Report of the Governor's Task Force on Mathematics, Science, Technology and International Education

Adopted November 20, 1990

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Governor's Task Force on Mathematics, Science, Technology and International Education

Executive Summary

Charge to the Task Force

Governor Perpich directed the Task Force on Mathematics, Science, Technology and International Education to:

- assess the current state of mathematics, science, and technology education in Minnesota
- review local, state, federal, and international improvement efforts
- recommend short-range and long-range methods to improve mathematics, science, technology, and international education in Minnesota
- study the feasibility of a resource center and school for Minnesota
- study and make recommendations for integrating international education and world languages with the study of mathematics, science, and technology.

Summary

In recognition of the changing and more demanding nature of future work and the need for Minnesota to be an integral part of a world marketplace, Governor Perpich appointed a group of citizens to examine the crucial issue of how to improve mathematics, science, technology and international education in Minnesota.

Minnesota students continue to perform well academically when compared to the rest of the nation. Minnesota's high school graduation rate (91%), is the highest in the nation, and two-thirds of the high school graduates go on to post secondary education within a year of completing school.

Minnesota students are part of the pool of students in the United States who do not perform well in mathematics, science, and world languages when compared to the achievement levels of students from other countries. These results should not reflect on just schools or teachers, but on the failure of our society to react to the demands of world competition. Student involvement and achievement in challenging subject matter should be promoted and valued. Leaders at all levels must support this change.

A disturbing finding of the task force was the underrepresentation and underachievement of females and people of color in mathematics and science. The task force examined programs which were effective and recommended additional efforts to promote the involvement of all populations in challenging subject matter.

Minnesota students are future competitors in an international market and must compete and compare favorably to the intellectual accomplishments of students of the world. A change in education can be accomplished by admitting that a problem exists, celebrating what has been achieved and cooperating in our vision for tomorrow. The following recommendations represent hundreds of hours of work, study and discussion.

Recommendations

Business, Community, and Family Involvement. The Task Force recommends that a serious campaign to improve public perception of education and to increase public awareness and valuing of educational needs be conducted. Business partnerships could promote change in the social climate of Minnesota schools. People change when they see a need to change, they know how to change, they are involved in the change, they are secure in changing, and they are encouraged and supported in the change.

Teachers and parents who promote participation and achievement in mathematics, science, technology and international education activities must be recognized and rewarded in our schools and communities. Student involvement and achievement in challenging subject matter should be promoted and valued. Community members and parents should be involved in advisory groups, mentors and tutors to promote learning. Grants and scholarships should be offered to promote community participation in education.

Improvements in Curriculum/Instruction/Assessment. Efforts to promote school improvement should be supported by statewide and local district efforts. School improvement efforts include:

- adoption of appropriate national standards where Minnesota standards fall short
- articulation of outcomes and appropriate curriculum, K-12 which integrates multicultural, gender fair, disability-sensitive goals
- adoption of interdisciplinary curriculum in mathematics, science, technology education, and international education
- support for learning experiences where students work cooperatively and experience a hands-on approach to learning.
- development and support for a diversity of instructional approaches to accommodate individual differences
- development and support of multiple assessment tools to assess and evaluate student progress
- the use of information technology in all areas of teaching and learning.

Recruitment and Participation of Females and People of Color. The task force recommends that programs be developed which support the full inclusion of diverse populations, particularly females and people of color, in science, mathematics, technology and international education. These programs may involve: recruitment of teachers, involvement of parents in family education programs, recruitment of students in advanced classes, support for academic challenges which encourage broad participation of all students and the development of appropriate curriculum materials.

Resource Centers for Collaborative Research and Development. A specialized high school for Science, Mathematics, Technology and International Education is feasible within the context of a comprehensive network of resource centers, all which must address educational strategies that meet Minnesota's specific needs in mathematics, science, technology, and international education. The high school will pilot and test innovative concepts and practices in their operational mode. Additionally, the high school will meet the learning needs of highly motivated and talented students. Special attention will be given to addressing the learning needs of students of color and females in the high school admissions and programming processes. The high school should focus initially on 11th and 12th graders, offering a full-time interdisciplinary program with students in residence, and other part-time program options for non-residential students.

Resource centers for Mathematics, Science, Technology and International Education are feasible and should address the educational strategies that meet Minnesota's specific needs in mathematics, science, technology and international education. These centers should be geographically accessible and be established for the purpose of conducting applied research in education to address the problems of teaching and learning. Activities and goals of the Centers include:

- research activities connected to specific problems identified by teachers and administrators. Conducted in clinical classroom settings, these activities would support collaborative relationships between K-12 education and institutions of higher education
- dissemination of research findings and outstanding practices through state and national networks using telecommunications technology
- identification of efforts nationally and internationally which are shown to be effective and provide continued support for effective programs
- development of integrated and multicultural, gender fair approaches to teaching and learning
- development of emerging professional standards and the implementation of existing standards such as NCTM has provided in mathematics, and develop similarly comprehensive standards in science, international education, technology education and the use of information technology in all areas of teaching and learning
- development of modern technology education programs;

- development of programs for students and teachers of color and for those who are female
- networking among K-12, higher education and industries, to facilitate improved education
- dissemination and coordination of information and programming statewide
- support for effective on-going programs which are effective;
- access to Minnesota's high-technology industries by teachers and students, K-12
- programming for students who demonstrate high motivation and talents with special attention to students of color and females
- access to career opportunities in mathematics, science, international education, technology education and the integration of information technology in all career areas.

While the committee agrees that an innovative high school is feasible, it recommends that with the limited revenues available, those funds should be directed toward the establishment of three resource centers, geographically distributed in the state. Three sites are recommended, one in southern Minnesota, one in the metropolitan area and one in northern Minnesota. Criteria for selection of sites should include those that address access and appropriateness.

Teacher Education. The Task Force recommends that there be an increase in opportunities and resources devoted to teacher education and long term staff development at the pre-service and inservice level. Strong involvement of institutions of higher education is recommended. The Task Force further recommends that teacher inservice programs be directed to describe outcomes which are expected as a result of training and fully assess the competencies of teachers engaged in learning related to expected outcomes.

Chapter 1

Task Force Description and Objectives

Introduction

There is a growing concern about the readiness of our students for the next century. What should a liberal arts education of the 21st century include? In recognition of the changing and more demanding nature of future work and the need for Minnesota to be an integral part of a world marketplace, Governor Perpich appointed a group of citizens to examine the crucial issue of how to improve mathematics, science, technology and international education in Minnesota. The following report and final recommendations represent hundreds of hours of work, study and discussion.

Background

Governor Perpich appointed task force members from a wide range of populations and organizations. These individual have shown dedication to the improvement of education in Minnesota and have expertise in a variety of areas. The Governor's Task Force on Mathematics, Science, Technology and International Education, appointed October 26, 1989, was composed of parents, teachers, administrators and representatives from higher education and special programs in mathematics, science and world languages. The Minnesota High Technology Council and private sector business representatives were also appointed to serve on the task force.
Many of the members are considered state and national experts in the areas of mathematics, science, technology, and international education.

Charge to the Task Force

Governor Perpich directed the Task Force on Mathematics, Science Technology and International Education to:

- assess the current state of mathematics, science and technology education in Minnesota
- review local, state, federal, and international improvement efforts
- recommend short range and long range methods to improve mathematics, science, technology, and international education in Minnesota
- study the feasibility of a resource center and school for Minnesota
- study and make recommendations for integrating international education and world languages with the study of mathematics, science and technology.

The thirty-nine member Task Force began meeting in December of 1989. Throughout the proceedings, task force members were joined by interested persons who contributed information and often participated in task force discussions. The Task Force was also assisted by eleven resource staff members from the Minnesota Department of Education.

Work Plan

The Task Force began its work by investigating the current state of mathematics, science, technology and international education in Minnesota. Presentations to the task force were followed by subcommittee meetings in each of the four areas included in the study. Each subcommittee examined data regarding the performance of Minnesota students in each area and compared the performance of our students to performance of other students in the United States and the world.

The subcommittee members also participated in onsite visits to schools and special programs. The members gathered information about promising practices and trends for the future improvement of education in mathematics, science, technology and international education. Preliminary reports by the subcommittees were prepared and submitted to the task force chairs.

The final phase of the task force work involved the development of goals for mathematics, science, technology and international education in Minnesota. This work was done by three subcommittees: one which examined school improvement; one which examined the feasibility of a math, science, technology and international education resource center school or schools; and one which focused on equity resources to ensure that Minnesota's improvements are well designed for effective teaching and learning among students of color and females. The final report was reviewed by the task force as a whole and recommendations were adopted. The work of the task force was concluded on November 20, 1990.

The Task Force heard presentations from many knowledgeable sources and specialists including:

Dean Ettore Infante, Institute of Technology, University of Minnesota
Lucienne Taylor, Executive Director, Twin City Institute for Talented Youth
Harvey Keynes, Director, University of Minnesota Talented Youth Mathematics Program
Jim Benson, President, Dunwoody Institute
Ron McKinley, Executive Director, Minnesota Minority Education Program
Katie Koch-Leveen and Steve Brehmer, Teachers in Space Finalists and Challenger Center Outreach Faculty
Pete Nelson, Control Data Corporation

Don Sullivan, MTS Systems
Wayne Roberts, Minnesota Mathematics League
Steve Watson, Minnesota High Technology Council
Lynn Steen, Minnesota Mathematics Mobilization
Representatives of the Winona Steering Committee for a Minnesota Center for Science, Mathematics and International Studies
Minnesota Department of Education Specialists in Mathematics, Science, Technology, International, Gifted and Talented Education and Federal Eisenhower Mathematics and Science Programs.

Overview of the Report

The information in this report is organized into five chapters:

- The Executive Summary provides a brief overview of the work of the Task Force and summarizes the major recommendations.
- Chapter 1 describes the charge to the Task Force and the work of the Task Force in the preparation of this report.
- Chapter 2 provides an introduction to the current status of education in Minnesota and in the world and offers a rationale for educational improvement.
- Chapter 3 describes specific efforts to improve the success of all learners in mathematics, science, technology and international education.
- Chapter 4 describes a study of the feasibility of resource centers and an innovative high school in Minnesota.
- Chapter 5 summarizes the recommendations of the task force.

Chapter 2

Current Status and the Need for Reform

A change in education can be accomplished if we don't focus on blame, admit that a problem exists, celebrate what has been achieved and cooperate in our vision for tomorrow.

The Minnesota Report Card

Minnesota students continue to perform well academically when compared to the rest of the nation. Minnesota's high school graduation rate (91%), is the highest in the nation, and two-thirds of the high school graduates go on to post secondary education within a year of completing school. The results of standardized tests, MEAT, PSAT, SAT, and the ACT, indicate students from Minnesota's schools compare favorably regionally and nationally. But given the needs for the 1990's and the 21st century, the comparison is not appropriate. Minnesota students are future competitors in an international market and must compete and compare favorably to the intellectual accomplishments of students of the world.

International comparisons. Minnesota students are part of the pool of students in the United States who do not perform well in mathematics, science and world languages when compared to the achievement levels of students from other countries. These results should not reflect on just schools or teachers, but on the failure of our society to react to the demands of world competition.

The *2nd International Mathematics Study*, a comprehensive survey of the teaching and learning of mathematics in twenty school systems around the world, illustrated the poor performance of U.S. students compared to their international peers. Students were tested at the eighth and twelfth grade levels at the end of the 1981-82 school year. The results were as follows:

GRADE	Rank
8th Grade Overall Achievement	14th out of 20
12th Grade Overall achievement	12th out of 15
8th Grade Arithmetic	10th out of 20
12th Grade Advanced Algebra	14th out of 15

Even when the top five percent of twelfth grade U.S. students are compared with their peers in other nations, the U. S. students ranked 15th out of 15. *A World of Differences: An International Assessment of Mathematics and Sciences* also tested thirteen-year-old students from five countries and four Canadian provinces. The United States once again scored near the bottom.

In addition, the National Geographic Society and Gallup Poll Survey recently reported that United States adults rank behind those in Sweden, West Germany, Japan, France, Canada, and Great Britain and rank ahead of those in Italy and Mexico. Young U.S. adults (age18 to 24) know the least about geography of any age group surveyed in any country. One in seven adults could not locate the United States on a world map; more than half did not know, even roughly, the size of the nation's population. One half of the U.S. adults could not point out South Africa on a map; one half could not identify even one South America country; and only 55 percent could locate New York, in fact, 37 different states were identified as New York.

Attitudes toward achievement. The Stevenson Study compared the performance of students in mathematics in Minneapolis, Minnesota; Taipei, Taiwan, and Sendai, Japan. This research compared the scholastic achievement of students in grades one and five. The students were given a series of tests, mothers and teachers were interviewed, and comparisons were made. The achievement of U.S. students fell below the achievement level of students from Taiwan and Japan. The mothers of the U.S. students expressed greater satisfaction regarding their children's performance even though they achieved far below their Taiwanese and Japanese peers.

The Value of Education

Central to the challenge of student competency is the issue of the value placed on education by U.S. society. Leadership must focus on the importance of academic achievement. Educational improvement cannot happen without involvement of the parents and community. In many ways our society is failing Minnesota's educational systems. Schools are being asked to provide many services that were one time the responsibility of parents and the community. Schools are capable of delivering many services, but not without the understanding and support of the community.

