
The subject, content of class ²	14.6	12.6	2.0	14.9	13.5	1.4
The work require- ments of the class	15.7	12.2	2.5*	42.8	47.2	-4.4
The students	8.0	7.0	1.0	15.1	15.5	15.3
The materials, equipment resources, for the class	2.4	1.4	1.0	3.8	3.9	0.1
The laboratory work and discussion periods	3.1	4.9	-1.8	1.9	2.9	-1.0
All aspects	10.1	8.9	1.2	4.9	2.5	2.4
Other	8.1	7.4	.7	1.1	1.6	-.5

¹Numbers in parentheses represent total responses, not the total number of respondents.

²Includes references to specific topics or activities covered in the class.

*Difference significant at the .05 level.

**Difference significant at the .01 level.

TABLE IVD
 DETAILED RESPONSES FOR CATEGORIES "TEACHER" AND "STUDENTS"
 AMONG MATHEMATICS STUDENTS, BY GENDER

ASPECT	ASPECT LIKED			ASPECT DISLIKED		
	Boys	Girls	Difference	Boys	Girls	Difference
The teacher ¹	26.9%	21.0%	5.9%*	16.0 ^a	12.0 ^a	14.0
The teacher's instructional behavior	56.8	65.4	- 8.6*	54.0	48.0	6.0
The teacher's interpersonal behavior	10.0	10.0	-	26.0	30.0	- 4.0
The teacher, other ²	6.3	3.6	2.7	4.0	10.0	- 6.0
TOTAL	(N=271)	(N=388)		(N=50)	(N=50)	
The students ¹	33.3	51.7	-18.4	28.1	11.4 ^a	16.7
The quality, interest and performance of the students	7.0 ^a	10.0 ^a	- 3.0	57.1	75.9	-18.2**
Student-student relationships	59.6	38.3	21.0**	14.1	12.6	1.5
TOTAL	(N=57)	(N=60)		(N=71)	(N=79)	

¹The category could not be subdivided further.

²Includes comments on the teacher's background and qualifications.

^aNumber of responses smaller than 10.

*Difference significant at the .05 level.

**Difference significant at the .01 level.

non-specific. It is risky, then, to offer any generalizations about the characteristics of classmates that elicited positive responses.

Comments about classmates were more likely to show up on the question about dislikes, and nearly all of those responses were specific: they referred either to academic aspects or to interpersonal ones. Most of the responses (67 percent) that criticized classmates had to do primarily with academic matters: student inattention, lack of interest, poor performance. The female respondents were significantly more likely than the male ones to criticize their classmates for academically-related reasons.

Certain parallels with the mathematics data can be noted in the science student data. First, a sizeable fraction of the favorable responses referred to the teacher; more of the responses from females (26 percent) than from males (20 percent) fell into that category (see Table IVE). Second, the largest proportion of unfavorable responses had to do with the work requirements; no gender differences appeared for this category.

But in other respects the science data do not repeat the pattern from mathematics. For one thing, the category into which the largest fraction of positive responses fell was the one on laboratory and discussion periods. Both boys and girls tended to report favorably on the laboratory experience. For another, boys were more likely than girls to mention things that they liked about their classmates.

I also looked at the detailed responses for the teacher and student categories to determine if there were gender differences. Sixty-five percent of the favorable remarks about teachers could be coded as instructional or interpersonal. As was true for the mathematics

TABLE IVE
ASPECTS OF THE CLASS LIKED AND DISLIKED BY
SCIENCE STUDENTS: GENDER COMPARISONS

ASPECT	Boys (N=508) ¹	Girls (N=642)	Difference	Boys (N=373)	Girls (N=441)	Difference
The teacher	19.7%	26.5%	- 6.8%**	12.6%	10.6%	2.0%
The subject, content of class ²	14.6	12.6	2.0	8.0	12.7	4.7*
The work requirements of the class	7.5	9.0	- 1.5	34.3	31.7	2.6
The students	7.3	4.2	3.1*	7.8	13.8	- 6.0*
The materials, equipment, resources for the class	6.3	4.7	1.6	6.2	7.7	- 1.5
The laboratory work and discussion periods	31.5	27.4	4.1*	9.4	9.8	- 0.4
All aspects	4.9	6.7	1.8	3.2	2.5	0.7
Other	8.2	8.8	- 0.6	18.5	11.1	7.4**

¹Numbers in parentheses represent total responses, not the total number of respondents.

²Includes references to specific topics or activities covered in the class.

*Difference significant at the .05 level.

**Difference significant at the .01 level.

students, more of the responses from girls (53 percent) than from boys (42 percent) mentioned instructional issues (see Table IVF). That seemed even more evident from the critical comments--more girls than boys criticized the teacher on instructional grounds--but the results must be interpreted cautiously, in that they were based on small numbers. The numbers of students responding unfavorably on their classmates were too small for analysis.

Gender differences emerged more clearly than did racial ones in the detailed analyses of perceptions of the classroom. On the next student outcomes--achievement--the opposite obtained: racial differences outweighed racial ones.

ACHIEVEMENT IN MATHEMATICS AND SCIENCE

The discussion which follows stresses achievement in mathematics. Two reasons underlie the focus. First, educators uniformly identify mathematics as a basic subject at the pre-college level; less consensus exists on the importance of various science courses for secondary school students. Secondly, more of the schools in this study administered tests in mathematics than tests in science.

The discussion begins with a summary of the outcomes in mathematics, analyzed by race and ethnicity. It then considers correlates of the poorer test performance of the minority students. It ends with comments on the effects of allocation to courses on achievement.

TABLE IVF
 DETAILED RESPONSES FOR CATEGORIES "TEACHER" AND "STUDENTS"
 AMONG SCIENCE STUDENTS, BY GENDER

ASPECT	ASPECT LIKED			ASPECT DISLIKED		
	Boys	Girls	Difference	Boys	Girls	Difference
The teacher ¹	34.0%	20.5%	14.5%**	23.4	6.4 ^a	-b-
The teacher's instructional behavior	42.0	53.5	-11.5*	46.8	82.9	-b-
The teacher's interpersonal behavior	16.0	20.0	- 4.0*	19.1 ^a	6.4 ^a	-b-
The teacher, other ²	8.0	5.9	2.1	10.6 ^a	10.6 ^a	-b-
TOTAL	(N=100)	(N=170)		(N=47)	(N=47)	
The students ¹	40.5	40.7	- 0.2	13.8 ^a	19.7	-b-
The quality, interest, performance of the students	13.5 ^a	18.5 ^a	- 5.0	75.9	68.8	-b-
Student-student relationships	45.9%	40.7	5.2	10.3 ^a	11.4 ^a	-b-
TOTAL	(N=37)	(N=27)		(N=29)	(N=61)	

¹The category could not be subdivided further.

²Includes comments on the teacher's background and qualifications.

^aNumber of cases fewer than 10.

^bDifference not computed, given small number of cases.

*Difference significant at the .05 level.

**Difference significant at the .01 level.

Race/Ethnicity and Test Performance

Mathematics performance was measured in four areas--computation, concepts, application, and a total mathematics score. The differences were far sharper between non-minority and minority students than between male and female students, although the size of the gap varied from one subtest area to another.

On the measure, total mathematics score, non-minority females had the highest mean rank; non-minority males were next; minority males, third, and minority females, last (see Table IVG). Specifically, non-minority females had a mean rank of 66.3, and although that was only slightly higher than the mean for non-minority males (65.2), it was considerably higher than the mean for minority males (39.6) and minority females (38.4). The scores for minority students of both genders were heavily skewed toward the lower end of the spectrum (see Figure 1); in contrast, non-minority students were concentrated above the fiftieth percentile.

I compared the group means to determine which, if any, were significantly different from one another. The racial differences were highly significant but the gender differences were not. In other words, minority males and females had similar ranks, and non-minority males and females were similar, but the ranks were quite dissimilar across racial lines (see Table IVH).

