their education programs at a college or university, there would be no decline in enrollments in higher education. However, the pressure for further education has basically gone around colleges and universities; we have now built a "second system" of post-secondary education in the U.S. whose total investment per year is about what is invested in colleges and universities put together--about $50 billion.

Colleges and universities have benefited from the rapid growth of continuing education programs, both credit and non-credit, now prescribed in many states for professional development in many fields. In that adults have families and jobs, the normal logistics of college courses have been altered--weekend colleges, evening courses, degree programs that require one Friday through Sunday package each month, etc. Whether or not content has been altered to meet the needs of the adult learner is not as easily addressed. In many cases, instruction is carried on as if the adults were normal post-pubescent adolescents, while the average age in the class may be 40, and the level of sophistication very high. It seems that whatever else the Baby Boom group did, it represents a very solid commitment to further education, but not necessarily a commitment to colleges and universities as the institutions whereby this new form of education may occur.

The Baby Boom has turned out to be a very innovative group, in terms of how they got into the job market, the patterns of living together they have pioneered, and the myriad of routes through which they learn. As a result of their persistence, the market for postsecondary education has become very disaggregated--there are a great many organizations that are providing educational services to adults, and because there are so many young adults (35 to 44), the diversification can be even greater. Because of the size of the Baby Boom, and because of their interest in learning rather than having all learning occur in one place, the further reduction in the influence of colleges and universities on this new "growth industry" seems certain. Five corporate education programs now offer their own degrees, and more are sure to follow. If higher education institutions want to become more active in the adult education area, they will have to modify their existing practices considerably. In addition, they have to keep watching the demography--if new adult programs are made ready by

1990, they may begin to catch the decline of the young adult population as the mouse passes on through the snake.

Certainly, the adult Baby Boomers have entered colleges and universities, but their participation has not been even by institutional type. Community colleges (which now have about half of all college and university enrollments) have clearly gone out of their way to meet the educational needs of adults, while prestigious liberal arts colleges, basically residential in nature, have not added large numbers of adults to their undergraduate student body. In most community colleges today, the average age of the students is 36 and climbing. More and more graduate degree programs are being tailored to the needs of adults, but these efforts seem to be more concerned with logistics and cosmetics than with the presentation and complexity of the content.

Other Issues

In 1950, the typical American family unit consisted of a working father, a housewife mother, and two or more school-age children. That pattern, which fit over 65 percent of the households in America in 1950, fits about 17 percent today. We are still overwhelmingly a nation of married people, but the stay-at-home wife and the two or more school-age children are no longer with us. As the birth rates increase in this decade, the number of working women will also increase, thus drastically increasing the need for day care facilities in the U.S. Multiple-earner families have become the dominant mode in America, producing a generation of "latchkey" children who are basically unattended by their families from the time they let themselves into the house with their own key in the afternoon until parents return from work in the evening.

The number of children reared in single-parent families has risen in spectacular fashion in the last decade. In 1980, the Census reported that of those children being born in 1980, 48 percent of them would basically be raised by a single parent. This is particularly important because of the new research that has established that children from single-parent families have a great deal of difficulty learning in schools--they are far more often discipline problems than are children with two parents living at home, and their level of school achievement is considerably lower than two-parent children. Thus, there is good reason to believe that a large segment of the current early elementary school class of the 1980's will be unable or unwilling to consider college when they are 18.

Although the Sun Belt still has a strong appeal as a place to move to, there are underlying signs of pathology in those areas which will alter the dynamics of higher education quite considerably. There is a new kind of poverty in the Sun Belt-- in Phoenix, the poverty area is almost 15 square miles. This happened because of the city's solution to the problem of increasing numbers of residents--don't increase the density of people per mile, just move the city limits out. As a result, there is a large area in the core of the city in which there are almost no services, no infrastructure, yet a large number of the city's poor live there. Houston is another city which has chosen to mortgage its future by not plowing current revenues back into the city in the form of improved infrastructure--better freeways, mass transportation, social services, etc. It may be that in many of the most rapidly expanding Sun Belt cities, in which the number of college-eligible youth will increase in the near future, there will have to be generated massive new sources of revenue for student financial assistance.

In addition to the major expansion of the 35 to 44 year old group at present, we are also encountering a rapid growth of the number of those over 65, of whom there will be 30 million by 1990. Those over 75 will also begin to increase dramatically-- 12 million by 1990. We have given little sustained attention to the educational needs of this rapidly increasing group (and remember that the Baby Boom arrives at this place in the snake by about the year 2000). As we think through educational initiatives for this age level, we might ponder whether or not a U.S. citizen, retired and living on a pension, has any rights to student financial assistance if he/she wishes to take courses or enroll for a degree. The normal arguments for investing in human resource development (access to the world of work, increasing productivity, etc.) do not apply, yet the person's educational needs may be very real and important. We also know that our elderly population will continue to improve in general health and vitality and will want to play a significant role in American life. Their numbers will be formidable in a political sense, and they vote in very large numbers. Education may well become one of the major issues on their agenda in the next two decades.

Summary and Conclusions

A number of trends have been mentioned in this paper which will have important implications for higher education. These include:

- During the decade, the U.S. overall population will show modest growth (242 million people by the year 1990), while the number of youth under age 20 will fall below 30 percent of the population for the first time in our history.
- At the tail end of this long decline, we can see that national birth rates are up since about 1979, producing an "echo" to the Baby Boom.
- Colleges and universities need to prepare for a general decline in high school graduates until 1998. However, Sun Belt and Frost Belt situations are in conflict, with increases in high school graduates coming early to Sun Belt states, and much later to the Frost Belt. Regional differences will continue to increase.
- A much higher percentage of the diminished youth cohort of the decade will be from minority backgrounds, from single-parent families, multiple earner families, and others who may have a difficult time getting prepared for college.
- A whole new array of service providers--industry, the military, government, and voluntary agencies--is educating three out of four adults being educated in the U.S., while colleges and universities are educating about one in four.
- A rapid expansion in the numbers of those over 65 may force us to develop a stance regarding their educational rights (both access and assistance).
- Women and Blacks have moved rapidly into better access to higher education, while Hispanics will show the most growth in the 1980's.
- A spectacular increase in the 35 to 44 year old age group will mark the economic developments of the 1980's, and gives cautious optimism for slow but consistent economic growth over the decade.

Because of intensifying differences in the U.S. by region, one can expect that far more educational decision-making will take place at the state and regional levels during the next decade or perhaps two. Those colleges and universities that have trimmed their sails during the 1970's through better management of human, fiscal and physical resources should be in a good position to survive with significance in the 1980s if they are realistic about the nature of the student cohorts that will be available to them. The more specific the "feeder" system, the better for the institution. (With the current high Mormon birthrate, Brigham Young University has no worries about having enough students.) The most vulnerable institutions will be liberal arts colleges and small universities that have relied on attracting a white, middle-class, suburban student body--there will simply not be enough of these students to go around. Increasing supplies of minority students and those in the 35 to 44 age range form two useful markets for institutions of higher education. In addition, collaboration with industry, the military, and other users of educational services can bring new programs to higher education. And the needs for new kinds of educational services among the over-65 age group should provide some stimulating new challenges in curriculum and faculty development for some institutions.