The following examples may serve to demonstrate the undervaluing education in the K-12 system:

- athletics receives more recognition and support than classroom activities or academic achievement
- television commercials promote the lottery more frequently than education
- few employers request a high school transcript when hiring students
- high school students are often required to work late into the evening on school nights.

Recognizing achievement. The Task Force recommends that a serious campaign to improve public perception of education and to increase public awareness and valuing of educational needs be conducted. Business partnerships could promote change in the social climate of Minnesota schools. Teachers and parents who promote participation and achievement in mathematics, science, technology and international education activities must be recognized and rewarded in our schools and communities. Student involvement and achievement in challenging subject matter should be promoted and valued. People change when they see a need to change, they know how to change, they are involved in the change, they are secure in changing, and they are encouraged and supported to change. Leaders at all levels must support this change.

Changing Demographics

The National Science Foundation reports that fewer students are selecting mathematics, science, and engineering as careers. The Foundation projects a shortfall in the number of mathematicians and scientists in Minnesota. With Minnesota's wealth of scientific and medical-based industries, the consequences of this could be hazardous to the economy.

The demographics of Minnesota's school populations and ultimately of the workforce are undergoing great change. Students of color represent approximately 50 percent of the students in the Twin Cities and now Minnesota has thirty school districts with minority enrollments of over 10 percent. According to national studies, by the year 2000, 68.4 percent of new entrants to the workforce will be women and people of color.

Strategies must be developed to recruit and involve people of color and females in all areas of academic work, particularily in mathematics, science, technololgy, and international education. An increased value on the involvement of underrepresented groups must be established to support a full policy of inclusion.

Underrepresentation and Underachievement

Students of color and females continue to underachieve and to be underrepresented in the target subjects of mathematics, science, and technology. (Sufficient data are not available on international education.) Achievement and participation data for the past two decades point to a persistent gap in the performance and participation rates of these students in advanced-level high school mathematics and science courses in comparison to white, Asian, and male students.

Furthermore, Minnesota institutions of higher education are not producing African American, American Indian, Hispanic American and female students in large numbers with degrees in scientific and technical fields. (See Appendix A.)

Racial and gender inequities. Problems are particularly acute for American Indian and African American children. They are far more likely to be underrepresented in advanced level high school mathematics and science classes, and are less likely to receive baccalaureate and graduate degrees in science and technical fields. Hispanic American students experience the same problems to a somewhat lesser extent.

Racial and gender inequities exist in the education of scientific and technical personnel. However, many people remain unaware or unconvinced that a serious problem faces our society. Even when the problem is recognized, few analyses provide a comprehensive picture of the nature, extent, and consequences of this situation. Given the enormity of the problem, recommendations for solutions rarely address the depth and roots of this issue.

Equity issues. Recommendations to address equity issues must be based on a comprehensive knowledge and understanding of the problems, and must themselves be comprehensive and meaningful to attack directly and significantly the causes and manifestation of educational inequity in science, technical and international studies.

Chapter 3

Promising Practices and Trends

"Mathematics is the key to opportunity . No longer just the language of science, mathematics now contributes in direct and fundamental ways to business, finance, health, and defense. For students, it opens doors to careers. For citizens, it enables informed decisions. For nations, it provides knowledge to compete in a technological economy. To participate fully in the world of the future, America must tap the power of mathematics."

Everybody Counts, National Research Council, 1989

Background and Current Status

"There is no algebra in my future."

Peggy Sue (circa 1955) in "Peggy Sue Got Married," CBS Fox Video 1986

When Peggy Sue went to school, students' needs for mathematics were two -fold: all students needed to be skilled in arithmetic and a select few needed to prepare for the study of calculus in college. This is no longer enough.

A new vision. Publication of the *Curriculum and Evaluation Standards for School Mathematics* by the National Council of Teachers of Mathematics (NCTM) in 1989 sparked a revolution in mathematics education. In addition, publications such as *Everybody Counts* (National Research Council, 1989), and *Reshaping School Mathematics* (National Research Council, 1990), have done an excellent job of providing a rationale for change. The publication of *Mathematical Sciences in Minnesota: A State Assessment* (Minnesota Mathematics Mobilization,1990) gives a picture of many dimensions of mathematics in the state. Coupled with the *Professional Standards for Teaching Mathematics*, due to be released by NCTM in March, 1991, these documents provide a "vision" for mathematics educators in restructuring the mathematics programs, K-12, in today's schools.

Minnesota high school requirements. While Minnesota prides itself on the high levels of education and technological competence of its citizens, recent international studies point to a growing awareness that ranking high in a study of the states is not sufficient to ensure adequate preparedness for today's students.

Though our students are proficient at computation, Minnesota students, along with other students in the United States, are not able to apply mathematics to unfamiliar or practical problems. Forty-three states require more mathematics in high school than Minnesota.

Females and people of color in teaching. Though the number of female teachers of mathematics nationally is very nearly equal to the number of males, in Minnesota there are four male mathematics teachers for every female, the highest ratio of any state. This imbalance hardly inspires young women to continue their study of mathematics since it appears to be a male domain. The picture for people of color in teaching is even worse. There are virtually no minority students preparing to teach mathematics. Elementary teachers, most of whom teach mathematics, have very minimal preparation, often only a single college course. Additionally, many of these teachers are products of Minnesota high schools, where they often discontinued their study of mathematics after ninth grade.

Resources. Despite this seemingly bleak picture, Minnesota is actually at the forefront in the area of mathematics education. Many students go well beyond the minimal requirements. There are innovative programs for outstanding students, such as the University of Minnesota Talented Youth Mathematics Program (UMTYMP) and the Minnesota State High School Mathematics League. The Minnesota Mathematics Mobilization, M^3, is a prototype for statewide collaboration of business and industry, schools, and higher education aimed at improvement of mathematics education. Many mathematics educators in Minnesota are nationally recognized leaders. The resources are here; we must tap them fully.

Learning how to learn. The direction we must take is determined by many changes around us: changes in the need for mathematics in people's lives, in the content of mathematics, and how mathematics is used. Dramatic changes have resulted from the availability of technology, including computers and inexpensive hand-held calculators, changes in society, in understanding how students learn, and of growing changes in economic competition in a global market. Students in a rapidly changing world need most of all to learn how to learn, and in this case, how to learn mathematics.

Promising Practices and Trends

The climate in Minnesota is generally supportive of mathematics and science. A large proportion of the population is well educated in these areas. Nevertheless, many Minnesotans share the view of the larger society that learning mathematics is only for the elite, those with "math minds". Therefore, the attitude of many is that the majority of students can and should be excused from studying any mathematics beyond arithmetic.

Mathematics is for everyone. Educators have made strong beginnings through statewide press conferences, leadership training, and work at state and national conferences to change these attitudes. These efforts must be continued while interest is still high and there is receptivity to attitudinal change.

Project PRIME (Project for Refocusing and Improving Mathematics Education) is the sort of leadership training that will effectively publicize new directions in mathematics. This project is an outgrowth of a conference held in March, 1990, in which sixteen state leaders were trained to help lead mathematics education into the twenty-first century.

As a statewide follow-up, Project PRIME has planned a state conference where sixty-four leaders, selected from sixteen regions of the state, will receive similar leadership training, and will then give sessions to teachers and other community members in their regions. Political leaders must join in this campaign to convince parents and all citizens of the importance of mathematics for all. This conviction can be demonstrated by high expectations for all students, as reflected in requirements and graduation outcomes.

Teacher Education. Secondary mathematics teachers are in the midst of changes, so rapid that even the most active, eager and energetic are unable to stay current in the field. Topics such as data analysis, recommended for students throughout their school years, are almost never studied by those preparing to teach secondary mathematics, except for the specialized topics related to thesis writing.

Overall requirements in mathematics are unchanged from a time when life was simpler and more stable. Meanwhile, the minimal preparation most teachers have had in pedagogy leaves them unprepared for the systems of delivery now recommended. Pedagogy describes the teaching strategies and methods used by teachers during the active phases of teaching and student learning. Few are skilled in organizing cooperative learning, in teaching with manipulative materials, in using laboratory approaches in mathematics instruction, or in teaching problem solving strategies.

Almost no one is prepared for the forms of assessment described in the NCTM *Standards*. Teachers need opportunities for retraining that will enable them to guide students to successfully learn mathematics for the twenty-first century. Summer and academic year institutes and offering stipends or graduate credit as incentives should be made available.

Minnesota elementary teachers also need to supplement their prior work in mathematics as society realizes the fundamental importance of mathematics in the curriculum, and as we revise the necessary content away from stress on computation toward a broader view of mathematics.

At the same time, those who particularly enjoy and are especially talented at teaching mathematics should be encouraged and given opportunities to become mathematics specialists at the lower or middle school levels. Summer and academic year institutes, similar to, but separate from those for secondary teachers, should be offered for all elementary teachers. Stipends and graduate credit should be awarded to teachers who participate in these activities.

In order to be well-prepared to teach what today's students need to learn, college students preparing to teach need new courses of study. Requirements for certification must be brought into alignment with the guidelines published by the National Council of Teachers of Mathematics and the Mathematical Association of America. These requirements should reflect the differing needs of students at different levels, and should be grouped by grades K-4, 5-8, and 9-12. Different levels reflect our current knowledge of developmental stages of learning as described by the new studies of mathematics education. These changes need to be effective immediately.

Recruitment of women and people of color. To begin to correct the gender and racial imbalances that exist between the mathematics faculty population and the distribution of students in the state, we must make great efforts to attract qualified women and minorities to the mathematics teaching field. Since role models are particularly important in education, it is crucial that we begin immediately to correct the current imbalance.

Competitive state grants and scholarships for college tuition and expenses, which are forgiven upon completion of three years of mathematics teaching in the state, would serve as an incentive for talented women and minorities to teach. School districts need incentives to hire women and minorities for open positions. Where a pool of qualified candidates does not already exist, it will be necessary to recruit minority teachers from outside the state. Efforts such as the Minority Teachers Incentives Program should be continued.

Support networks should be available for young women and people of color starting in grade five and continuing throughout high school. These should include career counseling, tutoring and group study and discussion. These activities should be led by suitable role models.

Improvement of the curriculum. All of the recent documents in mathematics as well as many other documents point to the fact that the traditional curriculum in mathematics is no longer suitable.

"To the Romans, a *curriculum* was a rutted course that guided the path of two-wheeled chariots. Today's mathematics curriculum, a course of study, follows a deeply rutted path directed more by events of the past than by the changing needs of the present."

Reshaping School Mathematics, 1990

Standards. The NCTM *Standards* have lead to strong national consensus on what the future course of study in mathematics should include. Leaders in this state have already made great strides at aligning the *Standards* with state and local outcomes. This reorganization must continue to integrate the *Standards* into K-12 curriculum, with broader topics in grades K-4 and 5-8, and more curricular integration in grades 9-12.

Curricular revision needs strong leadership at the state and district level and educators with experience teaching mathematics need to provide this leadership. Districts are making strong efforts to revise outcomes to coincide with the *Standards* through a curriculum review process. As a result, these processes are promoting the articulation of the mathematics curriculum, K-12.

An integrated approach. Throughout the curriculum, the expectations are that students will have access to calculators, computers and other technology and be encouraged to use them when appropriate. The use of these tools should be integrated throughout the mathematics curriculum, including assessments. Efforts to "teach the tool" as a special topic should be discouraged. All students should have equal access to technology tools.

A broad core of mathematics must be available to <u>all</u> students. Mathematics must be practical and useful, not abstract and esoteric. All efforts in mathematics education must support this overriding goal. Together with broader content in mathematics, strategies for delivery of instruction must be expanded.

We know students learn through active participation, using all their senses to make ideas their own. They learn together, by exploring and sharing verbally and in writing. In order for <u>all</u> students to be successful and confident in mathematics, all means must be taken to diversify the types of activities in the mathematics classroom and to include opportunities for all to learn.

Developmental levels. For each grade level grouping, there are variations in emphasis, determined by the developmental level of the students. For the K 4 level, an emphasis must be placed on forming basic concepts through active learning and on viewing mathematics as a 'sense-making' activity, rather than just a set of rules and procedures. During middle school grades 5-8, students need to continue their active learning, with hands-on models for new mathematical ideas, rather than only rote learning of mathematical operations. They should experience a wider variety of mathematical topics.

Students in grades 9-12 are capable of more abstract learning and are able to develop a variety of goals. Though all students need to continue learning and doing mathematics throughout their high school career, there will be some differentiation of depth and breadth of topics in mathematics education.

Improving assessment. Paper and pencil tests, particularly traditional objective-type tests, cannot adequately measure a student's grasp of mathematics. As we move to outcomes such as careful reasoning, valuing mathematics and becoming confident problem-solvers, teachers and others need more methods of evaluating student achievement. State assessment tools can lead the way by modeling various types of tests. Funding will be needed for development of alternative forms of assessment. Additionally, stipends must be available for trained scorers of open-ended tests which are designed to assess reasoning or problem-solving ability.

Assessment is used to diagnose the learning of individual students and prescribe instructional interventions, to provide instructional feedback to students, to award a grade and to evaluate programs.