Let us turn now to the results for the subtests in mathematics. There were three areas: computation, concepts, and applications. The latter two cover skills that are of greater cognitive complexity than the first area. All four groups had their highest rank on the computational subtest, but the scores were not the same across the

TABLE IVG

MEAN PERCENTILE RANKS IN READING AND MATHEMATICS
FOR MATHEMATICS STUDENTS, BY RACE/ETHNICITY AND GENDER

Test Area	Non-minority				Minority			
	Male Mean	Standard Deviation	Female Mean	Standard Deviation	Male Mean	Standard Deviation	Female Mean	Standard Deviation
Mathematics								
Total	65.5 (307)	25.9	66.3 (350)	25.0	39.6 (146)	26.6	38.4 (156)	24.6
Computation	61.5 (238)	24.9	66.8 (286)	24.2	44.4 (128)	25.0	45.7 (148)	24.7
Concepts	54.0 (110)	27.3	56.8 (128)	29.1	35.9 (103)	24.7	34.1 (134)	22.4
Application	55.5 (110)	29.5	56.8 (129)	27.3	30.5 (103)	24.6	30.6 (134)	21.4
Reading								
Total	65.1 (307)	25.4	67.4 (350)	23.8	36.0 (145)	23.1	37.6 (160)	21.6
Vocabulary	65.2 (238)	24.9	65.0 (286)	25.0	37.9 (128)	26.1	38.6 (152)	24.9
Comprehension	61.2 (238)	26.4	66.2 (258)	24.7	35.9 (128)	22.8	38.4 (152)	22.4

Figures in parentheses represent number of cases on which mean is based.

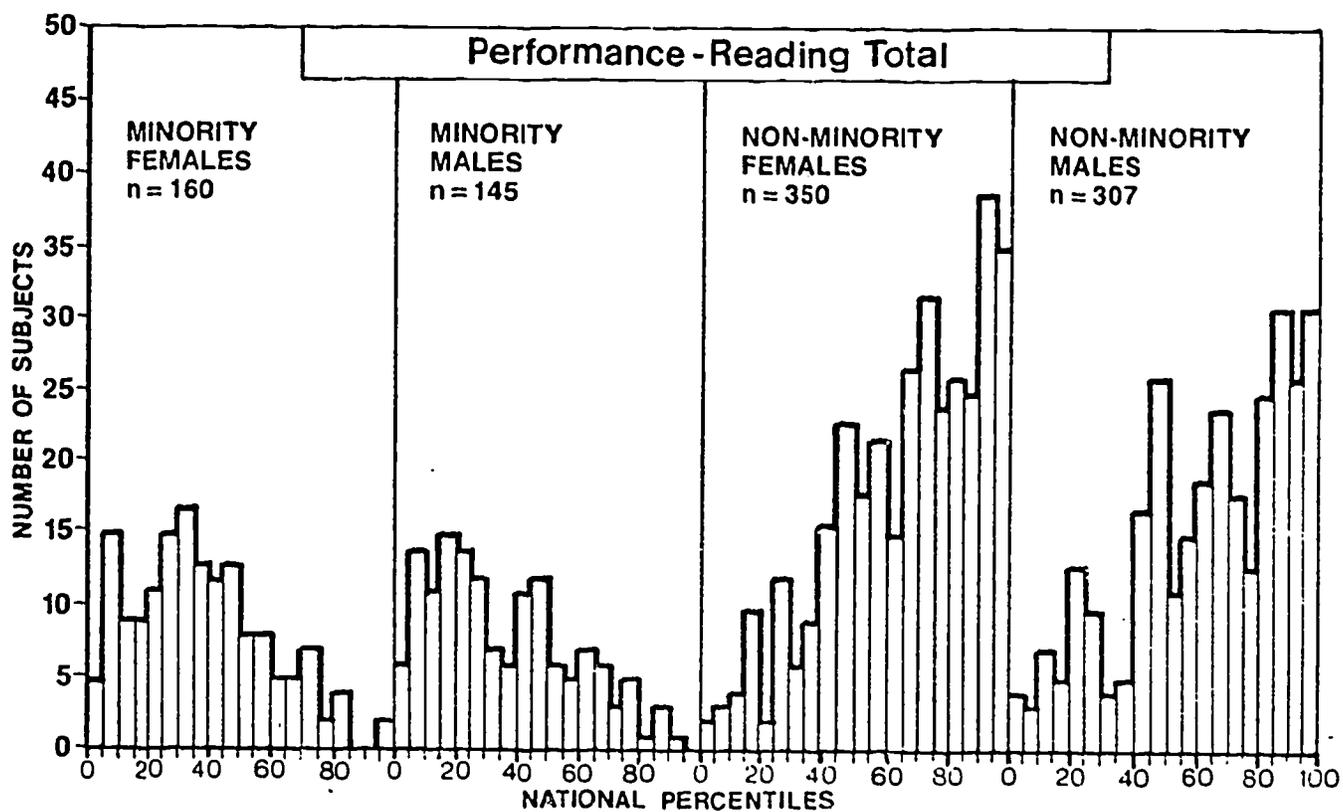
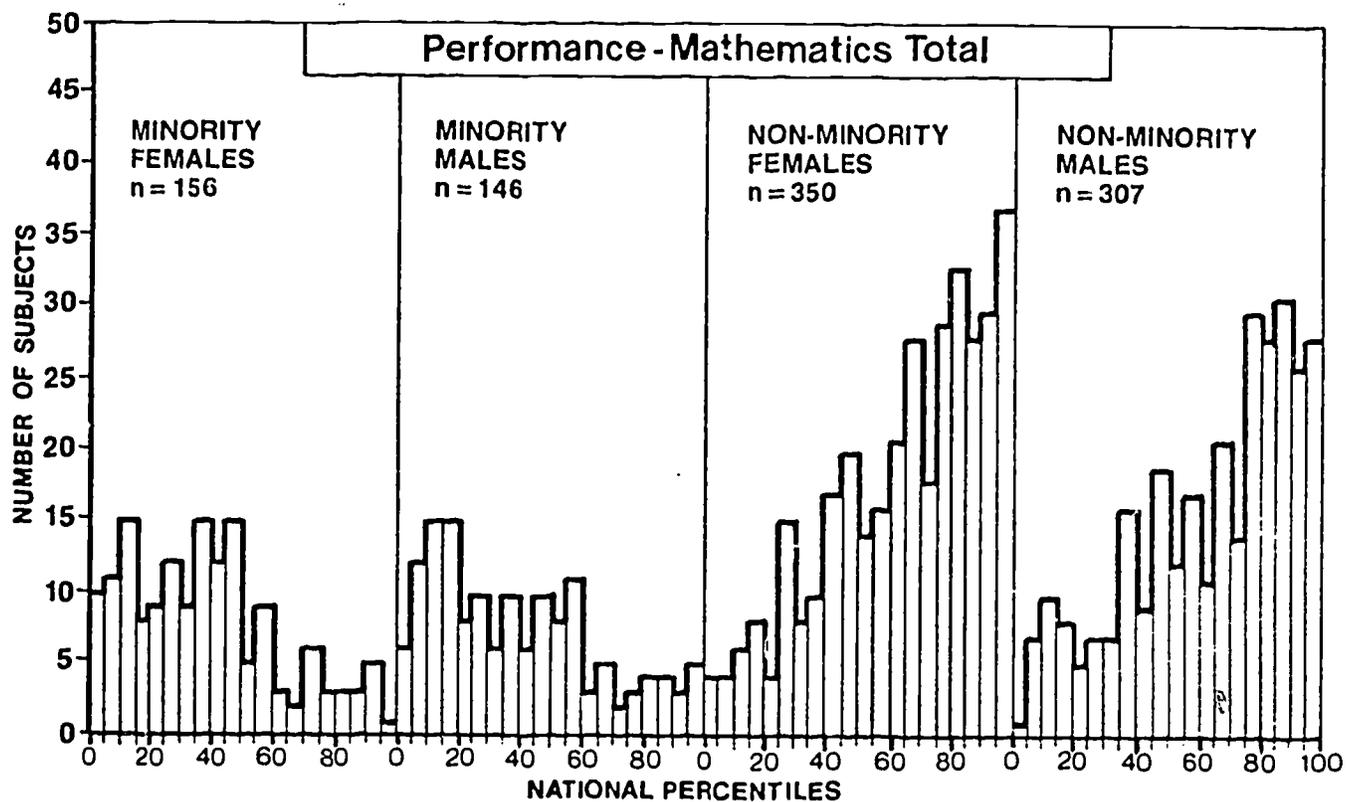