Many institutions that hired faculty in a small "age lump" during the sixties will find this same "age lump" retiring in a very short time frame. Some institutions will lose 50 percent of their faculty in a single five-year period. Early retirements and buy-outs may level this trend off somewhat. Maintaining good faculty morale during the 1980's will be difficult, but better management techniques should make it possible.

The 50 most selective institutions in the country will not need to worry about their selectivity--it may even increase in some institutions. But the ability of admitted students to pay their tuition bills may constitute a new worry for these and all other institutions. (Wesleyan was perhaps just being more honest than some when it admitted that ability to pay will be a factor in the admissions decisions of that institution.)

During the 1970's, it was easy for higher education institutions to ignore the growing needs of adults--as a result, new programs were developed that flowed around colleges and universities. During the 1980's, it will be impossible for higher education to ignore the declines in their "normal" 18 to 24 year old age group. But given the increasing variation in the various regions of the U.S., the problem of getting higher education's "act together" for the Congress and the Executive Branch will be a formidable problem for the end of the decade. Alice and the looking glass may be an accurate metaphor for the condition of higher education.

Finally, it is hoped that in times of demographic downturn, colleges and universities will not resort to cut-throat techniques designed to do each other in. Recruiting practices are already undergoing major changes, not all of them healthy. Genuine concerns for institutional self-sufficiency should be balanced by the idealism that will be needed to serve the educational needs of the students we have, not the students we wish we had.

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SECTION 3

Science, Math and Technology

1. Today's Problems, Tommorrow's Crisis
   A Report of the National Science Board
   Commission on Precollege Education in
   Mathematics, Science and Technology

2. Excerpts from Science and Engineering Education for the 1980's and Beyond
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3. Math Teachers Don't Add Up
   USA Today February 10, 1983

TODAY'S PROBLEMS TOMORROW'S CRISES

A Report of
the National Science Board
Commission on
Precollege Education in
Mathematics, Science and
Technology

National Science Board
National Science Foundation

About the National Science Board Commission on Precollege Education in Mathematics, Science and Technology

In response to the current decline in the quality and quantity of precollege mathematics and science education in the United States, the National Science Board (NSB) established the Commission on Precollege Education in Mathematics, Science and Technology. The NSB Commission is composed of 20 persons from a wide variety of fields and is co-chaired by William T. Coleman, Jr. and Cecily Cannan Selby.

The purpose of the NSB Commission is to define a national agenda for improving mathematics and science education in this country. It will develop an action plan that will include a definition of the appropriate roles and responsibilities of federal, state, and local governments, professional and scientific societies, and the private sector in addressing this problem of national dimension.

The Commission will be active over a period of 18 months and will issue interim reports on its findings. The Commission is charged to:

- Examine the existing evidence on the quality of precollege (all classes, K-12) education in mathematics and science;
- Identify where current practices and policies fail to ensure the entry, selection, education and utilization of the full range of potential talent in science, mathematics and engineering;
- Identify and analyze existing mathematics and science programs, teaching materials and teaching techniques whose success may justify imitation or adaptation;
- Develop an understanding of the roles that all systems—government and private organizations, professional groups and individuals—can play in improving mathematics and science education;
- Establish a set of principles, options and strategies which can be used to improve the quality of secondary school science and mathematics education.

About the National Science Foundation

The National Science Foundation (NSF) was established on May 10, 1950, as an independent agency of the Executive Branch of the Federal Government. Public Law 507 of the 81st Congress states that the "Foundation shall consist of a National Science Board (NSB) and a Director." The NSF Act assigns policy-making functions to the National Science Board and the administration of the Foundation to the Director. The policies of the Board on the support of science, development of scientific manpower and improvement of science education are generally implemented through the various programs of the Foundation.

NATIONAL SCIENCE BOARD
NATIONAL SCIENCE FOUNDATION
WASHINGTON, D.C. 20550

NSB COMMISSION ON PRECOLLEGE EDUCATION IN MATHEMATICS, SCIENCE AND TECHNOLOGY

October 18, 1982

Dr. Lewis M. Branscomb
Chairman
National Science Board
National Science Foundation
Washington, D.C. 20550

Dear Dr. Branscomb:

We are most pleased to transmit to you the first formal report of our Commission, "Today's Problems, Tomorrow's Crises." This report represents the Commission's assessment of the condition of precollege education in mathematics, science and technology in this country.

The problems summarized in our report--if left unresolved--will escalate in the years ahead. Thus, all Americans need to recognize the broad importance of mathematics, science and technology in the education of our youth. We hope, accordingly, that our report will receive wide dissemination.

The seriousness of the current situation underscores the Commission's resolve to develop, during the remainder of its life, an agenda for action for all sectors of society.

Sincerely,

William T. Coleman, Jr.

Cecily Cannan Selby

Today's Problems, Tomorrow's Crises

Introduction

Across the United States, there is escalating awareness that our educational systems are facing inordinate difficulties in trying to meet the needs of the Nation in our changing and increasingly technological society. We appear to be raising a generation of Americans, many of whom lack the understanding and the skills necessary to participate fully in the technological world in which they live and work. Improved preparation of all citizens in the fields of mathematics, science, and technology is essential to the development and maintenance of our Nation's economic strength, military security, commitment to the democratic ideal of an informed and participating citizenry, and leadership in mathematics, science and technology.

To meet these ends, our formal and informal education systems must have the commitment and the capacity to achieve three equally important goals:

- to continue to develop and to broaden the pool of students who are well prepared and highly motivated for advanced careers in mathematics, science and engineering;
- to widen the range of high-quality educational offerings in mathematics, science and technology at all grade levels, so that more students would be prepared for and thus have greater options to choose among technically oriented careers and professions; and
- to increase the general mathematics, science and technology literacy of all citizens for life, work and full participation in the society of the future.

The first goal needs little explanation, since maintenance of U.S. scientific and technological capacity requires superbly educated mathematicians, scientists, and engineers. As the total number of 18-year-olds in the population continues to decrease into the 1990's, the percentage of high school graduates entering preprofessional, college-level courses in science and engineering must increase to meet future manpower needs. In addition, to meet the country's needs for excellence, creativity, and innovation in its scientific work, we must develop and utilize the talents of all Americans, including women and minorities (now currently underrepresented in the science and engineering professions).

The critical value of the second goal has become widely recognized during the past few years. The current gap between opportunities for those with and without credentials in mathematics, science and technology will increase dramatically as the technological complexity of U.S. society increases. Industrial leaders have identified the current shortage of trained technicians as a serious barrier to increased productivity. Military commanders echo this concern about their manpower requirements for meeting national security needs. In such professions as law, journalism, and business management, there is also a growing demand for men and women with backgrounds in mathematics, science, and technology. The current and increasing shortage of citizens adequately prepared by their education to take on the tasks needed for the development of our economy, our culture, and our security is rightly called a crisis by leaders in academe, business, and government.