The following characteristics of appropriate assessment techniques suggested in the NCTM *Standards* should be adopted:

- assessment should focus on what students know and how they think about mathematics
- assessment should be an integral part of teaching
- assessment should focus on a broad range of mathematical tasks using a holistic view of mathematics
- assessment strategies should include problem situations that require the application of a number of mathematical ideas
- multiple assessment techniques which include written, oral and demonstration formats should be used
- calculators, computers and manipulatives should be used in assessment
- assessment includes the use of standardized achievement tests as only one of many indicators of student accomplishment of program outcomes
- assessment of the effectiveness of mathematics programs is accomplished through the systematic collection of information on outcomes, curriculum and instruction.

Prognostic testing, which is a preliminary placement test given to high school students to determine what their college placement in mathematics courses would be at the time of the test, acts as a strong motivation for students to choose appropriate courses during their high school years. The possibility of using this type of testing in Minnesota should be studied.

Involvement of teachers. National efforts such as the pre-summit and summit conferences on assessment in mathematics sponsored by the Mathematical Sciences Educational Board in 1990-91 should be supported with stipends by the state to increase participation in these events by mathematics teachers. A sizeable delegation from the state should be funded to attend these conferences. Participation promotes ownership of the necessary changes in mathematics instruction.

Students with special needs. The subjects of science and mathematics are often areas where gifted students excel. These students need a variety of enrichment opportunities. These could be provided through a variety of enrichment programs such as summer and academic year programs, where skills can be integrated while students explore advanced topics in depth. These students need freedom to advance in school courses at their natural rate, not penalized by practices such as sitting in courses where they have already met outcomes, or doing clerical work as a substitution for class. These are the scientists, inventors, researchers, engineers and professors of the future.

Students who have difficulty in learning mathematics desperately need survival skills. In the past we have often forced them to repeat the study of computation year after year, as though this were a necessary passageway to all other mathematics. Now that hand-held calculators can easily perform computations, these students can be freed to study fresh topics, with an opportunity to experience success, motivated by the usefulness of the ideas. Suitable instructional practices, active learning situations, and all possible forms of support aimed at success for all, will lead to learning.

All strategies should be supportive of the self-esteem of these students. Those who are behind or need extra time to solidify concepts should have opportunities for summer and academic year supplemental instruction, in a pleasant and non-remedial setting. This will be less costly than retraining or underemployment.

Recommendations for Mathematics Education

1. Continue the support at the state and local level for effective programs. Some examples include: Minnesota Mathematics Mobilization, University of Minnesota Talented Youth Mathematics Program, Math League, and Math Counts, EQUALS, El Primo Paso.

2. Expand academic opportunities for underrepresented groups to participate fully in the complete range of mathematical programs. This includes grants and scholarships for women and students of color to pursue mathematics teaching as a career.

3. Immediately revise the requirements for teacher certification to conform to NCTM/MAA guidelines. Establish a fund to support proposals for academic year and summer institutes enabling five hundred current elementary and secondary teachers to attain and maintain these requirements.

4. Raise statewide expectations of mathematical understanding as evaluated by the more comprehensive assessment tools now being developed to guarantee that students will be proficient in the essentials and applications of mathematics as described in the *NCTM Standards*.

Student 1: "Do you understand it?"

Student 2: "No."

Student 3: " I don't either."

Student 4: "I don't either, but it's cool."

Student 1: "Should we do a third one?"

Student 2: "We don't know how to do the last one."

Student 3: "We got a formula, isn't that enough?"

Student 2: "Okay."

Indicators for Measuring Mathematics and Science Education, RAND, 1989.

Background and Current Status

A new literacy. The information explosion and expanding technology demonstrates a clear need for scientific and technological literacy. International tests, assessments, and studies indicate that students in this country perform less well than their counterparts in other first and even second world nations. Furthermore, these differences increase as time in school increases. If the United States is to grow as a first world nation, tough questions must be asked, clear answers must be found and difficult choices must be made.

The following questions should be the basis for guiding the development of a new science education:

What competencies should students have to use scientific or technological information as productive citizens in a democratic society?

What kinds of science will meet the personal and career needs of students?

What can science education contribute to the enlightenment and understanding of values that are held by a society that is highly mobile and culturally diverse?

Concept integration. Recent national projects such as Project 2061, have taken the position that it is impossible to teach it all. Science textbooks increase in size with each edition to the point where there simply is too much to be covered in any one year. Science educators are recognizing that an essential ingredient for improved science instruction is " a less is more approach."

Broad themes should be adopted which focus on the big ideas, concepts and skills of science rather than science facts. While sounding simple, the "less is more" approach requires a carefully crafted curriculum, one that combines instruction, hands-on science, and diverse assessment techniques.

Current practices suggest that many of the topics presented are not developmentally (or even academically) appropriate for the intended age group. If science is to be relevant to the American populace, then basic themes must be developed systematically, starting in kindergarten and continuing through the twelfth grade. Basic concepts are constructed gradually, when children are developmentally ready to understand them. Finally, as the child progresses in his or her schooling those concepts are related and integrated.

Diversity. Throughout the United States, children of color as well as females are underrepresented in secondary school science. Without opportunities to enjoy science, there is little chance that they will ever choose science as a career. An increased emphasis on the selection of science content which is more relevant to students' lives is needed. When learners are actively engaged in real science, more learners will be successful. The development of multicultural, gender fair curriculum outcomes supports the inclusion of females and people of color in science education.

Promising Practices and Trends

The "hands-on" approach to instruction emphasizes active learning that takes on the form of a laboratory experience for students. Activities are devised which involve the discovery or illustration of important science concepts which have real life applications. Students explore natural phenomena directly and construct their own questions. This model of resource-based learning with active student involvement is a central component of improved science instruction.

At all levels, more students should participate in active learning experiences designed to intrigue and challenge them in an inviting and safe learning environment. Students' dispositions toward science are improved when students learn in an environment where they can safely ask challenging questions and feel responsibility for developing an opinion that is based on reason and research.

Articulated curriculum. Administrators need to ensure that there is K-12 articulation of student outcomes and that what is taught reflects the goals and objectives of the district, school, department or grade level. This is particularly important in the elementary grades where students are first exposed to hands-on science. A commitment to a balanced curriculum is encouraged where language arts and communication, mathematical reasoning and science processes are integrated.

Exemplary programs provide teachers with the opportunity to make decisions concerning how and what will be taught. Faced with a knowledge explosion, textbooks are bigger and more costly than ever. Teachers should be encouraged to select relevant resources which support the broad concepts that are central to scientific literacy for the average citizen. They rely on the research such as a state framework and/or concepts found in the American Association for the Advancement of Science, Project 2061.

Inquiry learning. Inquiry is the heart of all science instruction. In science, inquiry requires the integration of many processes and skills which engage the student in the discovery of concepts. Students work in the laboratory where they are not simply following a step-by-step formula, but work in an atmosphere of challenge.

Students are learning by inquiry when they access information bases to determine what has been done and compare a problem at hand with others that were or are similar. Inquiry learning is demonstrated when students seldom discover the one "right" answer, but use several methods of discovery.

Cooperative groups. The consistent use of small cooperative groups have been shown to increase student achievement, problem solving skills and attitudes toward Science. Students develop necessary skills to collect and display data, organize their thoughts, form hypotheses, and defend their conclusions. Cooperative teaching strategies are used to develop in students a responsibility for learning, a focus on scientific knowedge and processes and the development of the cooperatives skills which are essential to modern life.

Contextual science applications. Science exists for students outside of the immediate school environment. They see science applications in their everyday lives. Students should be encouraged to be directly involved in science and use scientific concepts and skills to make decisions involving problems which impact them or their community. The literate student is able to communicate ideas as well as evaluate data to arrive at rational decisions.

Rich and safe environment. The physical environment which is important to the new science literacy of the 90's should be designed for active science learning. This environment should allow for a teacher-student ratio which promotes inquiry learning. In this model, the teachers encourage student thinking and assist students in the development of their thinking abilities. The environment needs adequate safety provisions, equipment, resources and supplies which support the laboratory model of learning.

Improve assessment. The primary goal of assessment is to improve instruction with an assortment of appropriate assessment techniques being implemented. Clearly, what is measured or tested is valued and will be taught. Therefore, the exemplary teacher is familiar with assessment techniques that are used to provide diagnostic information for instructional planning that indicate performance on the acquisition of concepts and use of processes and whichdemonstrate achievement of commonly shared science outcomes.

Diagnostic assessment helps teachers to discover what children already know or what misconceptions they may hold. Performance testing is conducted when students are engaged in a learning activity and may measure problem solving ability or the use of scientific reasoning. Finally, some kind of measure of student achievement is a legitimate goal. Knowing how one student compares with another can be informative and helpful as long as children are compared using similar criteria and outcomes.

Teachers as professionals. Exemplary programs are designed to provide teachers with time for planning, time to arrange and develop curriculum as well as the opportunity and resources that allow them to attend professional meetings. The professional teacher is involved in the day to day life of the school and its student body, but is also active in professional organizations. They make a contribution.

Home and community partnerships. To increase scientific literacy and develop a heightened awareness of basic scientific values, concepts and skills, the community at large must value scientific literacy as well. As our society becomes more technologically oriented, everyday decisions become more difficult to make without a measure of scientific literacy.

Programs should be designed to encourage all students, particularly economically disadvantaged children, minorities and females to explore science. Family kits which involve science activities with parents are needed. Outreach programs which show the importantance of science education and involve the active participation by community institutions such as churches and boys'/girls' clubs are needed to involve more females and people of color in science careers.

The total community will remain healthy only as long as informed citizens can make decisions based on knowledge and experience. The community exists only as a collective of citizens, parents and students. In a democracy, the community is formed by its collective values. The goal of a new science education is increased scientific literacy for all students as well as the development of students who are able to achieve the highest performance in an international world.

Recommendations

1. Provide specific, categorical assistance to support science resource teachers (K-12) to provide leadership in science education and direct assistance to teachers and learners in all aspects of science learning.

2. Promote the use of cooperative groups, hands-on approaches to learning, the integration science and mathematics curriculum (especially at the elementary level), and the development of problem solving skills in students.

3. Increase the participation of females and people of color through the development of appropriate curriculum materials which are inclusive of diverse populations. Support special programs which offer incentives aimed at the recruitment of diverse populations. Recruit and retain teachers who serve as appropriate role models among all populations into the teaching profession.

4. Develop and support experiential science education programs for parents and students which encourage family learning, social responsibility and respect for the environment.

5. Develop and promote public support for science education through the involvement of community groups, businesses, and Parent/Teacher organizations.

6. Develop alternative methods of assessment based on outcomes which are reflective of important concepts and processes outlined in the American Academy for the Advancement of Science in Project 2061... Science for All Americans.

"The world is on the edge of a major lifestyle, business, industry and educational upheaval - an upheavel which will be fueled by rapid technological growth and by a very competitive worldwide marketplace. This upheavel brings with it major threats and opportunities to the business and economic base of the United States - all of which is predicated on the technological literacy of our citizens.

Because the American culture is distinctly characterized as technological, it becomes the function of our educational system to provide every student an insight and understanding of the technological nature of our culture. All persons must be knowledgeable of their technological environment so they can make rational decisions about their own lives on a day-to-day basis and participate in controlling their own destiny."

Technology: A National Imperative, 1988

Technology education is the broad study of all aspects of technology. Technology education is a bridge between academic knowledge and practice, between theory and application. Technology education offers a holistic, integrated approach, and has the unique ability to integrate other disciplines such as mathematics and science, in ways that are meaningful to students, and which foster levels of achievement and understanding that are not possible when these and other subjects are studied in isolation.

The Minnesota Task Force on Education for Employment (1988) concluded that all students must be taught work-readiness in a fully integrated curriculum. Work-readiness, sometimes called the fourth "R," includes the skills, basic knowledge, attitudes, values, and behaviors necessary to succeed in the working world. Among the skills specifically identified by the task force, which was composed of educators, business leaders, and community representatives, was technological literacy.

Technological literacy. In identifying the risk to the nation, the National Commission on Excellence in Education pointed out the need for a new basic skill called technological literacy. Technologically literate persons:

- understand what technology can and cannot do
- actively use technology
- understand how technology has evolved
- understand the impact of technology on society
- recognize that technology is not just machinery or wizardry, but rather is a sophisticated system which expands human potential
- understand systems, processes, machines, and materials
- have a proactive attitude toward choosing and designing their own future.

Background and Current Status

Technology is the application of knowledge, tools, and skills to solve practical problems and extend human capabilities. Some examples of technology as identified in Project 2061: Technology, are: materials, energy, manufacturing, agriculture and food, biotechnology and medical technology, environment (atmosphere),communications, electronics, computer technology, transportation, and space.

Technology is chiefly responsible for the increasing rate of change in the world. Technology is a process, but it is often better known or recognized through its products and their effects on society. Technology's role is doing, making, and implementing. Technology includes a well-defined body of knowledge, and additionally has the unique ability to integrate other disciplines such as mathematics and science, in ways that are meaningful to students.

The use of technology fosters levels of achievement and understanding that are not possible when these and other subjects are studied in isolation from their real-world applications. Teachers should integrate technology comprehensively, showing its role in history, its part in everyday life, and its potential for the future. Schools should provide students not only with theoretical, abstract knowledge, but also with opportunities for practical experiences using technology. Students must be familiar with the basic "tools" of technology.