Figure I 118

TABLE IVH
 DIFFERENCES IN MEAN PERCENTILE RANKS FOR MATHEMATICS,
 BY RACE/ETHNICITY AND GENDER

Mathematics Area and Group	Group		
	Non-minority females	Minority males	Minority females
<u>Mathematics total</u>			
Non-minority males	+ .8	-25.9*	-27.1*
Non-minority females	--	-26.7*	-27.9*
Minority males	--	--	-1.2
<u>Mathematics computation</u>			
Non-minority males	+5.3	-17.1*	-15.8*
Non-minority females	--	-22.4*	-21.1*
Minority males	--	--	+1.3
<u>Mathematics Concepts</u>			
Non-minority males	+2.8	18.1*	-19.9*
Non-minority females	--	-20.9*	-22.7*
Minority males	--	--	-1.8
<u>Mathematics applications</u>			
Non-minority males	+1.3	-25.1*	-24.9*
Non-minority females	--	-26.4*	-26.2*
Minority males	--	--	+0.16

Difference scores use group in left column as base.

*Difference statistically significant at .001 level, based on t-test comparisons.

groups. Again, non-minority females had the highest mean rank (66.8, see Table IVG), and that rank was significantly higher than the rank for minority males (44.4) and minority females (45.7). It was not greatly different than the rank for non-minority males, however (61.5).

Interestingly, while non-minority students did as well on applications as on concepts, minority students did worse on the latter than on the former. Minority males had a rank of 35.9 on concepts and an even lower mean rank--30.5--on applications; the figures were quite similar for minority females (34.1 and 30.6, respectively).

Non-minority students were near the fiftieth percentile on both measures.

The results confirm the pattern from the NAEP surveys, which have found that the higher the level of skill required, the poorer the performance of minority students. What I cannot determine, given that my data were not longitudinal, is whether the gap between minority and non-minority students has narrowed over time. The NAEP results point towards such a change.

The results reported thus far cover diverse courses. The next analyses refer only to students who were enrolled in comparable courses. As indicated in Chapter one, I placed courses into one of three categories: level one, courses for students performing at grade level; level two, for those somewhat above grade level; and level three - courses for the most advanced students.

The discussion turns to the findings for level one courses. There were eleven such courses across the schools in the sample, enrolling 83 students: 21 white males, 20 white females, 14 black males, and 28 black females. For each of the three subareas--computation, concepts,

and application--more white than black students scored within the top two quartiles. In computation, only 69 percent of the black students as compared with 93 percent of the whites ranked within the third and fourth quartiles (see Table IVI). Thirty-two percent and 49 percent of the whites were in the top quartile. For concepts, the top quartile contained 43 percent of the white and 16 percent of the black students. Within the third quartile the percentage of blacks was almost identical to percentage of whites.

The results for application resembled those for concepts. Whereas a similar percentage of white and black students fell within the third quartile, only 20 percent of the black as compared with 52 percent of the whites scored within the top quartile (see Figure 2).

Whether we highlight the trends for the entire sample or for the students in level one courses, we find scores for minority females which resemble those for minority males, not the scores of non-minority females. Contrary to what I had expected, non-minority females often outdistanced non-minority males. Hence, the rest of this chapter focuses primarily on the minority-non-minority patterns, in an attempt to explain the discrepancies that occurred.

Mathematics and Reading Achievement

Minority students tend to perform more poorly on standardized tests in reading than do non-minority students. A handful of studies on reading and mathematics would seem to suggest that the limited mathematics skills found among minority students are connected to their reading problems.

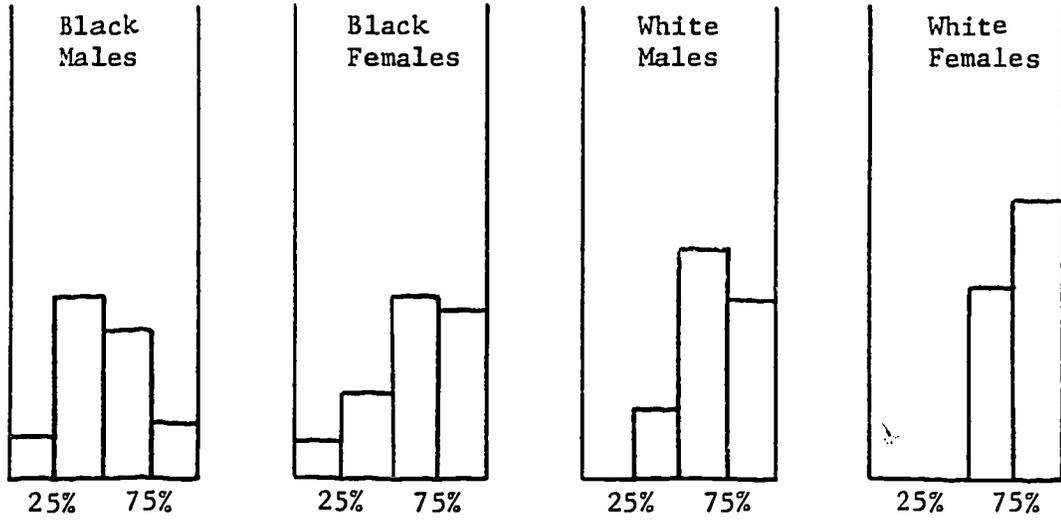
TABLE IVI

STUDENT PERFORMANCE ON COMPREHENSIVE TEST OF BASIC SKILLS, BY SUB-TEST AREA, RACE AND GENDER

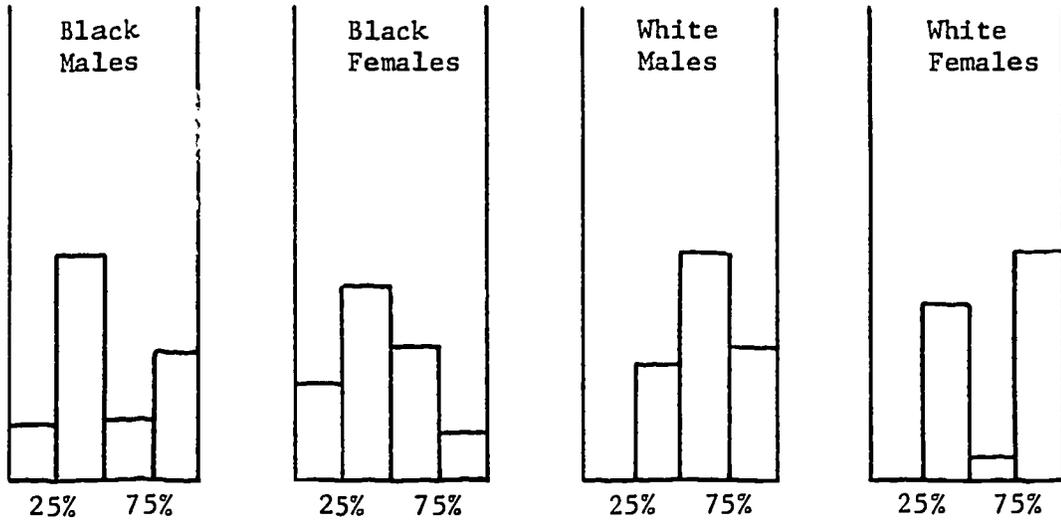
SUB-TEST AREA	RACE AND GENDER					
	BLACK			WHITE		
	Male (%)	Female (%)	Total (%)	Male (%)	Female (%)	Total (%)
<u>Computation</u>						
Bottom quartile	8	7	7	0	0	0
Second quartile	38	18	24	14	0	7
Third quartile	31	39	37	48	41	44
Top quartile	12	36	32	38	59	49
Mean percentile ¹	57.40	62.21	60.53	66.53	78.79	72.17
(N)	13	28	41	21	22	43
<u>Concepts</u>						
Bottom quartile	13	21	18	0	0	0
Second quartile	47	41	43	24	37	30
Third quartile	13	28	23	48	5	27
Top quartile	27	10	16	28	58	43
Mean percentile ¹	52.73	44.68	47.49	67.50	71.21	69.21
(N)	15	29	44	21	19	40
<u>Applications</u>						
Bottom quartile	20	32	27	5	0	2
Second quartile	26	32	30	23	25	24
Third quartile	27	20	23	27	15	21
Top quartile	27	16	20	45	60	52
Mean percentile ¹	54.60	44.46	48.00	68.59	71.76	70.05
(N)	15	25	40	22	20	42