The third goal is rooted in Thomas Jefferson's familiar dictum that an educated citizenry is the only safe repository of democratic values. The life and work of Jefferson and others make clear that a broad understanding of the relationships between science and society was considered by early Americans as integral to the ideal of the Republic. To lead full lives and to participate with confidence in contemporary American society, citizens need an understanding and appreciation of mathematics, science and technology.

This report reviews the status of math, science and technology instruction in our educational systems and explores some of the key problems and challenges facing those systems. The central conclusion to be drawn is that, in the aggregate, the U.S. educational systems currently are not satisfactorily achieving the second and third goals, and they will need assistance, although perhaps to a somewhat lesser extent, to meet the first.

The Principal Concern: Declining Achievement and Participation at a Time of Increasing National Needs

Data from a number of sources have documented declining student achievement in mathematics and science, as indicated by declines in:

- science achievement scores of U.S. 17-year-olds as measured in three national assessments of science (1969, 1973, and 1977);
- mathematics scores of 17-year-olds as measured in two national assessments of mathematics (1973, 1978); the decline was especially severe in the areas of problem-solving and applications of mathematics;
- mathematical and verbal Scholastic Aptitude Test (SAT) scores of students over an 18-year period through 1980; and
- students prepared for post-secondary study. Remedial mathematics enrollments at four-year institutions of higher education increased 72 percent between 1975 and 1980, while total student enrollments increased by only seven percent. At public four-year colleges, 25 percent of the mathematics courses are remedial; and at community colleges, 42 percent are.

The proportion and qualifications of high school seniors who will major in mathematics, science, and engineering have remained roughly constant over the past 15 years, although college engineering enrollments have increased steadily since the mid-1970's. Some students are also receiving more advanced experiences in secondary school science and mathematics as indicated by performance on advanced placement tests.

Nonetheless, adequate mathematics and science course opportunities are not available for *all* talented and motivated students. As many as one-third of U.S. secondary schools do not offer sufficient mathematics to qualify their graduates for admission to accredited engineering schools. Only one-third of the 21,000 U.S. high schools teach calculus, and fewer than one-third offer physics courses taught by qualified physics teachers.

The evidence on student participation and achievement indicates a wide and increasing divergence in the amount and quality of the mathematics, science and technology education acquired by those who plan to go on to college and study in those areas and by those who do not. Students in the latter category generally stop their study of mathematics and science at a relatively early age, perform considerably less well on achievement measures than the career-bound, and do not have opportunities to pursue appropriate courses in contemporary technology. Only nine percent of the students graduating from vocationally oriented secondary school programs in 1980 took three years of science, and only 18 percent took three or more years of mathematics. Hence, it is clear that while the first goal stated in the introduction presently is being fulfilled reasonably well, the second and third goals are not. In fact, the educational system may actually have carried out these latter goals better 20 years ago: the proportion of public high school students (grades 9 to 12) enrolled in science courses has declined since that time. Thus, the principal concern with student participation and achievement is with those who do not plan careers in mathematics, science, or engineering.

In addition, wide differences persist in achievement and participation levels among students from different social groups. Women have traditionally participated less than men in science, and members of various minority groups (specifically, if not exclusively, American Indians, Black Americans, Mexican Americans and Puerto Ricans) have participated less and performed less well on standard science and mathematics achievement tests than their white counterparts. Approximately 20 percentage points separated the mathematics achievement scores of 17-year-old black and white students on national assessment tests in both 1973 and 1978. Approximately 15 percentage points separated 17-year-old Hispanics and whites in both years. Between 1973 and 1978, nine-year-old black students showed a definite improvement in performance on mathematics achievement tests, while the average performance of nine-year-old white students declined and that of Hispanics remained constant.

Specific Contributory Problems

Studies and analyses of conditions in the U.S. educational system—including both its formal and its informal components—point to four problems that contribute to declining student participation and achievement levels.

Teachers

Individual teachers have considerable discretion in the selection of course content and instructional approaches and, therefore, play a pivotal role in the education of students. Superior teachers of mathematics, science and technology can motivate students to do well in their courses and can stimulate students to take more advanced courses and consider technically or scientifically oriented careers. Mediocre and poor teachers may dampen the enthusiam of good students and fail to recognize and stimulate the development of potential talents in others. Therefore, the documented shortage of superior teachers must be considered a prime contributing cause of decreasing student participation and achievement in mathematics, science and technology.

There is also a growing shortage of qualified secondary school mathematics and physical science teachers. In 1981, 43 states (of 45 responding) reported a shortage of mathematics teachers. For physics teachers, 42 states reported such shortages. In the same year, 50 percent of the teachers newly employed nationwide to teach secondary science and mathematics were actually uncertified to teach those subjects. From 1971 to 1980, student teachers in science and mathematics decreased in number—threefold in science and fourfold in mathematics—and only half of them have actually entered the teaching profession. In addition, 25 percent of those currently teaching have stated that they expect to leave the profession in the near future.

Some of the problems that affect the participation and achievement of students at all grade levels are:

- Among certified teachers of high school mathematics and science, very few have had the formal educational preparation required to provide students with an understanding of modern technology.
- There are few available opportunities for certified mathematics and science teachers to update or broaden their skills and backgrounds. Such training opportunities are essential due to the rapid advances taking place in mathematics, science and technology and the need to introduce new types of upper level courses for nonspecialists.
- There are few inservice programs to certify teachers who are presently not qualified to teach mathematics and science.
- Most teachers in the primary and middle school grades have not had training in science and mathematics or courses in methods to teach these subjects.
- District-level supervision has been reduced as a result of financial retrenchment or has been shifted from instructional to administrative support. As a result, relatively few people are available outside the classroom to provide quality control or to assist teachers with pedagogical problems.

Classrooms

Deficiencies in the numbers and qualifications of mathematics and science teachers are exacerbated by classroom conditions, including inadequate instructional time, equipment, and facilities.

The time available for adequate instruction in U.S. schools is far more limited than in other advanced countries. In the United States, the typical school year consists of 180 days, as contrasted with 240 days in Japan. This is further reduced by absenteeism, which amounts to an average of 20 days per school year. The typical school day is five hours long, compared with six- or eight-hour days in other countries. In addition, many periods of varying length throughout school days and weeks are devoted to non-academic pursuits, both reducing the hours available for instruction and diverting the time and energy of teachers to noninstructional duties. Problems associated with student discipline and motivation, which are severe in some schools and affect the general learning environment, have been well publicized.

Many science courses in schools throughout the country are being taught without an adequate laboratory component or with no laboratory at all. In some cases, laboratory apparatus is obsolete, badly in need of maintenance, or nonexistent. In other cases, such apparatus is not used because of a lack of paraprofessionals or aids to set up and maintain equipment, a condition that has become increasingly important due to the greater concern for safety in the schools.

Curricula

Curricula in mathematics and in several scientific disciplines were developed with federal support two or more decades ago to provide rigorous, modern course work for high school students interested in careers in mathematics, science and engineering. These curricula, and several generations of privately-developed successors, continue to serve their purpose, though many need to be revised.

Mechanisms must be developed to incorporate effectively into the curricula changes associated with advances in the disciplines and evolving contemporary technologies.