Technology education. Technology education involves studying the technologies of manufacturingand communication, for example. It helps answer questions such as: How are products designed and why do they look like they do? How are things made? How does and idea go from just that, an idea, to millions of copies of a richly illustrated magazine cover? Why are some products cheaper today than they were 40 years ago? How can a computer control a machine? How are the ideas for what a building or bridge look like communicated to the builder or buyer?

Promising Trends and Practices

Criteria for technology education. The International Technology Education Association (ITEA) sums up the general criteria for course content by saying that curriculum is based upon:

- an organized set of concepts, processes, and systems that are uniquely technological
- fundamental knowledge about the development of technology and its effect on people, the environment, and culture
- instructional content drawn from communication, construction, manufacturing, and/or transportation

- assistance to students in developing insight, understanding, and application of technological concepts, processes, and systems
- safe and efficient application of tools, materials, machines, processes, and technical concepts.

This task force encourages the ITEA criteria, but urges that the goals of technology be broadened and that increased emphasis be given to the social aspects of technology.

Technology integration. The practical applications and hands-on activities involved in technology education give academic subjects, especially science and mathematics instruction, concrete relevance. Walter Waetjen, chair of the Technology Education Advisory Council, writes that technology education's integrating role is "based on the concept that the school ought to be a setting where the student can put all the parts (academic disciplines) together in the context of reality and the world beyond the school." (Technology in Western Civilization, 1967) Through this approach, students gain appreciation of and greater interest in their education, increasing their motivation for learning.

Technology education is a new discipline which is most cases has evolved from industrial arts education. In the mid-80's, Minnesota adopted a "technology education" curriculum which closely paralleled the work of many other states, using the content organizers of communication, construction, manufacturing and transportation. While activity oriented like industrial arts, technology education's problem-solving approach emphasizes proces over product or project. Learner outcomes for technology education have been developed.

Most educators agree that students have higher levels of achievement and retention if they are provided a means to apply the theoretical knowlege which characterizes much of education. Students have far too few application experiences involving technology. Solving real problems through the use of creativity, hands-on experiences, and the development of real products should be essential components of the technology curriculum.

When Theodore Sizer spoke to the Minnesota Department of Education during the Summer of 1990, he stated that "students meed many more application, doing, and performance opportunities; they need to establish connections between theory and practice; there should be far less lecturing of students and more coaching them through application experiences."

Students face the same problems as America's business leaders -- putting it all together and making it work better than anybody else. Too few students ever have an opportunity in the school environment to pose and solve such problems.

Recommendations

1. Require that technology education learner outcomes be integrated into the K-12 curricula at all levels.

2. Require the integration of technology education into teacher preparation programs to ensure that all K-12 teachers are technologically literate.

3. Encourage the participation of all students by providing hands-on, experiential learning opportunities in technology education.

References

Technology: A National Imperative. A Report by the National Advisory Council. International Technology Education, Reston, Virginia, 1988.

Kransberg and Pursell, *Technology in Western Civilization*, Volume 1, New York: Oxford University Press, 1967, p.4.

James Johnson, et.al, "The Technology Panel, *A Project 2061 Panel Report: Technology* , Washington D. C.: American Association for the Advancement of Science, 1989, p.5.

"Just as students must have opportunities within their districts and within this state, we must offer them a chance to explore the world. Our economic survival depends on our knowing as much about our world neighbors as they know about us. We envision world languages beginning in the elementary grades, student and teacher exchange programs, and study abroad programs that concentrate on language, culture, government, and trade."

America In Transition: The International Frontier, Governor Rudy Perpich, National Governors' Association, 1989.

"Quien habla dos lenguas vale par dos personas."
"He who speaks two languages becomes two persons."

Spanish Proverb

Background and Current Status

International/global education is a relatively new curricular area and has many definitions and descriptions locally, nationally and internationally. With the exception of programs in world languages and cultures, relatively few systematic daily or yearly instructional opportunities exist for elementary and secondary students and there are few measures to evaluate or report student progress.

Understanding requires knowledge of, and respect for, the differences and similarities of the world's people, the processes of development, and how goods, services, and ideas are exchanged. Concern necessitates assuming responsibility for the needs of all people and commitment to finding a just and peaceful resolution to global issues.

Global education rule. The 1984 State Board of Education rule requires a minimum of 120 clock hours of "Contemporary World Problems." Because of the newness of international education as a field, there are few measures to evaluate or report student progress. The few national measures available indicate that Minnesota students, along with their counterparts in the central United States, score above the rest of the nation on international awarness.

In Minnesota over the last decade, our international program has emerged as the "Minnesota In The World and The World In Minnesota" Program. It was conceptualized by two previous State Board of Education Task Forces to help all Minnesotans develop an international or global perspective. This international or global perspective means viewing the world and its people with understanding and concern.

More than 30 percent of all Minnesota students in grades 7-12 study world languages. Enrollments in secondary language offerings are at an all-time high. Despite positive gains, Minnesota trails many other states in the study of world languages. Data for elementary school language programs are difficult to obtain but, while interest is high, the number of formal programs remains low. Language immersion programs in Minneapolis, Robbinsdale, and St. Paul are enjoying high success.

The goal is to ensure that by the year 2000 all Minnesota high school graduates will receive at least ten years of education that has been carefully integrated with a global-local perspective through a program that includes social studies, world languages, language arts, music, art, mathematics, science, technology, and other appropriate subjects.

Promising Practices and Trends

To support the implementation of international or global education, the Minnesota Department of Education is currently identifying learner outcomes for international education. Outcomes for global education focus on the essential elements of an inclusive education: cultural diversity and gender and disability equity with local and global perspectives.

Outcomes. The six conceptual elements that students must demonstrate prior to graduation are:

- understanding that diversity offers opportunities but poses potential conflict
- understanding the world as a series of emerging interdependent systems and that no one nation can successfully deal with contemporary world problems
- understanding emerging global trends and that there are alternatives and difficult decisions for the future
- understanding prevailing world conditions and the differing cultural value systems and global perceptions
- developing effective working relationships including interpersonal and international relations
- understanding the nature and process of change and that change is a permanent part of history.

Language immersion programs. These programs offer the regular elementary school curriculum through the medium of a second language to English-dominant children. Districts use open enrollment to offer immersion and other magnet programs to a wider geographic area to attract the number of students necessary to support an immersion program. Incentives for teacher education students and practicing teachers to prepare for these challenging programs are also needed.

International education programs. International Baccalaureate (IB) programs offer a two-year course of study, including a theory of knowledge class that encompasses logical thinking and appreciation of worldwide perspectives. Competencies in world languages, literature, art, music, mathematics and science are also included. An IB diploma provides a year of college course- work at the college level.

The Rural Minnesota In The World Project, the Great Lakes/Japan In The Schools Project, the Global Studies Resource Center, the Soviet Studies Guide, the Educators Exchanges, satellite television, and the International Video Exchange promote international and global education goals.

Recommendations

1. Promote efforts which ensure that international education, especialy non-Western studies, is an integral part of the basic education of all elementary, secondary, and postsecondary students with special attention to the inclusion of diverse groups.

2. Support programs or initiatives, especially in the early grades and in critical languages (Japanese, Chinese, Russian, and Arabic), and provide access to world language programs for all Minnesota students.

3. Offer incentive grants to local districts to offer global education opportunities to secondary students such as International Baccalaureate, Advanced Placement, and College in the Schools.

4. Provide learning opportunities for college and university graduates and business and adult community members to expand their international expertise and acquire communication skils in another language.

5. Improve pre-service education and offer inservice training to teachers to improve their knowledge about international issues. Inservice training may involve exchange opportunities which enrich the teacher's knowledge of international and global education. This will result in a better educated teaching staff and improved curriculum.

"Now, as computers and other emerging information technologies take their turn at the school house door, education has a choice. We can once more take the blame for not being innovative, for not wanting to change, for not caring enough to offer children the very best . . . or we can learn from our past experiences."

Louis Rhodes

Background and Current Status

Information technology. Information technology refers to the use of computers, interactive video, and other resources, and often involves some aspect of information storage, access, processing, or communication.

While Minnesota is a leading state in the use of information technology in schools, there still is much to be accomplished. Minnesota's information technology efforts began in the early 1970s with the creation of the Minnesota Educational Computing Consortium (MECC). MECC provided schools with some computer services, teacher training, evaluation and software development.

The past decade has seen computers, satellite dishes, and videocassette recorders become ordinary tools for many members of society. Word processing, telecommunications, databases, and CD-ROM are used routinely in the workplace. Information technology has become the primary means of information storage, access, processing, and communication in our society.

Changing roles. The traditional role of education has been to help students learn a knowledge base of facts. This knowledge allowed them to graduate from formal educational institutions and become effective citizens in our past agricultural and industrial societies. Factual knowledge was power.

Today information is continually changing. It is no longer enough to learn a finite body of knowledge which rapidly becomes outdated. Schools need to prepare young people to educate themselves throughout their lives. Understanding concepts and information skills is now more important than learning factual knowledge alone.

The integration of information technology into the school curriculum and the using of technology for improving teaching quality is the responsibility of every educator at every grade level. Unlike other subject areas, information technology impacts every teacher and should be available for use by every teacher. Thus, an adequate amount of hardware, materials, and training in how to use it and knowledge about what students need to know about it is necessary for every educator. This means that training must reach the entire educational work force including administrators. This is a major task!

Teacher training. While school districts, institutions of higher education, state education agencies and private companies have allocated resources for training teachers to use new technologies in the classroom, a review of the literature indicates that the level of training has been minimal at best. Specifically, Minnesota has continued to fund training for educators but training for technology usage competes with several other training efforts.

Data from a survey of 40 Minnesota schools indicated teachers want to do a better job of incorporating information technology into their curriculum and teaching but they strongly believe they need much more inservice to do this effectively. This same survey found that teachers responsible for teaching computer science courses hold licenses in diverse areas but approximately 70% of the respondents hold some form of mathematics license. Thus, one can conclude that most of the technology instruction in schools is provided in mathematics department classes and by mathematics instructors.

Harlan Cleveland, University of Minnesota, states: "Data and information processed into knowledge and wisdom, has become the dominate resource in the United States. People and nations that do not learn to participate in an information-based society may become the world's peasants." All Minnesota graduates must be technologically literate.

Promising Practices and Trends

Computer applications, particularly simulations, have yielded higher effects in achievement in science and mathematics than in any other area. Measurement tools attached to a computer and databases used in scientific experiments have been shown to help students master important analytical techniques, although the skill of the teacher is a critical factor. Results of studies where students use the computer to develop graphing skills are consistently positive.

Tutorials which involve drill and practice activities are the most researched applications of computer technology. Recent studies have consistently reported positive results. Tutorials are an effective supplement to traditional classroom instruction, particularly when used with elementary-age children. Computer Assisted Instruction (CAI) may be more effective for low-achieving students than for average and high ability students.

Logo and robotic applications in problem solving and general thinking skills have been found to make a significant difference and show promise as a method of improving cognitive skills.

New applications such as hypermedia, desktop presenting and interactive video are now being studied. Early results seem to suggest that these applications of technology seem even more useful in providing a variety of meaningful learning experiences than the earlier uses of computers such as drill and practice.

Recommendations

1. Require that information technology learner outcomes be integrated into the K-12 curricula. This implies the need for:

- inservice teacher training
- curriculum and learner outcome development
- business, professional, community, and other resource involvement
- equipment and facilities to enable hands-on learning
- development of age-appropriate experiences
- the use of instructional technology in all subject areas
- the availablity of technological teaching aids and teacher aids such as telephones, interactive television, satellite television, overhead projection devices, computers, videodisks, voice mailboxes, and support materials for every teacher.

2. Require that the university and college community develop coursework that integrates information technology into teacher training programs to ensure that all K-12 teachers are technologically literate. Evidence of this support is shown when colleges/universities:

- require competence in the use of information technology as part of the certification process;
- require courses in the development, use, and effects of information technology in the world society.

3. Encourage the participation of all students (including students of color and females) by providing hands-on, experiential learning opportunities. The following efforts support this goal:

- encourge the use of cooperative learning;
- encourage parental involvement by introducing parents to the uses of technology both in school open houses, and in community education programs.
- promote programs that encourage females and people of color to pursue technology-based careers.

4. Provide funding for research to study the most effective uses of information technology for learning and grants to increase the availability of information technology in schools.

Chapter 4

Resource Centers for Collaborative Research and Development

Resource centers for mathematics, science, technology and international education are feasible and should address the educational strategies that meet Minnesota's specific needs. These centers should be geographically accessible and be established for the purpose of conducting applied research in education to address the problems of teaching and learning. A specialized high school for Science, Mathematics, Technology and International Education is feasible within the context of a comprehensive network of resource centers, all which must address educational strategies that meet Minnesota's specific needs in mathematics, science, technology, and international education. The high school will pilot and test innovative concepts and practices in their operational mode.

Additionally, the high school will meet the learning needs of highly motivated and talented students. Special attention will be given to addressing the learning needs of students of color and females in the high school admissions and programming processes. The high school should focus initially on 11th and 12th graders, offering a full-time interdisciplinary program with students in residence, and other part-time program options for non-residential students.