¹For explanation, see Table 1.

Computation



Concepts



Applications

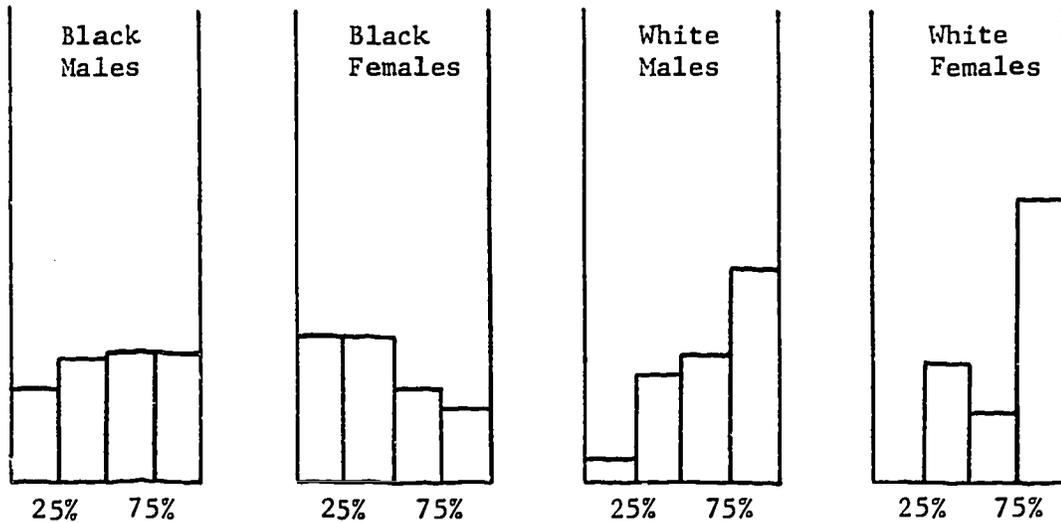


Figure II Distribution Over Quartiles by Race and Gender

That is the thrust of a project conducted on vocabulary and mathematics achievement among second graders. The project directors (Lyda and Duncan, 1967) tested students for their computational and reasoning ability at the beginning of an eight-week period, had the teacher present a series of arithmetical terms over the period, and then retested the students at the end of the time. According to the authors, student performance on both computation and reasoning improved significantly as a result of the vocabulary exercise. Cox and Wiebe (1984) concur with the view that vocabulary problems can hamper mathematics achievement. The authors have developed an instrument to measure children's ability to read mathematical terms. They validated the instrument by administering it to approximately 450 students in grades one through five in a Louisiana city, reviewing the results, and correlating performance on the instrument with performance on standardized tests in mathematics. They report that the instrument distinguishes students whose difficulties are conceptual from those with primarily computational problems.

One cannot conclude, however, that reading problems play the decisive role in the mathematics difficulties students have. For one thing, the Lyda-Duncan project contained no control group; in addition, it--as well as the Cox and Wiebe analysis--used elementary school students only. The patterns need not be the same for secondary school pupils. Even more significantly, other researchers have found no link between reading and mathematical deficiencies. Knifong and Holtan (1977) analyzed the written work of 35 sixth grade children on the word problem portion of the Metropolitan Achievement Test (1958 version) to determine if reading problems explained the mathematical errors that

were made. They looked at the mistakes that were not strictly computational ones and interviewed the students who had made them. Knifong and Holtan asked the students to read and interpret the problems. They found few instances of reading problems and concluded that limited arithmetical skills, not reading deficiencies, explained the mistakes.

Although we cannot assume that reading difficulties produce difficulties in mathematics, we should not dismiss the possibility. First, it might be, as one source argues that "good readers and math problem-solvers use several strategies automatically that poor readers or math problem solvers do not" (Kreese, 1984:598). Reading for understanding in mathematics, then, might require more than an ability to read the problem and describe its intent. Second, the link could be stronger between subareas within mathematics and reading than between global measures for both subjects. Third, reading perhaps is more significant for higher level mathematics performance than for essentially computational outcomes. Hence, there might be a closer tie between reading and mathematics for secondary school students than for elementary school pupils.

The results on reading achievement, consistent with the mathematics data shows non-minority females with the highest mean rank (67.4) and minority males the lowest (36.0, see Table IVJ). The differences within race were insignificant. Large numbers of non-minority females had scores above the fiftieth percentile, but few minority students--males or females--had scores that high (see Figure 1).

There were two subareas in reading: vocabulary and comprehension. But the results for both were nearly identical to those for reading

TABLE IVJ

MEAN PERCENTILE RANKS IN READING FOR MATHEMATICS
STUDENTS, BY RACE/ETHNICITY AND GENDER

Test Area	Non-minority				Minority			
	Male Mean	Standard Deviation	Female Mean	Standard Deviation	Male Mean	Standard Deviation	Female Mean	Standard Deviation
Reading Total	65.1 (307)	25.4	67.4 (350)	23.8	36.0 (145)	23.1	37.6 (160)	21.6
Vocabulary	65.2 (238)	24.9	65.0 (286)	25.0	37.9 (128)	26.1	38.6 (152)	24.9
Comprehension	61.2 (238)	26.4	66.2 (285)	24.7	35.9 (128)	22.8	38.4 (152)	22.4

Figures in parentheses represent number of cases on which mean is based.

total. There was no evidence, then, that students had more difficulty with reading comprehension than with vocabulary; in both cases, minority students experienced greater difficulty than did non-minority students.

The results corroborate the NAEP findings on differences between minority and non-minority performance in reading comprehension. These results show additionally only minimal differences in the reading performance of males and females who come from the same racial background.

Although minority students lagged behind non-minority students on both mathematics and reading performance, the gap was wider for the reading area. Minority females had a mean rank on mathematics total that was nearly 26 points below the non-minority male mean; on mathematics total, 29 points separated the two groups. The same trend occurred in the comparisons for minority females-non-minority females and for minority males-non-minority females; it was not evident for the two groups of males, however.

Although reading performance surpassed mathematics performance slightly, difficulties in reading seem to have implications for mathematics outcomes. Consider the relationships between reading and mathematics scores, and between reading total score and course grade (see Table IVK). The pattern obtained that, the higher the total reading score, the higher the total mathematics score ($r = .75$). I found as well that, the higher the total reading score, the higher the course grade at both time one ($r = .42$) and time two ($r = .38$). There were strong relationships, too, between reading subtest scores and mathematics subtest scores. For example, the correlation between

TABLE IVK

CORRELATIONS AMONG PERFORMANCE ITEMS, ALL MATHEMATICS STUDENTS¹

	Reading		Mathematics				Math Grades	
	Comprehension	Total	Computation	Concepts	Application	Total	1	2
Reading								
Vocabulary	.75	.92	.56	.63	.64	.64	.32	.18
Comprehension		.95	.65	.72	.75	.74	.42	.37
Total			.64	.72	.75	.75	.42	.38
Mathematics								
Computation				.81	.81	.94	.50	.39
Concepts					.83	.92	.42	.37
Application						.93	.41	.39
Total							.51	.50
Grade 1								.70

¹All correlations significant at beyond the .001 level.

reading comprehension and mathematics concepts was .72 and between the former and mathematics application, .75.