Another curricular concern is that upper level high school courses based on these curricula are too abstract and theoretical for most students. In fact, serious doubts exist about whether many of the commonly offered mathematics, science and technology courses in the secondary schools are, in their present form, of much value to students planning careers outside of mathematics, science or engineering. Few courses or widely accepted curricula are available with the explicit aim of providing such students with adequate preparation in mathematics and science. In addition, courses associated with modern technology are not available; most courses, in fact, make little reference to technology at all.

In the lower grades, mathematics courses emphasize basic computational skills rather than interpretation and application. Science courses at those levels often are empty of content and, generally, do not build upon the work of previous grades.

Appropriate courses in modern technology are not available. Few systematic attempts are made to integrate learning in mathematics, science and technology. As a result, little coherent preparation is offered for the disciplinary courses (usually earth science and biology) encountered for the first time in the ninth and tenth grades. This condition is particularly unfortunate, because a wealth of information supports the conclusion that students who dislike mathematics and science courses in the early grades, or who receive inadequate instruction in those grades, are unlikely to participate effectively in upper level courses.

Instructional Approaches

In general, precollege mathematics, science and technology instruction has yet to take advantage of the advances in technology and behavioral science of the past 20 years. For example, computers provide an immense opportunity to develop curricula and instructional approaches that might motivate larger numbers of students and increase the flexibility of the programs available to them. Computers and other modern technologies are available in many U.S. schools, and imaginative uses are made of these instructional aids in individual classrooms. However, computer software is generally inadequate, and the full potential of these technologies for instruction has received little attention.

Considerable progress also is being made in research in math and science education. The cognitive sciences are providing a wealth of informatin on the way people learn. For example, knowledge is now available about the relative degree of abstraction that students of a particular age can be expected to grasp. However, such information has yet to be systematically applied either in the development of mathematics, science, and technology curricula, or in the training of teachers of these subjects.

Finally, there is evidence that many students who have an interest in mathematics, science, and technology are not being reached through instructional approaches currently used in the classroom. Whereas many students do not like school science—and form this opinion by the end of third grade—many do like the science and technology that they see on television. They also like what they encounter at science and technology museums, planetariums, nature centers, and national parks. Many of these institutions facilitate science and technology education with their own after-school, weekend, and vacation classes. In addition, many school classes make field trips to such institutions. Because these programs are apparently more appealing than school science offerings, the innovative instructional approaches used in them should be examined and, where possible, applied to the classroom setting.

Public Perceptions and Priorities

Largely, public schools reflect, rather than determine, public perceptions and priorities. The condition of mathematics, science and technology education reveals an apparent misperception by the public that adequate course work need only be provided to students preparing for college-level study in these fields and that these courses are unnecessary for other students. This is consistent with the broader perception that excellence in science and technology is vitally important to the Nation but that it can and should be left to the experts. Thus, its pursuit has little to do with the day-to-day concerns of most people—except when major news events such as a nuclear reactor accident or a space shuttle launch intrude. This misperception about the mathematics, science and technology training needed by students in our schools is tragic for our society as a whole.

Yet, a reasonable fraction of the adult public is interested in science and technology. This is evident from the recent popularity of science magazines for nonspecialists, quality television and radio programs (particularly in the public media), and science and technology museums. Although a large fraction of the public enjoys science and technology, it appears that many consider school mathematics, science, and technology as isolated from the real world and not essential for most students.

That misperception is part of a public view that the aims, substance, and quality of public education do not reflect the considerable economic, social, and cultural changes that have occurred in this country since the late 1960's. Today, an increasing percentage of the work force is concerned with the retrieval, processing, and transmission of information. Yet, public school mathematics and science courses are, at best, only peripherally concerned and preparing students to work and live in a society that concentrates on such tasks.

Apparently, no consensus has been reached that the future prosperity and international position of the United States depend critically upon broader public attainment in mathematics, science, and technology. In addition, there is no consensus that high quality mathematics, science, and technology education is a matter of national concern, transcending state and local interests and responsibility. Mathematics and science requirements both for high school graduation and for college entry have generally declined over the past 15 years. Although there are some encouraging signs that this trend is reversing, only about one-third of the Nation's 16,000 school districts require more than one year of high school mathematics and one year of science for graduation.

National Science Board Commission

The absence of a national consensus on the importance of mathematics, science, and technology education for all citizens may be the central cause of the critical problem facing our educational systems. A broad national effort is essential. The National Science Board Commission on Precollege Education in Mathematics, Science and Technology has been established to address this condition. The Commission will define, over the next year, a national agenda that should provide an action plan for all sectors of society to use in the achievement of the three important educational goals outlined in the introduction to this report.

Sources

The data appearing in this report have been drawn from the sources that follow. Specific citations and additional references may be obtained on request from the office of the National Science Board Commission on Precollege Education in Mathematics, Science and Technology.

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Science & Engineering Education for the 1980's & Beyond

Prepared by the National Science Foundation & the Department of Education

October, 1980

CONTENTS

Appendices

Appendix A—Technical Notes

Bureau of Labor Statistics (BLS) Projections of 1990 Employment (Section II-B)

The BLS developed its projections for 1990 employment of scientists and engineers in a series of steps that linked aggregate economic activity to output by industry to employment by occupation. The first step started with assumptions covering the expected conditions of economic growth and Federal policy goals. In one set of projections, it was assumed that the Federal budget deficit would decline after 1980, reaching a level near $20 billion in 1990. For an alternative projection, BLS assumed that the budget would be balanced by 1983 and remain so through 1990. The unemployment rate was assumed, for all projections, to decline to 4.5 percent in 1990, whereas productivity per worker was assumed to rise annually at rates near the 2.6 percent level achieved between 1955 and 1968. BLS projected the 1990 labor force using the Series II population forecasts of the Bureau of the Census.

An econometric model was used with these assumptions to project the aggregate economy and to distribute the Gross National Product by category of demand. There are four such major categories: personal consumption expenditures, gross private domestic investment, net exports, and government purchases. Each component of demand was in turn broken into purchases made from 160 different industries, including, for example, dairy and poultry products, coal, and paper products.

In the next step, purchases from these 160 industries were introduced into an input-output model that had been adjusted to reflect projected 1990 production processes. This model is a large matrix (160 by 160) that tells what goods and services each industry buys from all other industries to produce its output. For example, the automobile industry purchases inputs from the steel, plastic, glass, rubber, electronics, and many other industries. This step generated outputs for each of the 160 industries.

For the final step linking outputs to employment, a labor demand model was used to project productivity, hours, and employment at the level of each industry. A matrix that distributes employment in each industry by detailed occupation was then used to estimate total 1990 employment in each of 380 different job categories. Only science and engineering occupations are reported here.

For more information, see BLS Bulletin 2030, *Employment Projections for the 1980s*.

National Center for Education Statistics (NCES) Projections of Baccalaureate and Master's Degrees in Science and Engineering (Section II-B)

The NCES estimated future degrees on the basis of its projections of college and university enrollments. The first step in the projection process was to calculate the percentage of the population enrolled in higher education in each of several recent years in each of several age groups. These percentages were projected into the future for each age group. The statistical method used to estimate future enrollments, exponential smoothing, places more weight on recent observations than on earlier ones.