Activities and goals of the Centers and high school include:

- research activities connected to specific problems identified by teachers and administrators. Conducted in clinical classroom settings, these activities would support collaborative relationships between K-12 education and institutions of higher education
- dissemination of research findings and outstanding practices through state and national networks using telecommunications technology
- identification of efforts nationally and internationally which are shown to be effective and provide continued support for effective programs
- development of integrated and multicultural, gender fair approaches to teaching and learning
- development of emerging professional standards and the implementation of existing standards such as NCTM has provided in mathematics, and develop similarly comprehensive standards in science, international education, technology education and the use of information technology in all areas of teaching and learning
- development of modern technology education programs;
- development of programs for students and teachers of color and for those who are female
- networking among K-12, higher education and industries, to facilitate improved education

- dissemination and coordination of information and programming statewide
- support for effective on-going programs which are effective;
- access to Minnesota's high-technology industries by teachers and students, K-12
- programming for students who demonstrate high motivation and talents with special attention to students of color and females
- access to career opportunities in mathematics, science, international education, technology education and the integration of information technology in all career areas.

The resource centers should respond to existing programs through financial support and collaboration, and should initiate programs when needs are identified and existing programs are not in place. An advisory council of representatives from all areas concerned with improved education should work with the professional staff of the resource centers to determine appropriate programming responding to current needs. Programs specifically targeted for teachers, children of color, and females are of primary importance. In addition, the implementation of the NCTM standards and the development and implementation of emerging standards in science, international education, and technology education is advised.

Recommendations

While the committee agrees that an innovative high school is feasible, it recommends that with the limited revenues available, those funds should be directed toward the establishment of three resource centers, geographically distributed in the state. Three sites are recommended, one in southern Minnesota, one in the metropolitan area and one in northern Minnesota. Criteria for selection of sites should include those that address access and appropriateness.

The Minnesota legislature should establish the funding for three collaborative centers for the advancement of mathematics, science, technology, and international education. These centers should be geographically accessible and be established for the purpose of conducting applied research in education to address the problems of teaching and learning. Activities and goals of the centers include:

- research activities connected to specific problems identified by teachers and administrators. Conducted in clinical classroom settings, these activities would support collaborative relationships between K-12 education and institutions of higher education
- dissemination of research findings and outstanding practices through state and national networks using telecommunications technology

- identification of efforts nationally and internationally which are shown to be effective and provide continued support for effective programs
- development of integrated and multicultural, gender fair approaches to teaching and learning
- development of emerging professional standards and the implementation of existing standards such as NCTM has provided in mathematics, and the similar development of those comprehensive standards in science, international education, technology education and the use of information technology in all areas of teaching and learning
- development of modern technology education programs
- development of programs for students and teachers of color and for those who are female
- networking among K-12, higher education, and industries, to facilitate improved education
- dissemination and coordination of information and programming statewide
- support for effective ongoing programs which are effective;
- access to Minnesota's high technology industries by teachers and students, K-12
- programming for students who demonstrate high motivation and talents with special attention to students of color and females
- access to career opportunities in mathematics, science, international education, technology education, and the integration of information technology in all career areas.

Chapter 5
Summary of Major Recommendations

Business, Community, and Family Involvement. The Task Force recommends that a serious campaign to improve public perception of education and to increase public awareness and valuing of educational needs be conducted. Business partnerships could promote change in the social climate of Minnesota schools. People change when they see a need to change, they know how to change, they are involved in the change, they are secure in changing, and they are encouraged and supported in the change.

Teachers and parents who promote participation and achievement in mathematics, science, technology and international education activities must be recognized and rewarded in our schools and communities. Student involvement and achievement in challenging subject matter should be promoted and valued. Community members and parents should be involved in advisory groups, mentors and tutors to promote learning. Grants and scholarships should be offered to promote community participation in education.

Improvements in Curriculum/Instruction/Assessment. Efforts to promote school improvement should be supported by statewide and local district efforts. School improvement efforts include:

- adoption of appropriate national standards where Minnesota standards fall short
- articulation of outcomes and appropriate curriculum, K-12 which integrates multicultural, gender fair, disability-sensitive goals
- adoption of interdisciplinary curriculum in mathematics, science, technology education, and international education
- support for learning experiences where students work cooperatively and experience a hands-on approach to learning.
- development and support for a diversity of instructional approaches to accommodate individual differences
- development and support of multiple assessment tools to assess and evaluate student progress
- the use of information technology in all areas of teaching and learning.

Recruitment and Participation of Females and People of Color. The Task force recommends that programs be developed which support the full inclusion of diverse populations, particularly females and people of color, in science, mathematics, technology and international education. These programs may involve: recruitment of teachers, involvement of parents in family education programs, recruitment of students in advanced classes, support for academic challenges which encourage broad participation of all students and the development of appropriate curriculum materials.

Resource Centers for Collaborative Research and Development. A specialized high school for Science, Mathematics, Technology and International Education is feasible within the context of a comprehensive network of resource centers, all which must address educational strategies that meet Minnesota's specific needs in mathematics, science, technology, and international education. The high school will pilot and test innovative concepts and practices in their operational mode. Additionally, the high school will meet the learning needs of highly motivated and talented students. Special attention will be given to addressing the learning needs of students of color and females in the high school admissions and programming processes. The high school should focus initially on 11th and 12th graders, offering a full-time interdisciplinary program with students in residence, and other part-time program options for non-residential students.

Resource centers for Mathematics, Science, Technology and International Education are feasible and should address the educational strategies that meet Minnesota's specific needs in mathematics, science, technology and international education. These centers should be geographically accessible and be established for the purpose of conducting applied research in education to address the problems of teaching and learning. Activities and goals of the Centers include:

- research activities connected to specific problems identified by teachers and administrators. Conducted in clinical classroom settings, these activities would support collaborative relationships between K-12 education and institutions of higher education
- dissemination of research findings and outstanding practices through state and national networks using telecommunications technology
- identification of efforts nationally and internationally which are shown to be effective and provide continued support for effective programs
- development of integrated and multicultural, gender fair approaches to teaching and learning
- development of emerging professional standards and the implementation of existing standards such as NCTM has provided in mathematics, and develop similarly comprehensive standards in science, international education, technology education and the use of information technology in all areas of teaching and learning
- development of modern technology education programs;
- development of programs for students and teachers of color and for those who are female
- networking among K-12, higher education and industries, to facilitate improved education
- dissemination and coordination of information and programming statewide
- support for effective on-going programs which are effective;
- access to Minnesota's high-technology industries by teachers and students, K-12

- programming for students who demonstrate high motivation and talents with special attention to students of color and females
- access to career opportunities in mathematics, science, international education, technology education and the integration of information technology in all career areas.

While the committee agrees that an innovative high school is feasible, it recommends that with the limited revenues available, those funds should be directed toward the establishment of three resource centers, geographically distributed in the state. Three sites are recommended, one in southern Minnesota, one in the metropolitan area and one in northern Minnesota. Criteria for selection of sites should include those that address access and appropriateness.

Teacher Education. The Task Force recommends that there be an increase in opportunities and resources devoted to teacher education and long term staff development at the pre-service and inservice level. Strong involvement of institutions of higher education is recommended. The Task Force further recommends that teacher inservice programs be directed to describe outcomes which are expected as a result of training and fully assess the competencies of teachers engaged in learning related to expected outcomes.

Appendix A: Diversity Data

Minnesota High School Graduates by Race 1974-75 to 1988-89
Minnesota Dropout Rate By Race 1980-81 to 1988-89
Enrollment in Algebra II 1982-83 to 1985-86
Enrollment in Geometry 1982-83 to 1985-86
Enrollment in Second-Year Biology 1982-83 to 1985-86
Enrollment in Chemistry 1982-83 to 1985-86
Enrollment in Physics 1982-83 to 1985-86
Gender Differences in Mathematics/Science 1966-67 to 1988-89
ACT Scores by Race 1987-1990
SAT Math Scores by Race 1987-1990

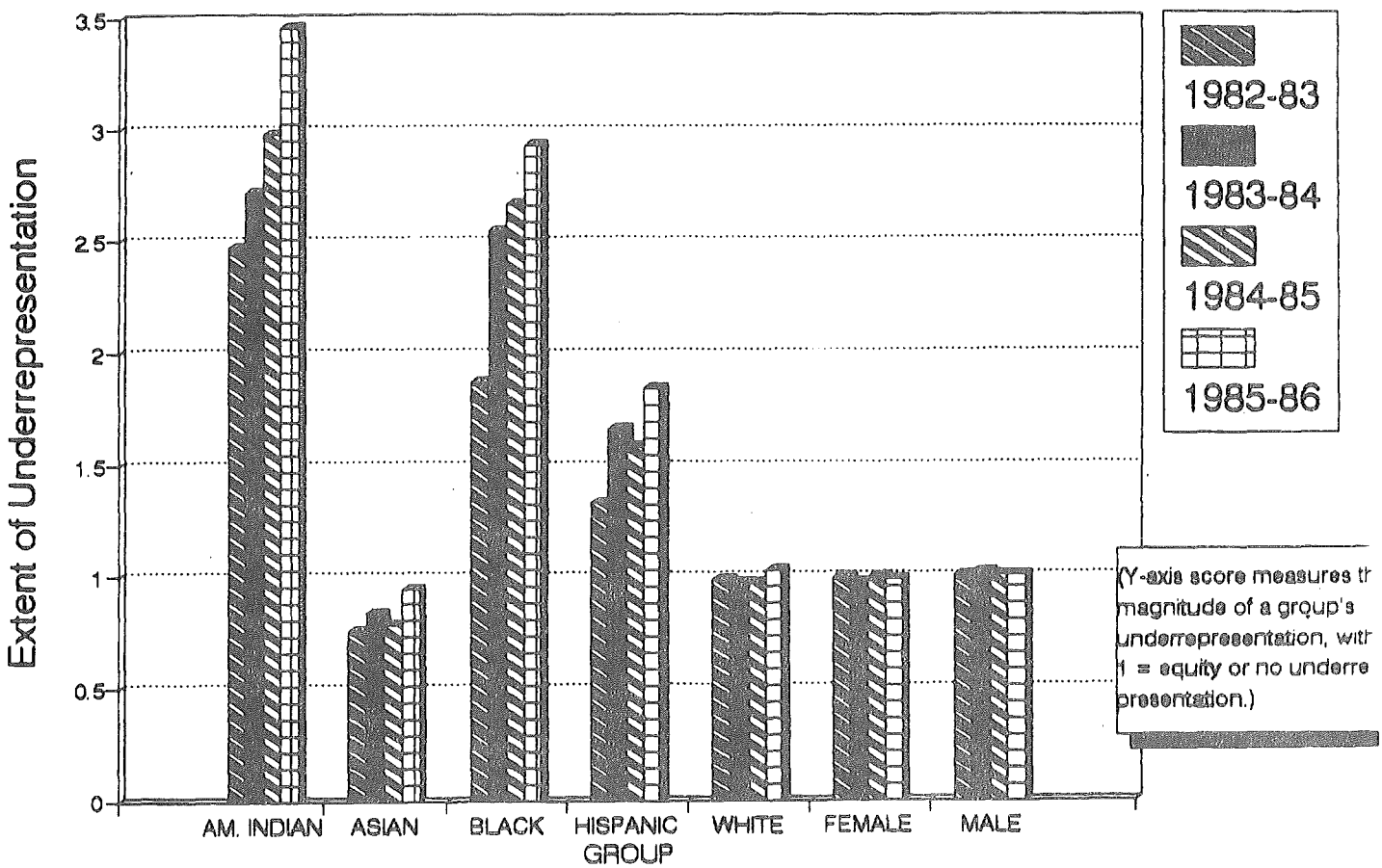
Minnesota High School Graduates by Race

SCHOOL YEAR	AMERICAN INDIAN	ASIAN	HISPANIC	BLACK	WHITE	TOTAL	PERCENT MINORITY
1974-75	456	124	269	540	64048	65437	2.1%
1979-80	496	322	374	609	63137	64938	2.8%
1980-81	500	397	302	609	61512	63320	2.9%
1981-82	547	633	329	683	59451	61643	3.6%
1982-83	506	821	292	583	55306	57508	3.8%
1983-84	489	815	335	629	53201	55469	4.1%
1984-85	468	795	313	642	50974	53192	4.2%
1985-86	465	766	334	605	49419	51589	4.2%
1986-87	459	965	333	743	51033	53533	4.7%
1987-88	427	1065	423	915	51815	54645	5.2%
1988-89	438	1184	485	1016	49999	53122	5.9%