The strong relationships between comprehension and both concepts and application deserve particular notice. For the sample as a whole, performance on the comprehension test had a stronger relationship to the mathematics conceptual score ($r = .72$) than it had to the computational score ($r = .65$). Perhaps difficulties in reading have a greater impact on higher mathematics skills than on lower level ones, such as the ability to compute.

The findings underscore the importance of examining school, classroom, and teaching process; the attitudes of students do not explain the patterns. All of the reading subtest scores were positively related to mathematics course grade; that was true as well for all of the mathematics subtest scores. The mathematics computation score had a higher correlation with the final grade ($r = .49$) than did the mathematics concepts score ($r = .37$). Possibly, instruction in mathematics stressed and rewarded performance in computation more than it did performance on conceptual problems. The observational data uphold that assumption. Recall from Chapter 2 that teachers tended to be more product than process oriented. It may be that minority students do not tend to be autonomous learners: they depend on what is transmitted within the classrooms. If cognitive skill development is not emphasized, then these students do not develop this skill. The final chapter considers the ways in which teaching emphasis intersect with student characteristics to produce student achievement outcomes.

Achieving Minority Students

When I compared minority students in the aggregate with non-minority pupils, I found the trends the previous sections emphasize. Not all minority students ranked below their colleagues, however. The small component of Asian students (24) in the sample generally outperformed all other students on the mathematics tests (see Table IVL). Significantly, most of these students were Southeast Asian refugees who only recently had settled in one of study sites. The recency of their immigration may account for their poorer performance--compared with that of other students--on the reading tests.

Asian students were not the only category with relatively high achievement scores in mathematics. Black students in the level three courses had achievement scores and grades which matched those of their classmates. But fewer black than white students were in such courses. Excluding the all-black schools, I found that the level three courses in mathematics enrolled over 40 percent of the white mathematics students in the study but only 20 percent of the black students. This pattern hints that an understanding of allocational practices may give more information on performance than an understanding of student attitudes or perceptions.

TABLE IVL
 PERFORMANCE OF ASIAN STUDENTS AND THE TOTAL SAMPLE

AREA	STUDENT GROUP								
	ASIAN STUDENTS (Math and Science)			ALL STUDENTS (Mathematics)			ALL STUDENTS (Science)		
	<u>Mean</u>	<u>SD</u>	<u>(N)</u>	<u>Mean</u>	<u>SD</u>	<u>(N)</u>	<u>Mean</u>	<u>SD</u>	<u>(N)</u>
<u>PERFORMANCE</u> ¹									
Reading									
Vocabulary	49.25	27.53	20	55.49	28.29	911	50.68	28.60	538
Comprehension	49.35	25.88	20	54.99	27.93	910	51.81	28.14	538
Total	51.12	27.03	24	57.03	27.77	1089	53.74	28.24	652
Mathematics									
Computation	79.10	23.00	20	58.25	26.54	908	55.03	28.82	537
Concepts	67.63	28.49	19	46.98	28.82	551	50.54	30.71	382
Applications	56.28	25.18	18	45.17	29.60	552	48.11	28.71	379
Total	73.30	20.96	23	57.91	28.54	1087	54.27	28.90	647

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CHAPTER V
THE ISSUES REVISITED

I began this study with two fundamental assumptions: the goals of precollege mathematics and science teachers need elucidation; and insight on those goals might illuminate the reasons for gender and racial disparities in student outcomes. I based the latter assumption on the view that the pursuit of certain goals might lead to classroom strategies and teaching practices which could enhance achievement and interest in mathematics and science by female and minority students.

The results of the study call for a reassessment of the second assumption. I expected to find noteworthy differences in both attitudes and achievement between male and female, minority and non-minority students. The findings show a more complex pattern. First, no significant differences appeared between males and females, even on the tests of conceptual skill in mathematics. Interestingly, others have reported the same pattern, as I indicated in Chapter I. It may be, then, that the gender differences which once prevailed have diminished over the years. Second, the attitudes of minority students were no less favorable to mathematics and science than were those of nonminority students. Again, this may represent a recent shift. Third, nonminority students did not always outperform minority students. There was no marked difference in the grades that these students received. Although the standardized test scores of minority students in the aggregate deviated from the scores for the sample of nonminority students, the difference was not evident within the classroom. The next section

elaborates on this point and considers its implications for the minority-nonminority comparisons.

CLASSROOM LEVEL ANALYSIS

The discussion of student attitudes towards mathematics and science in Chapter IV shows that the aggregate analyses conceal some of the contrasts which appeared among classrooms. A review of the results on achievement underlines that theme. Specifically, I found from my assessment of achievement test scores and final grades in a select group of mathematics classrooms that minority-nonminority patterns converged far more within classrooms than they did across schools.

I chose from the longer list of classrooms two groups: pre-algebra classrooms (total number: 9) and algebra I classrooms (total: 7). I examined the percentile ranks for the component, total mathematics score, and determined where, compared to their classmates, minority and female students stood. Rather mixed findings appeared in the relationship between gender and test score: in half of the classes in which a male-female difference existed, the highest percentile rank had been attained by a female. Moreover, in half of the classes, the lowest rank was achieved by a female. Thus, male-female parity obtained (see Table VA).

The outcomes were not nearly as congruent between minority and nonminority students: there was but one instance in which a black student had outscored all white students. Black and white students were equally likely to appear as the lowest ranking students in the classes, nonetheless. Moreover, many of the black students had achievement results which surpassed those which many of their classmates scored.

TABLE VA

DISTRIBUTION OF MATHEMATICS TEST SCORES ACROSS SAME
COURSE IN DIFFERENT SCHOOLS

School/Class	Number of Students	Test Score ¹ Range	Student with Highest Percentile Rank Ethnicity	Student with Highest Percentile Rank Gender	Student with Lowest Percentile Rank Ethnicity	Student with Lowest Percentile Rank Gender
<u>Pre-Algebra</u>						
Alpha	13	6-62	White	Female	White	Male
Gamma	24	1-80	White	Male	Black	Male
Theta	26	33-95	White	Female	White	Female
Iota	24	68-97	White	Female	White	Female
Kappa-Class A	20	18-60	Black	Male	White	Male
Kappa-Class B	19	11-62	White	Female	White	Male
Kappa-Class C	13	18-70	White	Female	White	Female
Kappa-Class D	18	16-78	White	Male	Black	Female
Kappa-Class E	16	6-68	White	Male	Black	Male
<u>Algebra I</u>						
Alpha	6	36-74	White	Female	Black	Female
Beta	13	48-98	White	Male	Black	Female
Gamma	19	9-76	White	Male	Black	Female
Delta	27	2-48	White	Female	Black	Male
Eta	18	60-96	White	Female	Black	Male
Iota	29	10-98	White	Female	Black	Male
Kappa	20	6-90	White	Male	White	Female

¹The figures given are for percentile ranks on the component, "total mathematics score," for the several standardized tests.

²Two students - one black, the other white - ranked at the 95th percentile on the mathematics total score. One was male, the other female.

³This was an all-female class.

⁴These classes had only one of the two racial/ethnic groups.

The data on grades for these classes must be considered with care; the numbers are small. They suggest, nonetheless, that minority students performed comparably with the other students (see Table VB). This gives further support to the notion that race does not pattern classroom outcomes.