Bachelor's and master's degrees were projected on the basis of their past statistical associations, as indicated by regression analysis, with undergraduate and graduate enrollments, respectively. Awards at these two levels were distributed among the science and engineering and other fields on the basis of past trends and statistical relationships.

For more information, see *Projections of Education Statistics to 1988-89* (in preparation).

National Science Foundation (NSF) Projections of the Supply and Utilization of Doctoral Scientists and Engineers (Section II-B)

Estimates of the 1990 science and engineering Ph.D. market were adapted from the publication, *Projections of Science and Engineering Doctorate Supply and Utilization: 1982 and 1987* (NSF 79-303), which was prepared in 1978. It was assumed that the annual changes in Ph.D. supply and employment projected for the period 1977–1987 would continue through 1990.

To generate the utilization figures reported in NSF 79-303, NSF used econometric modeling and trend extrapolation to estimate the number of science- and engineering-related positions that may be available by field for doctorates in 1978. NSF projected the two largest categories of science and engineering employment, academia and industrial research and development, through the use of demand equations that were derived from regression analysis. These equations related employment to demand variables such as research and development spending and the number of science and engineering baccalaureates awarded (an index of teaching loads) in a year. Other categories of science and engineering employment in government, nonprofit organizations, and industry (other than research and development) were projected through extrapolation of past growth trends.

To generate estimates of 1987 supply by field, NSF used a recursive econometric model that reflects the relation between the Ph.D. labor market and the number of doctorate graduates. In this model, poor employment opportunities in a given year result in lower graduate school entrance and completion rates, and hence in fewer graduates in future years, whereas better market conditions induce higher rates, and hence more future graduates. Projected market conditions depend upon the interaction between demand variables and the number of new graduates in each field.

For more information on NSF prediction methods, see NSF 79-303.

Information Base on Pre-College Science and Mathematics Education (Section V)

The information base available for the review of science and mathematics education in elementary and secondary schools is particularly extensive, since NSF recently sponsored an assessment of the status of the Nation's elementary and secondary school education practices in science, mathematics, and social science. Three complementary approaches were undertaken—survey, case study, and literature review. This aggregate effort is referred to as the *Status Study*. The results were published in six volumes in 1978. A seventh volume comprising the Status Study overview and summary documents of the three interrelated approaches was also published as follows.

a. Overview and Summaries
   - The Status of Pre-College Science, Mathematics and Social Studies Educational Practices in U.S. Schools: An Overview and Summaries of Three Studies.

b. The national survey of teachers, principals, and superintendents regarding training, materials, and educational practice was contracted to Iris Weiss of Research Triangle Institute. The survey findings are reported in one document.
   - Report of the 1977 National Survey of Science, Mathematics, and Social Studies Education.

c. The case studies covered eleven in-depth investigations of ongoing educational practices. This study was contracted to Robert Stake and Jack Easley at the University of Illinois, Urbana. The case study findings are available in a two-volume set.
   - Volume I: Case Studies in Science Education. The Case Reports.
   - Volume II: Case Studies in Science Education. Design, Overview and General Findings.

d. The literature review, contracted to Stanley Helgeson, Ohio State University, examined published and unpublished documents related to existing needs statements in science, mathematics, and social studies. The results of this review are being published in three volumes:
   - Volume I: The Status of Pre-college Science, Mathematics and Social Science Education: 1955–1975. Science Education.
   - Volume II: The Status of Pre-College Science, Mathematics and Social Science Education: 1955–1975. Mathematics Education.
   - Volume III: The Status of Pre-College Science, Mathematics and Social Science Education: 1955–1975. Social Science Education.

To help make the nearly 2,000 pages of materials in these seven volumes more accessible and useful for different audiences and for policymakers, NSF invited nine organizations to analyze the studies independently and write reports. These nine reports are not only descriptive, they are also normative. Each organization was asked to extract from its analysis the major needs in science education from the point of view of its membership. Thus, collectively, the reports give an idea of what problems and issues are thought to be most important, what the system's strengths and weaknesses are believed to be, and what the most important strategies for improvement might be. Although the formats for each report differ, they all contain, either explicitly or implicitly, a set of recommendations for the improvement of science education. These nine reports have been published in a single volume (available July 1980) under the title:

- What are the Needs of Precollege Science, Mathematics and Social Science Education? Views from the Field.

All of this material was available to most of the persons who contributed to or were involved in this review. This great wealth of information does not lead immediately and directly to an inevitable set of conclusions as multiple interpretations are always possible especially when normative factors are brought to bear. Nevertheless, the content of Section V of this review represents a reasonable consensus of the views expressed in the light of the available information.

In addition to these sources, NSF has recently issued the *Science Education Databook*, which is a compendium of quantitative information portraying science education in the United States. It contains information collected from a wide variety of sources that are described in an annotated bibliography.

Appendix B—International Comparisons in Science and Engineering Education

There has been some concern about the relative trends in the production of scientists and engineers in the U.S. as compared with other highly industrialized countries. This concern centers on the important question of whether the U.S. faces a reduced ability, relative to other countries, to generate and incorporate technological change in its production and utilization of goods and services.

Comparisons between the U.S. and our international competitors suggest that our eminence in basic research is secure (Section II-D).[1] However, our ability to apply technology to our military and industrial pursuits may well be hampered by the relatively low level of scientific and mathematical competence of our nonscientists and, in some respects, by the apparent cooling of science interest among our students generally. For example:

- There is anecdotal evidence from U.S. industry that in some highly technical areas the time required to produce a product has increased as workers' base level of understanding of science and mathematics has decreased over the past decade.[2]
- The U.S. military complains that it is more and more difficult to find officers and NCOs who are qualified to be trained to operate the increasingly sophisticated military hardware.[3]

The body of this review notes some anxiety about two subject matter areas: engineering and the computer professions. While the U.S. has current shortages and future shortfalls in these areas, the Soviet Union, Germany, and Japan are producing much larger proportions of engineers and applied scientists than we are.[4] At the same time, these countries are educating a substantial majority of their secondary school population to a point of considerable scientific and mathematical literacy, in part because they apparently believe that such literacy is important to their relative international positions. For example:

- The recent Committee of Inquiry into the Engineering Profession in Great Britain (the "Finniston Report")[5] laid the decline in the ability of Britain to compete in international trade squarely on the lack of vigor of the engineering profession and recommended, among many other things, that ". . . all pupils should be strongly encouraged to maintain the study of mathematics and physics at least until after 'O' level . . ."[6] (national competence exams given at the end of secondary schooling).
- As a part of its analysis of engineering in other countries, the Finniston Report stated that ". . . the level of education of the average Japanese worker is markedly higher than that of his U.K. counterpart; this applies at all levels of the firm, especially on the shop floor. . . . The strength of Japanese engineering is in our view partly due to the standard of education of those involved in the engineering dimension at working level."[7] Though the difference in the level of worker education between Japan and the U.S. is not as broad, there is concern that the same general conclusion may be warranted.
- Regarding Germany, the Finniston Report notes that from secondary school "A student specialising in classics or modern languages . . . can cope with an engineering degree course because he will have kept up his mathematics and science throughout his period at school."[8] In other words, even a student who majors in modern languages in secondary school learns enough science and mathematics to be able to attend engineering school and compete with others who have majored in science.
- In the Soviet Union, there are national elementary and secondary curricula in science and mathematics which, in content and scope, surpass that of any other country.[9]