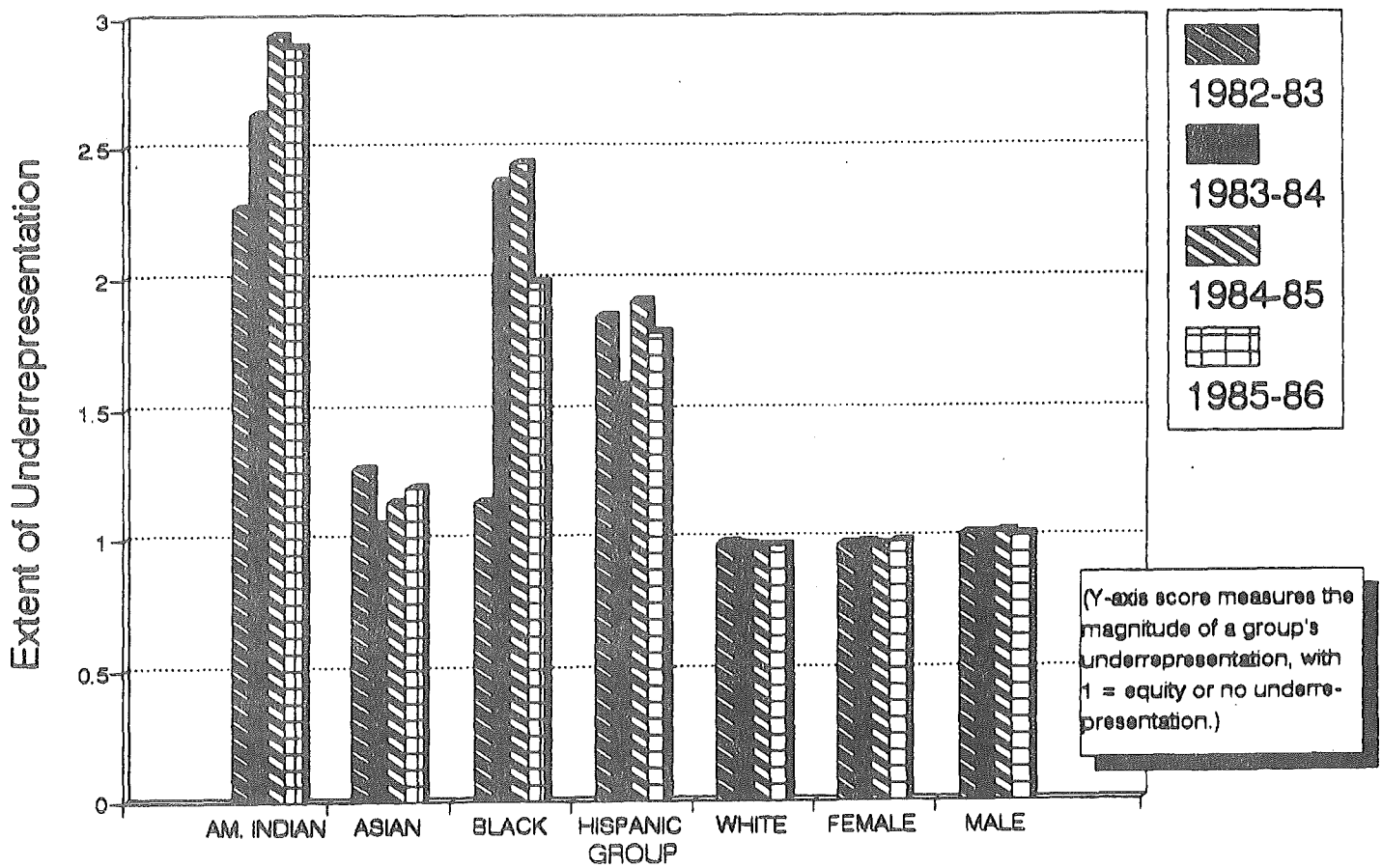
Minnesota Dropout Rate by Race

SCHOOL YEAR	AMERICAN INDIAN	ASIAN	HISPANIC	BLACK	WHITE	TOTAL
1980-81	10.8	1.6	5	11.4	2.4	2.6
1981-82	10.9	4	5.8	12	2.2	2.5
1982-83	10.8	2.9	5	9.6	1.8	2.1
1983-84	9.2	2	4.9	9.7	1.9	2.2
1984-85	10.1	1.9	5.8	10.6	2.2	2.5
1985-86	10.8	2.6	6.6	9.3	2.3	2.6
1986-87	9.4	2.7	6.9	10.6	2.5	2.9
1987-88	11.6	3.1	8.1	11.3	2.6	3
1988-89	11.1	3.8	8.9	12.9	2.7	3.2

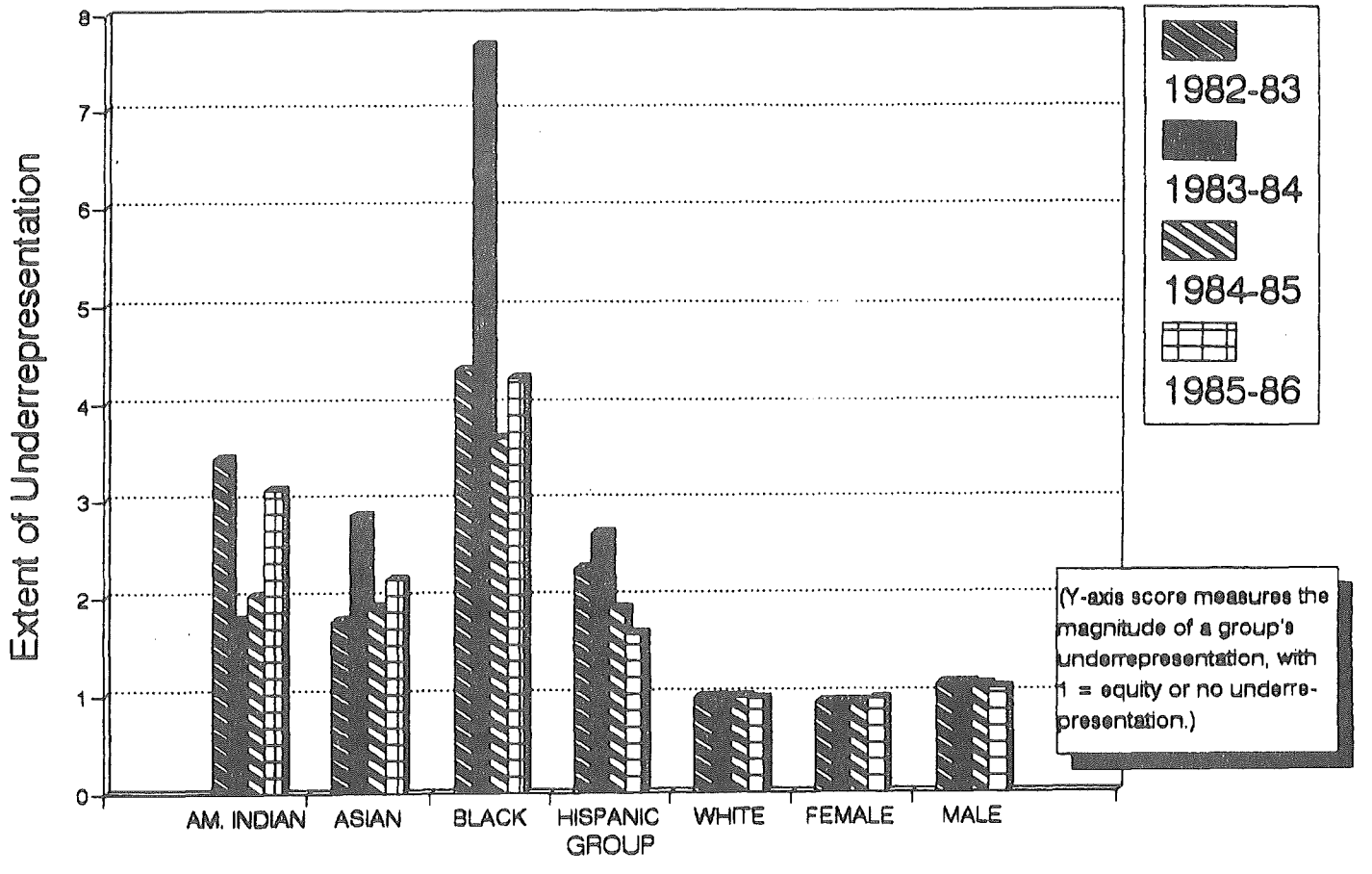
ENROLLMENT IN ALGEBRA II
1982-83 to 1985-86



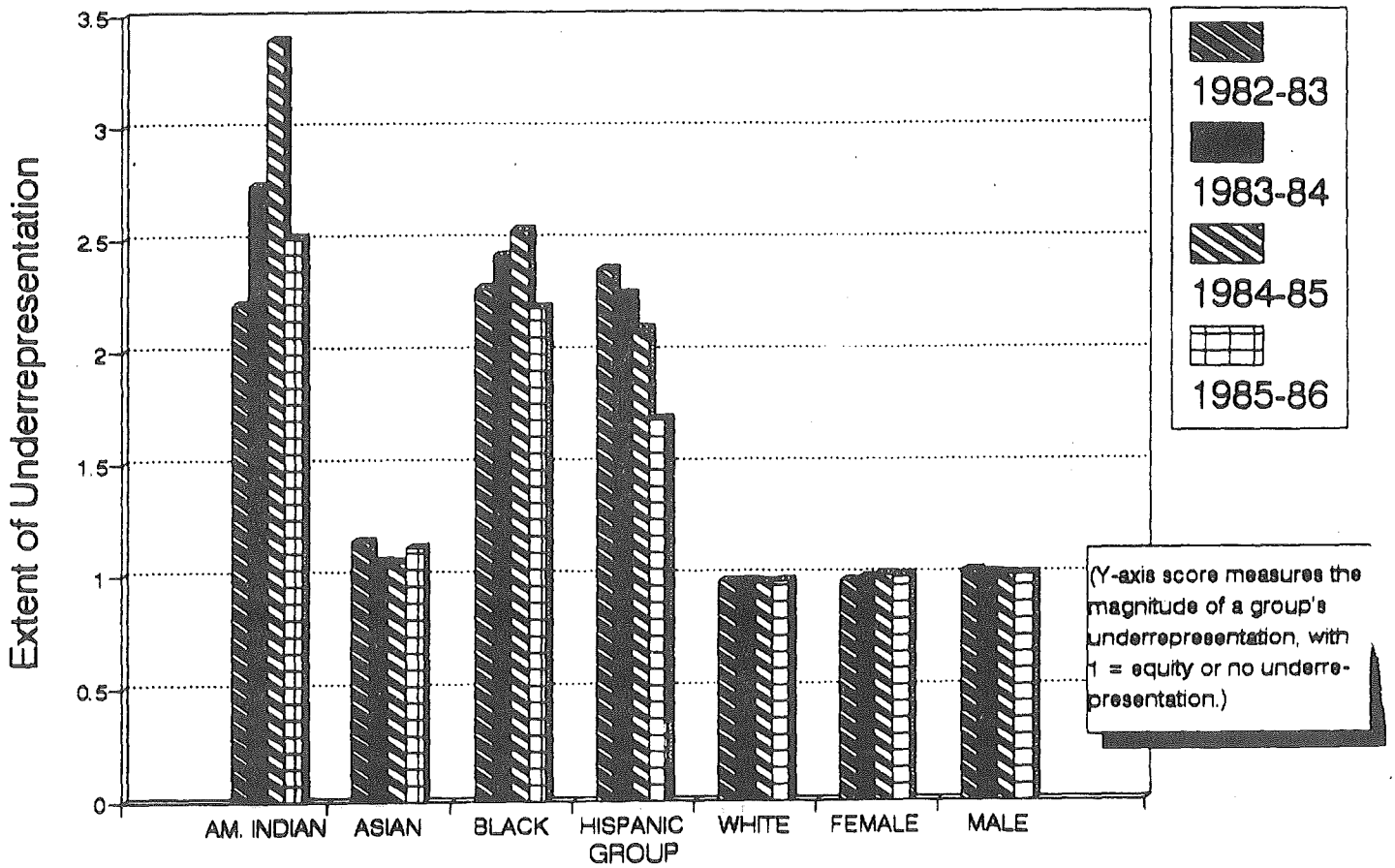
ENROLLMENT IN GEOMETRY
1982-83 to 1985-86