One of the remarkable features in the achievement test scores for the selected classrooms is the contrast in the range of scores. The algebra I class at Eta Senior High School had a fairly concentrated range of percentile ranks (60th-96th), when compared against many of the others. Significantly, the rank for the highest scoring student (48th percentile) at Delta Senior High School fell short of the rank for the lowest scoring pupil in the Eta classroom. Likewise, none of the students in the pre-algebra class at Iota Junior High School had scores as low as the students in two of the pre-algebra classes in Kappa Middle School.

The results lend support to the allocation thesis that the distribution of characteristics in the school, in addition to staffing patterns, determines at least in part enrollment trends in the mathematics curriculum. Kappa offered algebra I to its top students; but its best students would have been middle range ones at Beta Junior High School.

Students have different opportunities to participate in mathematics and science programs. The student who scores relatively low in a particular school may not have the same chance to learn about a subject as does his comparable-scoring counterpart elsewhere. This is a difficult situation to appraise. One could lament the student's exclusion, on the basis that it will deprive the person of some exposure

TABLE VB

DISTRIBUTION OF FINAL GRADE IN SELECTED MATHEMATICS
CLASSES, BY ETHNICITY AND GENDER

<u>School/Class</u>	<u>Number of Students</u>	<u>Number of A's & B's Received</u>	<u>Minority Students</u>		<u>Female Students</u>	
			<u>Total</u>	<u>Percent Receiving A's & B's</u>	<u>Total</u>	<u>Percent Receiving A's & B's</u>
Gamma	19	6	11	36.4	6	33.3
Kappa-Class A	20	2	9	<u>1</u>	7	<u>1</u>
Kappa-Class B	19	7	7	(1) ²	13	38.5
Kappa-Class D	18	8	5	40.0	11	54.5
Kappa-Class E	16	7	10	50.0	8	50.0

¹The two highest grades went to white males.

²A percentage has not been calculated here, but one of the seven minority students in the class received a B.

to the subject. Alternatively, one could argue that the course populated by lower-scoring students cannot cover the material that would be accessible to higher-scoring students. The former group, the argument continues, would be misled if they thought that by completing the course with a particular title, they were as knowledgeable about the subject as any of its other enrollees.

I cannot resolve the matter, for it is not empirically based. I have two reasons for raising the topic: to stress the need for more research at the classroom level which examines minority education; and to underscore the importance of analyses on allocational processes.

GENDER, RACE, AND THE CLASSROOM

Social Orientation Revisited

I had set forth the social orientation hypothesis to account for male-female differences in achievement on higher order skills. Given the absence of those differences in this study, it might seem reasonable to discard the thesis. I do not endorse that position. The fact that females were slightly more likely to comment on the behavior of those around them than were males warrants attention. The impact of this difference need not appear in the measures this study adopted, but if indeed males and females bring different orientations to the classroom, the implications merit analysis. Quite possibly, the teachers in the sample used approaches which neutralized the effects of the difference in orientation.

Racism: The Unspoken Problem

The teachers in the study expressed far greater sensitivity to the topic of race than to that of gender. We asked teachers to indicate the racial and gender composition of their classes. Some found the request for the information on race highly disconcerting; one teacher replied that she did not notice the characteristics of her students. A questionnaire item asked teachers to assess how well their programs served racial minority students. The responses clustered in the category "very well."

Generally, the responses from students supported the view that the schools and classrooms provided similar experiences for all students. As I described in chapter IV, there were no racial differences for the sample as a whole in the comments made about teachers, peers, and the classroom.

Some disturbing signs did appear, nonetheless, especially within some of the Southern schools. Two of the junior high schools served the same Southern county, but one was located in an affluent suburb while the other traditionally had drawn its students from rural communities. The district operated a busing plan that carried the lower-income--both black and white--students from the area near the second school to the suburban school. But black teachers in both schools pointed to continued disparities: the children who were bused had little opportunity to participate in extracurricular activities, both because of the busing arrangements and because of their more limited economic resources. The suburban school was able to recruit and retain young, energetic teachers; the rural school tended to be staffed by an older cohort.

One of the black science teachers reported that Southern norms had intruded into her class on more than one occasion. She recalled an incident in which a student had refused to carry out an assignment because he discovered that the scientist whom he was to research was black. His mother, he told the teacher, had told him that he did not have to write a paper on a black man.

In a school located in a different community, both black and white students in one classroom commented on the attitudes of the teacher. A small number of students wrote that what they liked least about the class was the attitude of the teacher: they called him "bigoted" and "racist." This response was unusual and cannot be regarded merely as sour grapes, for the students in the class received rather high grades. The various signs suggest that attitudes about race may become entangled in mathematics and science education. Racism need not be a widespread phenomenon to have significant consequences.

SUMMARIZING THE RESULTS

So far I have dealt with the second assumption: an analysis of goals could improve our understanding of performance in and attitude toward mathematics and science. Let me return to the assumption that the goals of teachers warrant attention.

I had thought initially that a study of goals should benefit most the education of students. Yet, as I talked with the teachers, administrators, and counselors, I became aware of their interest in a discussion of teaching objectives in mathematics and science. Many of the teachers felt isolated, cut off from any community in which they could consider various philosophies of education. Time and time again I

heard wistful accounts of the teacher institutes that the National Science Foundation had sponsored. Individuals who had participated in those institutes recalled that the programs had allowed them to learn of new developments, exchange teaching hints, and examine and revise their educational objectives. Teachers had adopted given approaches, not because they had thought them through, but because they had to adjust to the resources they had and the information with which they were familiar. As the various commissions and committees on mathematics and science education pursue their responsibilities, they would do well to include practicing teachers; these teachers have few opportunities for the sort of reflection in which the commission members routinely engage.

It may be that an analysis of goals will not explain differences in student performance. Yet, if some teachers respond to the demand that they work to affect student attitudes while others strive to instill factual knowledge that information should prove illuminating, for both of these emphases find their defenders. Through what processes have these orientations come to prevail? Those who seek to reform precollege education may benefit from research on goals, especially if that research shows how some goals come to gain widespread acceptance among practitioners.

APPENDICES

OBJECTIVES IN MATHEMATICS EDUCATION

I.

1. First, we would like to know about the broad educational objectives you pursue as a mathematics teacher. How would you rank the objectives that follow?

- | | RANK |
|---|-------|
| a. Providing students a foundation on which they can study higher level mathematics. | _____ |
| b. Instilling in students a positive attitude toward mathematics. | _____ |
| c. Having students develop the ability to perform various mathematical operations accurately. | _____ |
| d. Teaching students to understand basic mathematical concepts and rules of operation. | _____ |
| e. Having each student see the personal relevance of mathematics learning. | _____ |
| f. Other _____ | |

For items 2-5, please use the following system:

- 1 - First objective is more important
- 2 - Second objective is more important
- 3 - Both objectives equally important
- 4 - Neither objective is important

- 2. In the mathematics courses you teach, which is more important to you: (1) having students understand the various uses of mathematics, or (2) having them learn fundamental computations? _____
- 3. Which is more important: (1) having students learn to translate statements into symbolic or graphic form, or (2) having them see mathematical patterns and symmetries? _____
- 4. Which is more important: (1) having students learn to reason and think critically, or (2) having them learn basic terminology and rules? _____
- 5. Which is more important: (1) having students become proficient in performing calculations, or (2) having students see the relationship of mathematics to their other courses? _____

For the next set of statements, please indicate your level of agreement or disagreement.

- 1 - Disagree strongly
- 2 - Disagree somewhat
- 3 - Undecided
- 4 - Agree somewhat
- 5 - Agree strongly

6. The study of mathematics should consist primarily of learning definitions and rules. _____
7. Students should be taught to explain mathematical terms and processes in their own words. _____
8. Mathematics teaching should focus on the application of mathematical knowledge and methods to social concerns. _____
9. It is more important that students learn to see patterns in data than that they know mathematical terminology. _____
10. The major function of advanced mathematics courses should be to prepare students for college mathematics. _____
11. Mathematics consists more of ideas and principles than of formulas and procedures. _____
12. One of the most important reasons for studying mathematics is that it helps the student learn to think according to strict rules and procedures. _____
13. All high school graduates should have some basic knowledge of trigonometry. _____

II

For the next group of items, please think of one mathematics course that you teach regularly, and answer the questions with reference to that course.