The import of the last three points is that in Japan, Germany, and the U.S.S.R., national policy promotes the comprehensive science and mathematics education of far greater numbers of people than are expected to engage in scientific and engineering pursuits. In the Soviet Union and Japan, especially, managerial positions in both government and industry are heavily populated by people with engineering degrees.[10]

Over the past 15 years or so, while British training of engineers fell behind so drastically that a comprehensive inquiry was commissioned by the government,[11] while Germany and Japan continued to stress science and mathematics for all their secondary students, and while U.S. secondary students not intending to major in science or engineering were choosing to take fewer science and mathematics courses, those countries' share of world trade in manufactured items (excluding food and fuel) changed as follows:[12]

	Share of World Trade		Engineering Graduates As A Proportion of Relevant Age Group
	1963	*1977*	*(1977-78)*
United Kingdom	15%	9%	1.7%
W. Germany	20%	21%	2.3%
Japan	8%	15%	4.2%
United States	21%	16%	1.6%

Between the same years (1963-1977) productivity increased in the manufacturing industries of the United Kingdom, West Germany, Japan, and the U.S. (using 1963 as the base year) by 51 percent, 114 percent, 197 percent, and 39 percent, respectively.[13]

In considering cross-national comparisons of training in science and engineering one must be cautious, because educational systems are not parallel and often are quite dissimilar. For example, the group labeled "engineers" in one country may include an unknown number of those termed "technicians" in the U.S. Nevertheless, some of the differences in outcome are dramatic.

In Japan, for instance, the number of degrees granted to engineers in recent years has surpassed the number granted in those same years in the U.S., though its base population is roughly one-half of ours.[14] In Japan, 20 percent of all baccalaureate and about 40 percent of all master's degrees are granted to engineers,[15] and these figures have been nearly stable for the past 10 years.[16] This compares with a figure of about five percent at each degree level in the U.S.[17] Japanese education officials point out that students view the engineering degree as a "ticket" to business and social success in much the same way as the liberal arts degree (and now the M.B.A. degree) was viewed in the U.S. two generations ago.

It is reported that only about 50 percent of the engineers produced each year in Japan enter the engineering profession. The others become civil servants and managers in industry. Around one-half of the senior civil service hold degrees in engineering or related subjects, and one-half of those are at the postgraduate level. In industry, about 50 percent of all directors have engineering qualifications.[18]

The large number of Japanese students who enter scientific fields (65 percent of baccalaureate degrees[19] vs. 30 percent in the U.S.) is made possible by a secondary educational system which has a heavy emphasis on science and mathematics. There is a national guideline for lower secondary education (grades 7–9) which calls for about 25 percent of the classroom time to be mathematics and science courses, and virtually all students are thus exposed.[20] In secondary school, nearly all of the college-bound students (roughly one-third of the total) take three natural science courses (physics, chemistry, biology, or earth science) and four mathematics courses (algebra, geometry, calculus, or statistics) during their three-year high school career.[21]

There has been significant effort in recent years to revise and update the high school science teaching in Japan, and it is now heavily influenced by the U.S. Physical Science Study Committee (PSSC) and the Biological Science Curriculum Study (BSCS) materials. Chemistry has been upgraded by a committee on chemical education set up by the Chemical Society of Japan.[22]

Mathematics instruction has a more rapid pace in Japan than in the U.S., and a much higher proportion of students take the more advanced courses. Geometry is taught in the 7th, 8th, and 9th grades. Trigonometry is also studied in the 9th grade. Calculus, probability, and statistics are offered in high school.[23]

The overall quality of this instruction appears to be high. The International Project for the Evaluation of Education Achievement ranked Japanese 13-year-olds highest in mathematical achievement among 12 countries including the U.S. and several European countries. Japanese students were also the most positive in their liking for mathematics.[24]

In Germany, the general preparation is similar. There is a standard curriculum for all students through the 10th grade, and the only variation is in specialized science-oriented schools where each subject is studied more intensively.[25]

Science begins in the 3rd grade with biology one to two hours a week, in the 5th grade, chemistry and physics are begun (as laboratory courses). All three sciences are taught two to three hours a week in that grade, and geometry is introduced. The study of algebra begins in the 7th grade. As students progress through the grades, the amount of contact with science and mathematics increases.[26]

At the end of 10th grade, all students who have an average of about B or B+ (this varies a little by state) may continue to upper secondary schooling—grades 11 to 13. Those whose grades are lower attend vocational school and begin apprenticeships in a variety of pursuits. The students who attend upper secondary school (currently about 28 percent of the 10th grade population, up from only six percent ten years ago) declare three major and five minor interests, one of each of which must be a science (which is pursued five hours a week as a major and two to three hours as a minor). Mathematics at the 11th grade level includes algebraic functions and differential calculus. By the end of the 13th grade, students have studied integral calculus, statistics and probability, and vector analysis. At this level, too, those with special interest in science take more intensive courses.[27]

About 75 percent of the upper secondary graduates go on to universities, and roughly one-third of those pursue a science, engineering, or mathematics degree.[28]

Thus, the overall picture in Germany is one of a very high level of science and mathematics literacy among college graduates as well as a strong science/mathematics understanding among the general population. This provides them with the basic tools to continue their education (German law guarantees that all people are entitled to a free education to as high a level as they desire) at a later point in their careers, as many choose to do.

The situation in the Soviet Union is less clear. The country has achieved virtually universal education through about the first ten years of schooling. Most of those students (about 60 percent) go on to complete General Secondary School[29]—grades 9 to 10 (or 11)—and are exposed to a mathematics and science curriculum which, according to one observer, surpasses that of any other country including the U.S.[30] Algebra and geometry are taught in the 6th and 7th grades, advanced algebra and trigonometry are taught in grades 8 to 10, and calculus, which a total of about 500,000 Americans take during their last year in high school or their first in college, is a part of the high school curriculum for over 5,000,000 Soviet students. In addition, all youngsters are required to complete five years of physics, four of chemistry (including a year of organic chemistry), and up to four of biology depending on whether they attend specialized (i.e., vocational) or general secondary schools.[31] While students in specialized secondary schools (about 12 percent of 8th grade graduates) are exposed to less science except in specialty fields related to engineering technology, the avowed goal of Soviet educational policy is to ensure that the future labor force will facilitate the transformation of the economy to a scientific-technical base and to supply more technologically oriented people to fill the military ranks.[32]

About five times as many (with a population base about 1½ times ours) Soviet students as American students go on to engineering training.[33] In the Soviet Union engineering is considered to be the standard liberal arts education. Moreover, it has been pointed out that though training is variable, at the better institutions the first Soviet degree in engineering represents a content level closer to our master's than to our bachelor's degree.[34] In other sciences, the Soviet Union produces fewer chemists and biologists than we do, about the same number of physicists/mathematicians, and a few more environmental scientists.[35]

This picture of engineering, mathematics, and science education in the Soviet Union is not complete; there are some major problems. Secondary school curriculum changes mandated a decade ago have been implemented slowly and have not spread throughout the educational system. The secondary science courses have little laboratory work associated with them and are generally learned by rote. Rural schools tend to be poor. At the university level, science and engineering education is very narrow-gauge; i.e., students specialize sharply at a very early point. The sizable non-Russian-speaking minorities in the country are at a disadvantage because the best university instruction in science and engineering is in Russian.[36]

There is little specific data, but informed U.S. opinion is that there is widespread underemployment of the science and engineering work force in the Soviet Union. New graduates generally begin at the lowest rungs of the production ladder and work their way up slowly. Perhaps more important, fungibility and mobility in the fields of science and engineering are very low compared with the United States. A member of the Soviet science and engineering work force is trained almost for a specific job and usually remains with a particular institution for a whole career.[37] This results in a system that, in the opinion of some, is very slow to rise to new specialities and has a reduced ability to innovate.