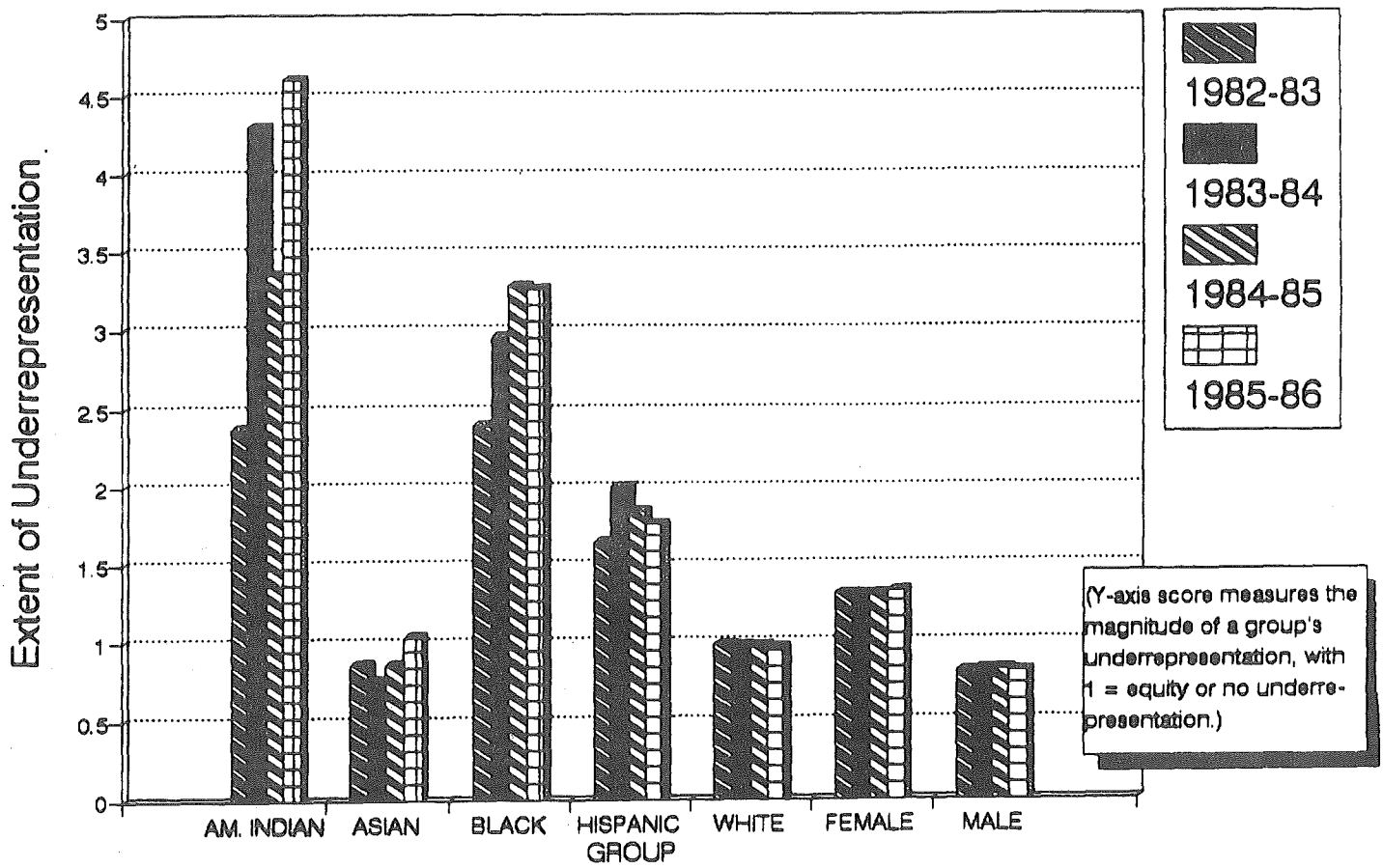
ENROLLMENT IN SECOND-YEAR BIOLOGY
1982-83 to 1985-86



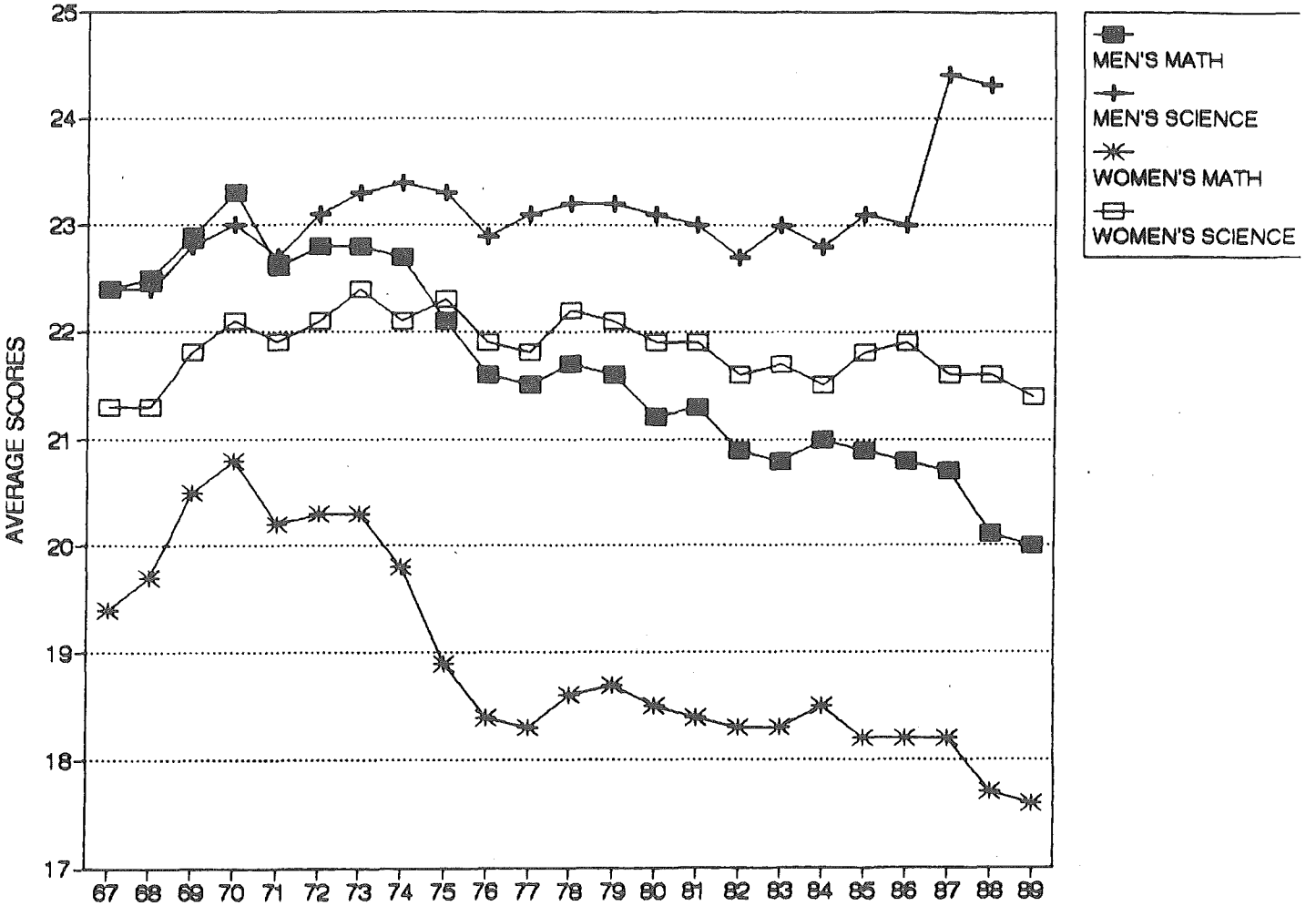
ENROLLMENT IN CHEMISTRY
1982-83 to 1985-86



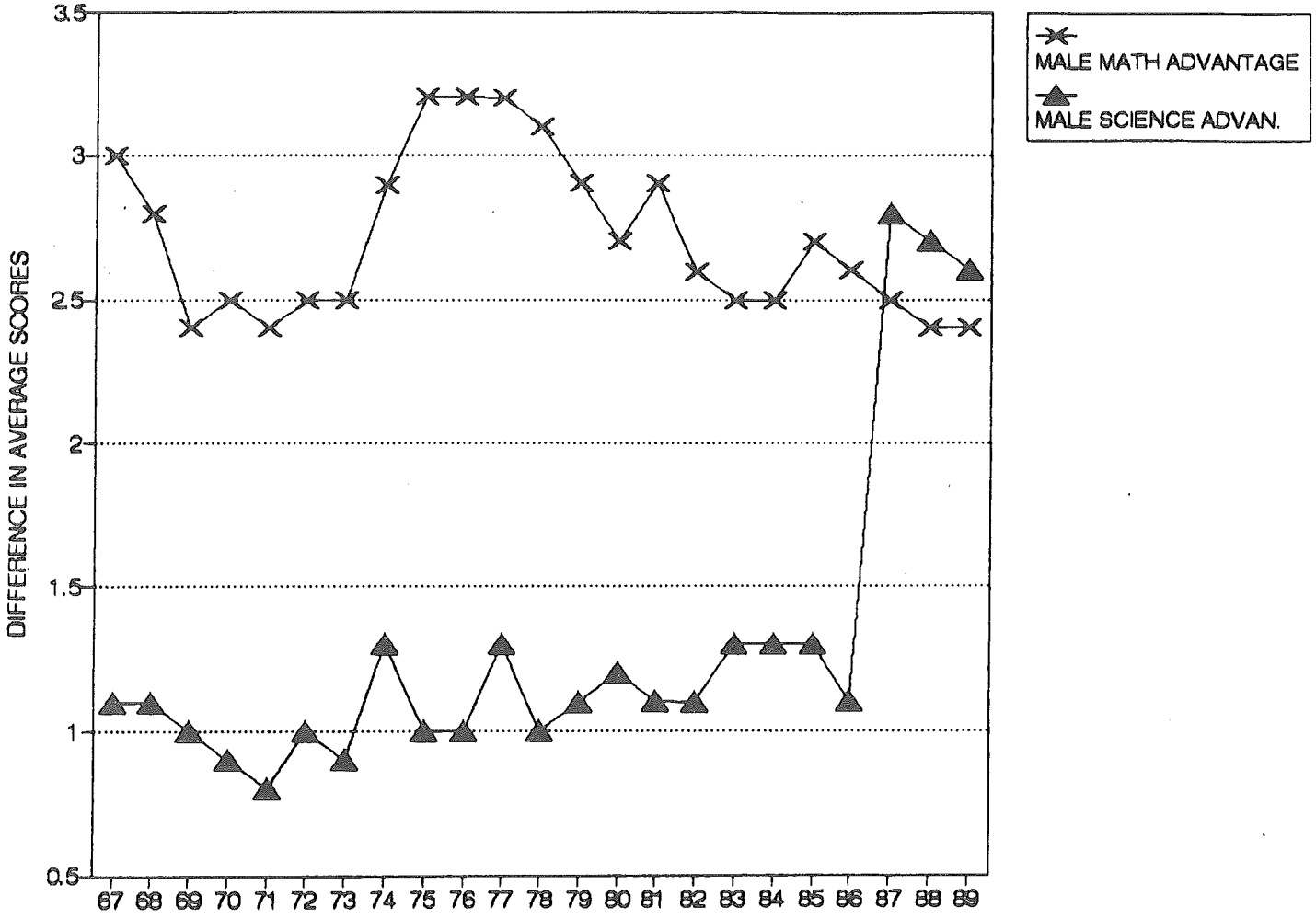
ENROLLMENT IN PHYSICS
1982-83 to 1985-86