14. What is the title of the course? _____

For an average (5-day) school week, please indicate how often you are likely to do the following.

- 1 - Never
- 2 - 1 or 2 days
- 3 - 3 or 4 days
- 4 - Every day

15. Lecture to the class? _____
16. Give a quiz or test? _____
17. Give the students homework? _____

We are interested in knowing about the content you emphasize in the tests which you construct. How would you rank each of the following in describing what you look for on your tests?

RANK

17. Ability of the student to recognize particular mathematical symbols. _____
18. Ability of the student to translate verbal statements into mathematical symbols. _____
19. Ability of the student to spell mathematical terms correctly. _____

20. Ability of the student to recall formulas and rules covered in the course. _____
21. Proficiency of the student in performing computations. _____

For each statement below, please indicate the degree to which it describes your instructional approach.

- 1 - Completely false
- 2 - More false than true
- 3 - Undecided
- 4 - More true than false
- 5 - Completely true

22. I vary my teaching techniques to meet the needs of students at different ability levels. _____
23. I give greater attention to non-college bound than to college-bound students. _____
24. I place more emphasis on the reasoning involved in solving problems than on the learning of rules and formulas. _____
25. After I explain the basic concepts and principles, I expect the student to develop the methods for solving the problem. _____

III

Now we would like to turn to mathematics education programs in general. We are interested in knowing your assessments of your own school program, and the things you would look for in judging others. First, please indicate how adequately your program does the following:

- 1 - Very inadequately
- 2 - Somewhat inadequately
- 3 - Undecided
- 4 - Somewhat adequately
- 5 - Very adequately

26. How adequately does your program inform students about careers in mathematics? _____
27. How adequately is classroom work related to "real world" experiences in your program? _____
28. How adequately does your program serve mathematically talented students? _____
29. How adequately does your program prepare students for technical careers? _____

If you were asked to comment on the quality of a secondary school mathematics program, how relevant would you consider the following to be?

- 1 - Very irrelevant
- 2 - Somewhat irrelevant
- 3 - Undecided
- 4 - Somewhat relevant
- 5 - Very relevant

- 30. Number of different mathematics courses taught. _____
- 31. Number of females taking advanced mathematics courses. _____
- 32. Number of teachers with post-graduate degrees in mathematics. _____
- 33. Number of graduates who continue to study mathematics. _____
- 34. Number of trophies and awards won in mathematics competition. _____
- 35. Number of mathematics books and magazines in the library. _____

IV

Personal Background (Circle your response)

- 36. Which one of the following ethnic designations best describes you?
 - 1. American Indian, Native American
 - 2. Chicano, Mexican American, Hispanic
 - 3. Puerto Rican
 - 4. Oriental, Asian American
 - 5. Black, Negro, Afro-American
 - 6. White, Caucasian
- 37. What is your sex?
 - 1. Male
 - 2. Female
- 38. What is the highest level of professional preparation you have completed?
 - 1. Bachelors degree
 - 2. Bachelors degree and additional credits
 - 3. Masters degree
 - 4. Masters degree and additional credits
 - 5. Doctoral degree
 - 6. Other _____
- 39. What is the main subject that you teach?
 - 1. Art
 - 2. Business Education
 - 3. English/Language Arts
 - 4. Foreign Languages and Literature
 - 5. History
 - 6. Industrial Arts/Voc. Education
 - 7. Mathematics
 - 8. Science
 - 9. Social Studies
 - 10. Other (specify) _____
- 40. How many years have you been teaching? _____
- 41. How many years have you been at your present school? _____

OBJECTIVES IN SCIENCE EDUCATION

I

1. First, we would like to know about the broad educational objectives you pursue as a science teacher. How would you rank the objectives that follow?

	RANK
a. Providing students a foundation on which they can study advanced science courses.	_____
b. Instilling in students a positive attitude towards science.	_____
c. Having students develop the ability to carry out laboratory experiments successfully.	_____
d. Teaching students to understand basic concepts and principles in science.	_____
e. Having each student see the personal relevance of scientific knowledge and skills.	_____

For items 2-4, please use the following system:

- 1 - First objective is more important
- 2 - Second objective is more important
- 3 - Both objectives equally important
- 4 - Neither objective is important

2. In the science classes you teach, which is more important to you:
(1) having students understand the social relevance of science or
(2) having them recognize and recall fundamental principles in science? _____
3. Which is more important: (1) having students learn to reason and think critically, or (2) having them learn basic scientific terminology and rules? _____
4. Which is more important: (1) having students learn to make accurate observations in the laboratory, or (2) having them learn to apply science knowledge and skills to their daily lives? _____

For the next set of statements, please indicate your level of agreement or disagreement.

- 1 - Disagree strongly
 - 2 - Disagree somewhat
 - 3 - Undecided
 - 4 - Agree somewhat
 - 5 - Agree strongly
5. The study of science should consist primarily of learning definitions and rules. _____
6. To learn science the student should be provided with situations which demonstrate the concept but which require him or her to figure it out.

7. Science teaching should focus on the application of scientific knowledge and methods to social concerns. _____
8. Laboratory investigations should follow specified directions and procedures predesigned to illustrate a concept. _____
9. Each student should use his own ways of exploring, interpreting, and reporting on the experiments done in the laboratory. _____
10. The major function of advanced science courses should be to prepare students for college science. _____
11. Science consists more of ideas and principles than of formulas and procedures. _____
12. It is more important that students learn basic facts in science than that they learn how to do laboratory experiments. _____

II

For the next group of items, please think of one science course that you teach regularly, and answer the questions with reference to that course.

13. What is the title of the course? _____

For an average (5-day) school week, please indicate how often you are likely to do the following:

- 1 - Never
- 2 - 1 or 2 days
- 3 - 3 or 4 days
- 4 - Everyday

14. Lecture to the class? _____
15. Give a quiz or test? _____
16. Give the students homework? _____

We are interested in knowing about the content you emphasize in the tests which you construct. How would you rank each of the following in describing what you look for on your tests?

RANK

17. Ability of the student to recall the scientific definitions covered. _____
18. Ability of the student to state correctly the laws and principles taught. _____
19. Ability of the student to spell scientific terms correctly. _____
20. Ability of the student to recall formulas and rules covered in the course. _____
21. Ability of the student to describe procedures followed in laboratory experiments. _____

For each statement below, please indicate the degree to which it describes your instructional approach.

- 1 - Completely false
- 2 - More false than true
- 3 - Undecided
- 4 - More true than false
- 5 - Completely true

- 22. I vary my teaching techniques to meet the needs of students at different ability levels. _____
- 23. I give greater attention to non-college bound than to college-bound students. _____
- 24. In the course I use a lot of teaching aids, such as audio-visual materials. _____
- 25. I place more emphasis on the reasoning involved in solving problems than on the learning of rules and formulas. _____

III

Now we would like to turn to science education programs in general. We are interested in knowing your assessments of your own school program, and the things you would look for in judging others. First, please indicate how adequately your program does the following.

- 1 - Very inadequately
- 2 - Somewhat inadequately
- 3 - Undecided
- 4 - Somewhat adequately
- 5 - Very adequately

- 26. How adequately does your program prepare students for more specialized work in science? _____
- 27. How adequately does your program inform students about careers in science? _____
- 28. How adequately is classroom work related to "real world" experiences in your program? _____
- 29. How adequately does your program serve racial minority students? _____
- 30. How adequately does your program prepare students for technical careers? _____

If you were asked to comment on the quality of a secondary school science program, how relevant would you consider the following to be?