Though the problem areas in the education and employment of Soviet scientists and engineers appear to be many, their potential capacity to compete internationally should not be underrated. There are many signs that the inefficiencies are being recognized and the Soviets' general acceptance of the legitimacy of science and engineering pursuits provides a context in which quality may well improve very rapidly.

For all of these countries, it is difficult to separate the effects of government policy, market factors, and social pressures. What is clear is that in each case there is a strong national commitment to quality science and mathematics instruction as an essential part of the pre-college educational process. The result is a work force which, at all levels, has a relatively high degree of science and mathematics skill, and this has been a factor in the very rapid expansion of technical industries.

References

1. In 1977 (the most recent year available), the U.S. produced 38 percent of the world's scientific and technical articles. Moreover, U.S. scientific and technical literature was cited in non-U.S. articles at a rate 15 percent higher than could be expected from the U.S. share of the world literature. These two indicators have stood at virtually the same level since at least 1973. See pages 150 and 152 of *Science Indicators 1978*, Report of the National Science Board, 1979.

2. As far as could be determined, there is no written substantiation of this comment, but the point has been reported from several separate conversations. Because of its "softness," it would not have been included here except that it links two widely observed phenomena (decrease in U.S. worker productivity and decrease in students' general levels of understanding of science and mathematics) in a way which is consistent with similar concerns in Japan and the Soviet Union.

3. Submissions of both the Department of Defense and the Air Force (Appendix D-4) emphasize the twin problems of recruiting and retaining technical personnel and the "close to revolutionary" pace of technological advance which draws on new disciplines which, according to the Air Force, will "have to be widely represented among USAF military and civilian personnel very soon." In the "Summary of Briefings" attached to the Air Force submission, it is pointed out that "All Soviet active duty pilots receive a highly intensive technological education even though they rarely serve in other than operational assignments."

4. Engineers far outnumber applied scientists in each of the countries named. In recent years the number of engineering graduates as a proportion of the relevant age group has been approximately 6.5 percent for the U.S.S.R., 4.2 percent for Japan, 2.3 percent for Germany, and 1.6 percent for the U.S. If it is assumed that one-half of all new mathematics and physical science graduates in the U.S. (1.16 percent of their age cohort) and all new computer professionals (0.25 percent) enter applied fields, the maximum total proportion of new engineering and applied science graduates relative to their age group in this country is 2.43 percent. This is comparable to the rate for Germany, which has 2.3 percent engineers and an estimated 0.25 percent for new applied scientists.

5. *Engineering Our Future*. Report of the Committee of Inquiry into the Engineering Profession. Her Majesty's Statement Office, London. January 1980. (This commission was chaired by Sir Montague Finniston and its report is commonly referred to as the "Finniston Report.")

6. *ibid*, p. 50.

7. *ibid*, p. 209.

8. *ibid*, p. 219.

9. From an unpublished paper by I. Wirszup. The description of the scope and quality of the Soviet secondary science and education has been substantially corroborated by conversations with Dr. Nicholas DeWitt, Dr. Murray Feshbach, and by information contained in "A Summary Report on the Educational Systems of the United States and the Soviet Union: Comparative Analysis" prepared by SRI International for the National Science Foundation. March 1980. (Appendix G).

10. Information about Japan is taken from the Finniston Report, *op. cit.*, Note 5, pp. 211-212. Information about the USSR is from conversation with Dr. Thane Gustafson, The RAND Corporation.

11. The Finniston Committee was formed in July 1977.

12. Shares of World Trade appear as Table 1.3 on page 11 of the Finniston Report (Note 5). Engineering graduate information is from Table 4.1, p. 83, of the same report.

13. Adapted from Table 1-15, p. 156, of *Science Indicators 1978*, *op. cit.*, Note 1.

14. Japanese information from *Statistical Abstract of Education, Science and Culture* published by the Ministry of Education, Science and Culture, Tokyo, 1979 edition. U.S. information from *Earned Degrees Conferred*, yearly series published by the National Center for Educational Statistics, Department of Health, Education, and Welfare (DHEW), 1980 edition.

15. Adapted from Table 3, pp. 72-75, Japanese *Statistical Abstract of Education, Science and Culture*.

16. *ibid*.

17. *op. cit.*, Note 14.

18. This description is given in the Finniston Report, *op. cit.*, Note 5, pp. 211-212.

19. *Statistical Abstract of Education, Science and Culture*, Table 3, *op. cit.*, Note 5, pp. 72-75.

20. From *Education in Japan*, U.S. Office of Education, 1974, corroborated and updated by conversation with Mr. Wada, the Education Attache, Embassy of Japan.

21. *ibid*.

22. *op. cit.*, Note 20.

23. *ibid*.

24. *ibid*.

25. Copies of secondary school lesson plans for mathematics, chemistry, and physics, supplemented by conversation with Mr. Horst Breckwoldt, Principal of the German School in Potomac, Maryland, and Ms. Dorit Geurtsen-Bandmann, Director of Guidance at the same school.

26. *ibid*.

27. *ibid*.

28. *op. cit.*, Note 25.

29. Nicholas DeWitt, "Summary Findings: The Current Status and Determinants of Science Education in Soviet Secondary Schools." (NRC Paper, Appendix D-1).

30. *op. cit.*, Note 9.

31. *op. cit.*, Note 9, p. 3.

32. *ibid*, p. 5.

33. This varies a bit depending on which year is used for the comparison. Table 8, p. 29, of the SRI International report (Note 9) presents figures from 1960 to 1977.

34. *op. cit.*, Note 29. However, SRI International (Note 9) expresses slightly different opinion regarding the few engineering specialties which have been directly compared.

35. *op. cit.*, Note 9, p. 30 (Table 9), and p. 33 (Table 12).

36. Conversation with Dr. Thane Gustafson corroborated by conversation with Dr. Murray Feshbach.

37. Conversation with Dr. Thane Gustafson, partly corroborated by information from the Soviet Desk, U.S. Department of State.

Appendix C—Minorities, Women, and the Physically Handicapped in Science and Engineering

Equality of opportunity is a keystone of Federal educational policy. Although the problems facing minorities, women, and the physically handicapped in science and engineering education are in many respects different, the common thread that ties them together is that of overcoming barriers to equality of opportunity.