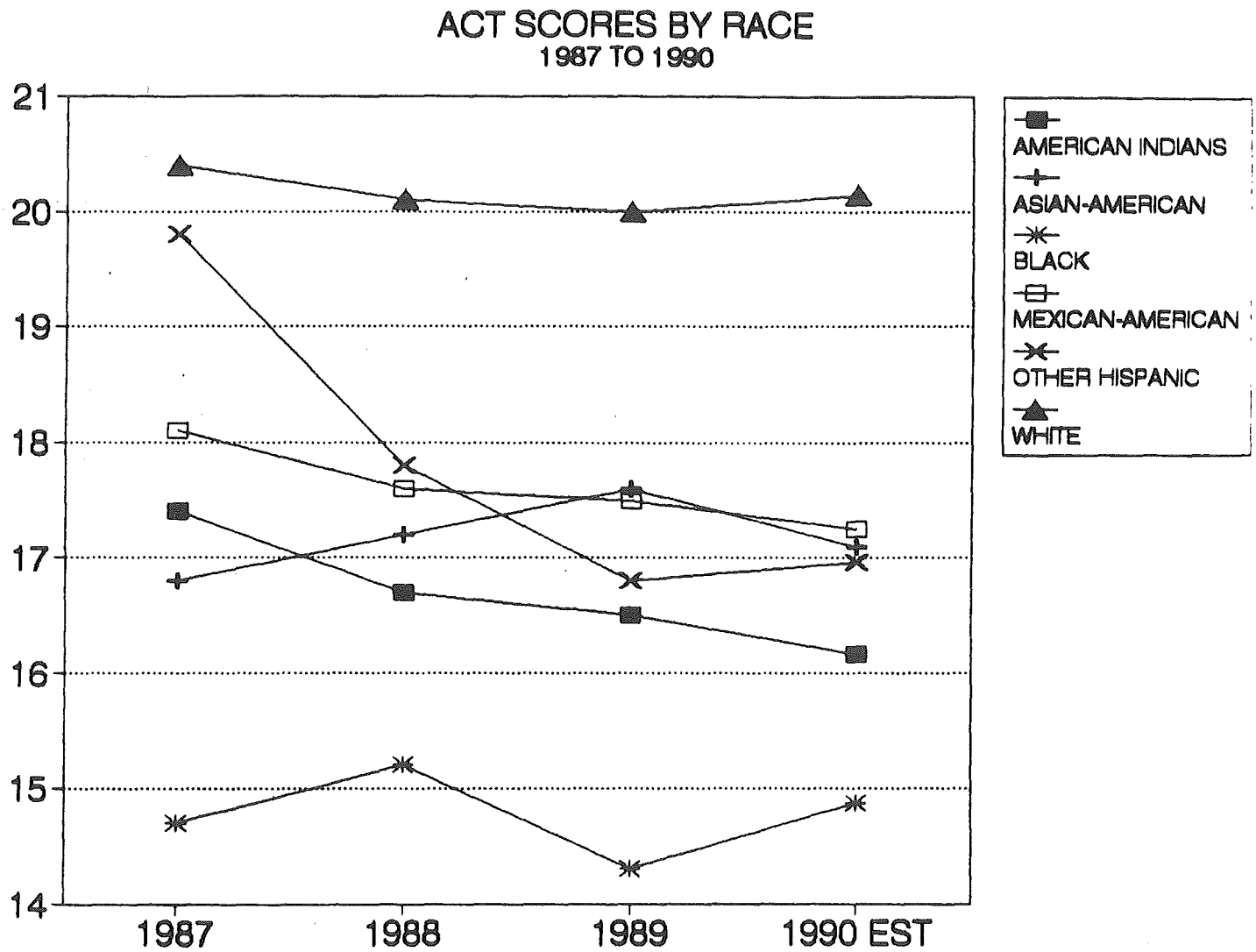


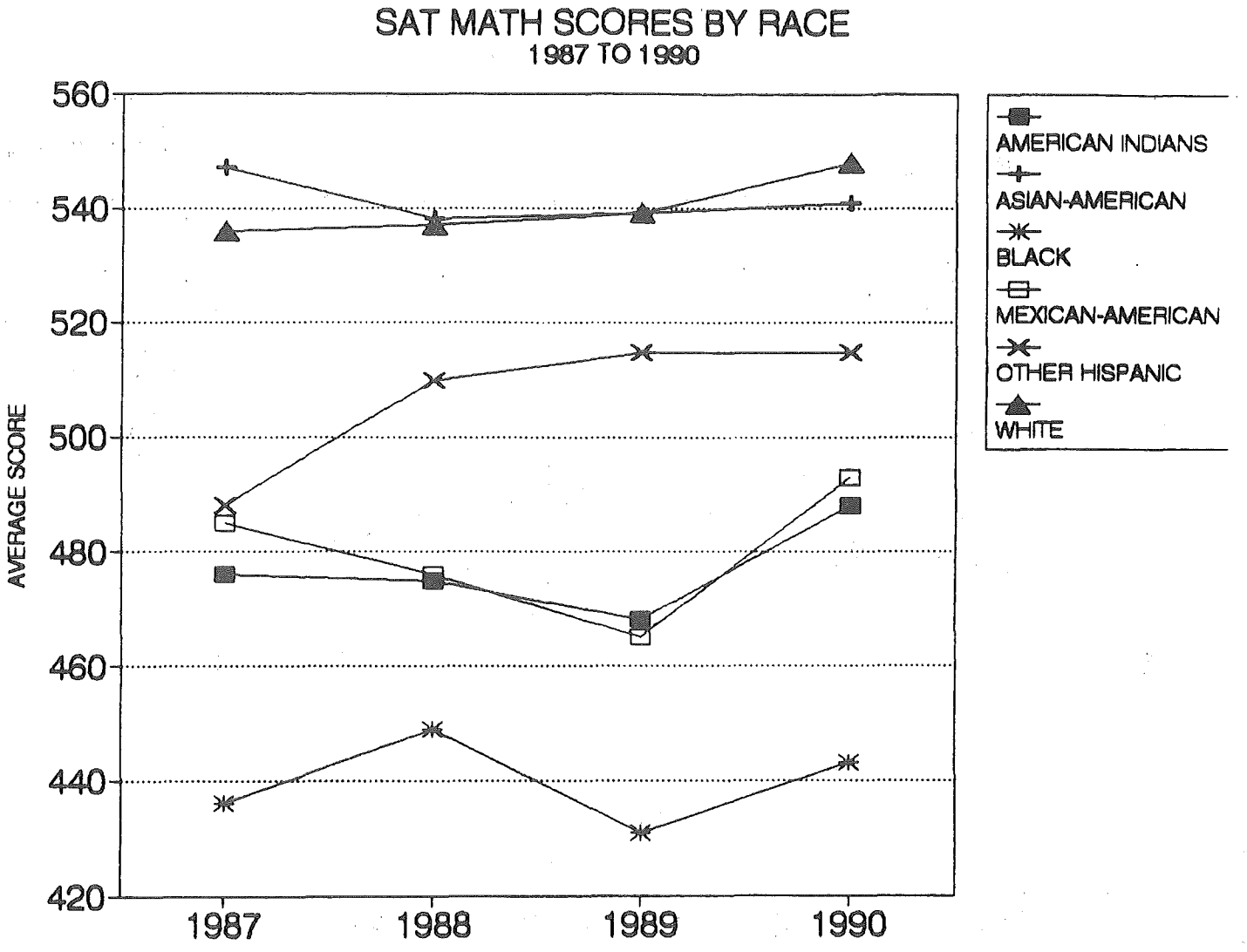
GENDER DIFFERENCES IN MATH/SCIENCE
ACT TESTS: 1966-67 to 1988-89



GENDER DIFFERENCES IN MATH/SCIENCE
ACT TESTS: 1966-67 to 1988-89




ACT SCORES BY RACE
1987 TO 1990
21
20
19
18
17
16
15
14
1987
1988
1989
1990 EST
AMERICAN INDIANS
ASIAN-AMERICAN
BLACK
MEXICAN-AMERICAN
OTHER HISPANIC
WHITE


SAT MATH SCORES BY RACE
1987 TO 1990
AVERAGE SCORE
560
540
520
500
480
460
440
420
1987
1988
1989
1990
AMERICAN INDIANS
ASIAN-AMERICAN
BLACK
MEXICAN-AMERICAN
OTHER HISPANIC
WHITE

Appendix B: Promising Practices and Programs in Mathematics Education

Suggested Readings:

Blackwell, David and Henkin, Leon. *Mathematics, a Project 2061 Panel Report.* American Association for the Advancement of Science, Washington, D.C., 1989.

Commission on the Education of Teachers of Mathematics. *Guidelines for the Preparation of Teachers of Mathematics.* National Council of Teachers of Mathematics, Reston, Virginia, 1981.

Committee of the Undergraduate Program in Mathematics. *Recommendations on the Mathematical Preparation of Teachers.* Mathematical Association of America, 1983.

Mathematical Sciences Education Board. *Mathematics Education: Wellspring of U.S. Industrial Strength. Report of a Symposium.* Washington, D.C.

Minnesota Department of Education. *Model Learner Outcomes for Mathematics Education.* Minnesota Curriculum Services Center, St. Paul, Minnesota, 1990.

Minnesota Mathematics Mobilization. *Mathematical Sciences in Minnesota: A State Assessment.* Northfield, Minnesota, 1990.

National Academy of Sciences. *Everybody Counts, A Report to the Nation on the Future of Mathematics Education.* National Academy Press, Washington, D.C., 1989.

National Academy of Sciences. *Reshaping School Mathematics, A Philosophy and Framework for Curriculum.* National Academy Press, Washington, D.C., 1990.

National Council of Teachers of Mathematics. *Curriculum and Evaluation Standards for School Mathematics.* Reston, Virginia, 1989.

National Council of Teachers of Mathematics. *Guidelines for the Post-Baccalaureate Education of Teachers of Mathematics.* Reston, Virginia, 1989.

National Council of Teachers of Mathematics, *Professional Standards for Teaching Mathematics,* Reston, Virginia, 1991.

Stenmark, Jean Kerr. *Assessment Alternatives in Mathematics,* Regents, University of California, Berkeley, California, 1989.

Task Force on Women, Minorities and the Handicapped. *Changing America: The New Face of Science and Engineering, Interim Report.* 1988.

Appendix C: Promising Practices and Programs in Science Education

Prior to developing its preliminary report the sub-committee in science education cited several Minnesota programs that they considered exemplary. In the short time they had to conduct their investigation, it is certain that some exemplary programs may have been overlooked. Please consider what follows to be a partial, but representative listing:

Business Partnerships

Minnesota High Technology Council is a coalition of high technology companies interested in furthering and improving the quality of mathematics and science education in Minnesota. It does this through a K-12 Committee.

Northern States Power Company conducts both student and teacher inservice programs. They support the Minnesota Science Challenge, The Minnesota Minigrant Program and the Presidential Award finalists in science education.

Honeywell, Inc. conducts an annual teacher's academy for high school teachers, makes engineers available to schools and has supported two higher order thinking skills conferences in science and mathematics.

Minnesota Mining and Manufacturing Company (3M) provides support for the Minnesota Science challenge, has a scientists-in-the-school program known as Science Wizards, provides intern programs for teachers, and mentor programs for students.

Unisys, Inc. supports several science and mathematics education initiatives including the Minnesota Minigrant Program, the Minnesota Science Challenge and has provided support for a conference on performance based assessment.

Cray Foundation provides funding for the Minnesota Minigrant Program. It has provided support for a higher order teaching skills study of science and mathematics educators and for a conference on authentic assessment. Cray supplied the initial funding for the science electronic communications network, PSInet.

Curriculum and Instruction

Minnesota Learner Outcomes in Science, Minnesota State Department of Education

Project Synthesis, a program, funded by the National Science Foundation, that resulted in recommendations on integrating science and society issues into the science curriculum

Project 2061, American Association for the Advancement of Science. Literacy goals in science, mathematics, and technology.

Grants

Higher Education Coordination Board (Higher Education Dwight D. Eisenhower Grants to provide inservice education to science and mathematics teachers

Professional Organizations and Staff Development

Minnesota Science Teachers Association:

--Spring and Fall Workshops (speakers, presentations, workshops)

--Elementary Science Teacher Improvement Program (ESTIP) in cooperation with Augsburg College

GO4ST8 PHYSICS, an informal, but active group of physics teachers in association with the University of Minnesota

Schools to Visit

Examples of schools providing a curriculum which infuses science concepts into the whole curriculum using interdisciplinary approaches and "hands-on-minds-on" learning.

Galtier and Maxwell Science Magnet, St. Paul, Maureen Flanagan, 612/293-5176

Willard Elementary School Magnet, Minneapolis, Joseph Premo, 612/627-2536

John Adams Junior High School, Rochester, David Arlender, 507/285-8858

Miltona Science Magnet, Miltona, Cortland Krogstad, 218/943-2371

Roosevelt Health Careers Medical Magnet, Minneapolis, Irene Tlach, 612/627-2658

Summatech Science Magnet, North High School, Minneapolis, Rebecca Scott, 612/627-2778

Physics Program Osseo High School, Jack Netland, 612/425-2323

Wayzata High School,Wayzata CHEMCOM Program, The American Chemical Society, Elizabeth Thornton, 612/476-3019

Science Education Programs

A wide variety of learning experiences are provide to students through programs, events and challenges.

Minnesota Academy of Science Programs:

Regional and State Science Fairs (Projects and Research Papers)
Engineering and Humanities Symposium (Research Presentations)
Fall Field Studies
Winchell Awards for outstanding graduate and undergraduate research in the sciences

Hands Together Science, a family science program, developed by the University of Minnesota that is designed for K-4 students and their parents--take-home kits and class work

Medical Careers Program for Minority Students, University of Minnesota

Appendix D: Promising Practices and Programs in Technology Education

Organizations

Minnesota Technology Education Association (MTEA)
Don Siems, President
Waseca High School
Waseca, Mn 56093

International Technology Education Association (ITEA)
1914 Association Drive
Reston, Va 22091
703/860-2100

Materials

The following materials are available from:

Minnesota Curriculum Services Center
70 West County Road B2
Little Canada, MN 55117
612/483-4442

The Minnesota Plan for Industrial Technology Education
Communication Technology
Energy and Power Utilization Technology
Production Technology
Transportation Technology
Research and Development Handbook

Model Learner Outcomes for Industrial Arts/Industrial Technology
available from:

Tom Ryerson
Industrial Technology Specialist
Minnesota Department of Education
550 Cedar
St Paul, MN 55101

An extensive catalog of technology education curriculum materials, studies, monographs, resource guides, career guides, videos, standards, and promotional materials is available from:

International Technology Education Association (ITEA)
1914 Association Drive
Reston, Va 22091
703/860-2100

Schools To Visit

Hibbing Jr. High School
Contact: George Pogelerc

Little Falls Middle School
Contact: Dave Lutzwick

Olson Jr. High - Bloomington
Contact: Bruce Barnes

Redwood Falls Jr. High School
Contact: Jerry Meschke

Roseville Middle School
Contact: Bruce Bernin

Southwest Jr. High School
Forest Lake
Contact: Sam Gaustad

Graphic Communications Programs

Brainerd High School
Contact: Ray Sipper

Little Falls High School
Contact: Steve Robinson

Roseville Area High School
Contact: Rod Tooley

Principles of Technology

Spring Lake Park High School
Contact: Ron Hoheisel

Taylors Falls High
Required PT Programs for all 10th graders
Contact: Mike Sandell

Supermileage Vehicle Design and Construction

Irondale High School
Moundsview
Contact: Keith Anderson

New Ulm High School
Contact: Jim Pickus

Waseca High School - Waseca
Contact: Keith Sykora

Computer Assisted Design and Drawing (CADD)

Mayo High School - Rochester
Contact: George Berg

Wayzata High School - Wayzata
Contact: Norman Schroeder

Aviation Program

Sauk Rapids High School
Contact: Curt Olson

General Programs

Crookston High School
Contact: Gordon Tolbert

Hermantown High School
Contact: Bruce Pylka

Litchfield High School
Contact: Ed Meyer

Machine Tool Technology Programs

Bloomington Kennedy High School
Contact: Robert Ginn

Brainerd Sr. High School
Contact: Robert House

Electronics/Micro-Computer Repair Programs

Little Falls High School
Contact: Tom Steinke

Minnetonka High School
Contact: Ed Grimm