- 1 - Very irrelevant
- 2 - Somewhat irrelevant
- 3 - Undecided
- 4 - Somewhat relevant
- 5 - Very relevant

- 31. Number of laboratories and amount of equipment in them. _____

- 32. Number of females taking advanced science courses. _____
- 33. Variety of instructional materials available to teachers and students.

- 34. Number of graduates who continue to study science. _____
- 35. Number of trophies and awards won in science competitions. _____
- 36. Number of science books and magazines in the library. _____

IV

Personal Background (Circle your response)

- 37. Which one of the following ethnic designations best describes you?

1. American Indian, Native American	4. Oriental, Asian American
2. Chicano, Mexican American, Hispanic	5. Black, Negro, Afro-American
3. Puerto Rican	6. White, Caucasian
- 38. What is your sex?

1. Male	2. Female
---------	-----------
- 39. What is the highest level of professional preparation you have completed?

1. Bachelors degree	4. Masters degree and additional credits
2. Bachelors degree and additional credits	5. Doctoral degree
3. Masters degree	6. Other _____
- 40. What is the main subject that you teach?

1. Art	6. Industrial Arts/Voc. Education
2. Business Education	7. Mathematics
3. English/Language Arts	8. Science
4. Foreign Languages and Literature	9. Social Studies
5. History	10. Other (specify) _____
- 41. How many years have you been teaching? _____
 How many years have you been at your present school? _____

MATHEMATICS QUESTIONNAIRE

Student Number
or Name _____

Sex (circle one)

M

F

Age _____

Grade _____

154

MATHEMATICS QUESTIONNAIRE

Given below are several statements. There are no right or wrong answers to them. You are asked if you agree or disagree with each one. Here is an example:

Example 1. I like mathematics SA A U D SD

If you agree strongly with the statement, circle the letters SA (strongly agree). If you agree but not completely, circle A (agree). If you disagree but not totally, circle D (disagree); if you disagree strongly, circle SD (disagree strongly). Finally, if you neither agree or disagree, that is, you aren't sure, circle U (uncertain). *Try this out with example 2 below.

Example 2. This class is very interesting to me . . . SA A U D SD

Do not spend much time with any statement, but be sure to answer every statement. Work fast, but carefully.

I. The statements that follow ask you about mathematics in general.

1. Mathematics is fascinating and fun. SA A U D SD
2. My parents do not encourage me in my study of mathematics SA A U D SD
3. Mathematics has been my worst subject SA A U D SD
4. I expect to have little use for mathematics after I get out of high school SA A U D SD
5. My friends think mathematics is an important subject SA A U D SD
6. I am sure that I can learn mathematics SA A U D SD
7. My teachers have encouraged me to take all of the mathematics I can SA A U D SD
8. My parents do not think of me as being good in mathematics SA A U D SD
9. Mathematics lessons bore me SA A U D SD
10. I enjoy being given a set of mathematics problems to solve SA A U D SD
11. I'm not the type to do well in mathematics SA A U D SD
12. Anyone can learn mathematics SA A U D SD

13. Knowing mathematics will help me get a good job SA A U D SD
14. My parents expect me to do well in mathematics SA A U D SD
15. My friends look down on people who get good grades in
mathematics SA A U D SD
16. Mathematics is a worthwhile and necessary subject . . . SA A U D SD
17. I do not enjoy working on mathematics problems SA A U D SD
18. Taking mathematics is a waste of time for me SA A U D SD
19. My teachers do not expect me to get good grades
mathematics SA A U D SD
20. My parents think that I am smart in mathematics SA A U D SD

II. The next statements have to do with this class. Again, tell whether you agree or disagree with each one.

21. This is a well organized class SA A U D SD
22. The teacher is unfriendly to the students SA A U D SD
23. There is a great deal of confusion during most class
periods SA A U D SD
24. Most of the students in this class enjoy it SA A U D SD
25. My teacher thinks I can do well in this class SA A U D SD
26. This class is more a social hour than a place to
learn something SA A U D SD
27. The class is directed at the smartest students SA A U D SD
28. This class is harder for me than any of the others
I am taking SA A U D SD
29. The teacher takes a personal interest in each
student SA A U D SD
30. Most of the students in this class pay close
attention while the teacher is talking SA A U D SD
31. The teacher rarely lets students ask questions SA A U D SD
32. In this class I do as little work as possible SA A U D SD
33. I am happier in this class than in any other class . . SA A U D SD

34. For me, this class is easy SA A U D SD
35. The teacher encourages students to present their own
ideas SA A U D SD
36. I dread this class SA A U D SD
37. We always have enough time to finish our work SA A U D SD
38. Anyone can do well in this class SA A U D SD
39. It is difficult to keep up with the assignments in
this class SA A U D SD
40. Students in this class don't do much work SA A U D SD

III. As you think about this class, what do you like most about it and what do you like least? What would you keep, if you were teaching it, and what would you change? Your answers should be short.

41. What do you like most? _____

42. What do you like least? _____

IV. Finally, what is your background?

43. Which would you call yourself?

- | | |
|--|--------------------------------|
| 1. American Indian, Native American | 5. Black, Negro, Afro-American |
| 2. Chicano, Mexican American, Hispanic | 6. White, Caucasian |
| 3. Puerto Rican | 7. Other _____ |
| 4. Oriental, Asian American | |

SCIENCE QUESTIONNAIRE

Student Number
or Name _____

Sex (circle one)

M

F

Age _____

Grade _____

158

147

SCIENCE QUESTIONNAIRE

Given below are several statements. There are no right or wrong answers to them. You are asked if you agree or disagree with each one. Here is an example:

Example 1. I like science SA A U D SD

If you agree strongly with the statement, circle the letters SA (strongly agree). If you agree but not completely, circle A (agree). If you disagree but not totally, circle D (disagree); if you disagree strongly, circle SD (disagree strongly). Finally, if you neither agree or disagree, that is, you aren't sure, circle U (uncertain). Try this out with example 2 below.

Example 2. This class is very interesting to me . . . SA A U D SD

Do not spend much time with any statement, but be sure to answer every statement. Work fast, but carefully.

I. The statements that follow ask you about science in general.

1. Science is fascinating and fun SA A U D SD
2. My parents do not encourage me in my study of science SA A U D SD
3. Science has been my worst subject SA A U D SD
4. I expect to have little use for science after I get out of high school SA A U D SD
5. My friends think science is an important subject . . . SA A U D SD
6. I am sure that I can learn science SA A U D SD
7. My teachers have encouraged me to take all of the science I can SA A U D SD
8. My parents do not think of me as being good in science SA A U D SD
9. Science lessons bore me SA A U D SD
10. To find out why something happens, I prefer doing an experiment over being told SA A U D SD
11. I'm not the type to do well in science SA A U D SD
12. Anyone can learn science SA A U D SD

13. I would like to be a scientist when I leave school . SA A U D SD
14. My parents expect me to do well in science SA A U D SD
15. My friends look down on people who get good grades
in science SA A U D SD
16. Science is a worthwhile and necessary subject SA A U D SD
17. Science is not very interesting SA A U D SD
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19. My teachers do not expect me to get good grades
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- 2. Chicano, Mexican American, Hispanic
- 3. Puerto Rican
- 4. Oriental, Asian American
- 5. Black, Negro, Afro-Americans
- 6. White, Caucasian
- 7. Other _____



CLASSROOM BEHAVIOR IN MATHEMATICS AND SCIENCE EDUCATION

Wisconsin Center for Education Research

1982-83

SCHOOL _____

DATE _____ CLASS: SUBJECT AND TIME _____

TEACHER _____ ATTENDANCE _____

GIVING
INFORMATION

TARGET
(EC, SG, IS)

METHOD
(LC, DM, DC, AV, OT)

LEVEL
(PD, PC, BO)

ASKING
QUESTIONS

RESPONSE
OPPORTUNITY
(DN, OV, CO)

LEVEL
(PD, PC, BO)

FEEDBACK
Correctness
(CT, PT, IC, NF)

Tone
(PF, NEF, NGF)