In each case the Federal Government plays an important role in moving toward the objective of equality of opportunity. The role is expressed through court decisions (e.g., Brown vs. Board of Education), public laws (e.g., P.L. 94-142, the Education of All Handicapped Children Act), grant and fellowship programs (such as the Graduate and Professional Opportunities Program, which particularly supports women and minorities studying science and engineering), Federally funded public television programs (e.g., *3-2-1 Contact*, a science series for 8- to 12-year-olds emphasizing opportunities for minorities and women in science and technology), and through a variety of other means as well.

Status of Minorities in Science and Engineering

1. *Education and Employment*

Although racial minority groups made up over 22 percent of the U.S. population in 1976, they accounted for only about four percent of all scientists and engineers.[1] Even that figure does not truly reflect the situation because the various groups differ from one another in their participation in science and engineering and one subgroup, the Asian-Americans, is overrepresented (in terms of its proportion in the total population) in engineering and all science areas except psychology and social science.

Table 1 shows that ethnic and racial minority groups, except for the Asian-Americans, are severely underrepresented in engineering and in all the sciences. Blacks earn degrees somewhat more often in psychology and social science and less often in the physical sciences and engineering. Hispanics tend to lag in all the fields about equally, though, again, there is some favoring of the less mathematically based pursuits. There are so few Native Americans who receive degrees in some fields that the proportions are very unstable (e.g., three Ph.D.'s in engineering, one in computer science, 15 M.S. degrees in biological science, etc.), but there does not appear to be any particular field to which they gravitate.

There is some indication that over the past few years the proportion of minority students in science and engineering (and in higher education in general—see the *National Report* series published by the Admissions Testing Program of the College Board) has been increasing. In engineering, for example, Black, Hispanic, and Native American enrollment was 5.7 percent of the freshman class in 1973 and 8.03 percent in 1977.[2] The latter figure is still only one-half of the proportion of these groups in the total U.S. population.

Many economic, social, educational, and psychological reasons have been advanced to help explain why minority students choose science and engineering careers less frequently than do White/Anglo students. Whatever the causes, the minority underrepresentation in science-oriented pursuits begins early in the educational process.[3] Blacks and Hispanics enter college at lower overall rates than Whites,[4] and Hispanics opt for two-year institutions (where science and engineering training is less available) at a rate nearly double that for White and Black students.[5]

Once started in college, both Black and Hispanic students withdraw at slightly higher rates than do White students at four-year institutions and at markedly higher rates at two-year institutions. Under all circumstances, the withdrawals

TABLE 1.
Minority student representation among degrees granted in Engineering and Science fields.

Proportion (%) of Degrees Awarded 1975–76

	Engineering			*Computer Science*			*Mathematics*			*Physical Science*			*Biological Science*		
Proportion in U.S. Population 1977	*BS*	*MS*	*Ph.D.*	*BS*	*MS*	*Ph.D.*	*BS*	*MS*	*Ph.D.*	*BS*	*MS*	*Ph.D.*	*BS*	*MS*	*Ph.D.*
Black 11.6	2.9	1.3	0.6	5.8	2.1	—	4.9	3.1	0.9	2.9	2.4	0.9	4.1	3.1	1.3
Hispanic...................... 5.3	1.8	1.4	0.6	1.6	0.6	0.4	1.5	1.3	1.3	1.3	1.0	0.8	1.6	0.8	0.6
Native American 0.4	0.3	0.2	0.1	0.1	0.3	0.4	0.3	0.2	0.1	0.3	0.2	0.2	0.3	0.2	0.1
Asian American 1.3	2.1	3.0	4.2	2.2	2.6	1.6	1.9	2.4	2.3	1.5	2.6	2.5	2.2	1.9	2.5
Total Degrees Granted (Thousands) .	45.6	16.0	2.8	5.6	2.5	0.2	15.9	3.9	0.9	21.2	5.4	3.4	54.2	6.6	3.4

	Psychology			*Social Science*		
	BS	*MS*	*Ph.D.*	*BS*	*MS*	*Ph.D.*
Black	6.3	5.2	2.4	8.5	5.4	2.6
Hispanic......................................	2.5	2.3	1.5	2.4	1.8	1.0
Native American	0.4	0.2	0.2	0.4	0.2	0.2
Asian American	1.2	1.1	0.8	1.1	1.2	0.9
Total Degrees Granted (Thousands)	49.8	7.8	2.6	126.4	15.9	4.2

SOURCE: Adapted from Table V-21; p. 121 *Science Education Data Book*, NSF, 1980.

are heavily (73 percent–88 percent) for non-academic reasons,[6] which suggests that economics plays a significant role.

In terms of persistence toward degrees in science and engineering, Table 1 shows that except for Asian-Americans, minority groups make up decreasing proportions of degree recipients as they progress from B.A. to M.A. to Ph.D. levels.

2. *Standardized Test Scores*

Results of the Scholastic Aptitude Tests (SATs) indicate large differences between majority scores and scores for the Black minority. Data recently released by the Educational Testing Service show that during the five-year period from 1972–73 to 1976–77, Black students scored 119 points lower than Whites on the verbal section, and 134 points lower than Whites on the mathematics section.[7]

Similar results are found on a variety of other standardized tests, including the NAEP mathematics and science achievement tests, with Hispanics often scoring, on the average, roughly mid-way between Blacks and Whites.

Native Americans, possibly because of their small numbers, are rarely included as an identified subgroup in educational statistics. Their opportunity to participate in science and engineering pursuits may be even more greatly hampered than with the Black and Hispanic minorities because a great many attend rural schools which have very poor resources. Moreover, it is difficult to assess the extent of many problems because the Bureau of Indian Affairs and the Office (now the Department) of Education have used different criteria to define who is a "Native American" and thus have made strikingly different estimates of the total number.

Federal action can help to narrow the gap—notably through efforts to eliminate racial discrimination, through steps taken to reduce the general disadvantage of minority populations (e.g., poverty, malnutrition), and through compensatory educational programs (such as Title I and Head Start). However, college-bound seniors planning to study the sciences generally have high SAT scores. In particular, those planning to study physical science and engineering have higher scores on the average than those planning study in any other field. Since few Blacks and not many more Hispanics have had the necessary training to score at these high levels, the problem of significantly improving minority representation in science and engineering is large and progress is likely to be slow.

Status of Women in Science and Engineering

1. *Employment*

In 1976 only about nine percent of the science and engineering work force were women, with the great majority being in science rather than engineering.[8]

Although women are still clearly underrepresented in these professions, the situation has improved substantially during the past decade. A sizeable and growing fraction of the most recently trained scientists and engineers in the work force are women. Between 1974 and 1976 the number of women scientists and engineers increased at a rate nearly double that for men (15 percent vs. 8 percent). In 1978, women received 24 percent of all master's degrees granted in science and engineering fields and 19 percent of the Ph.D.'s, with the numbers heavily weighted toward the biological and social sciences. Even in the physical sciences and engineering, fields in which women are particularly underrepresented, the proportion of the bachelor's degrees earned by women has climbed rapidly since 1970.[9]

Persistence of women in science and engineering employment is high; education is not "wasted" on women in any sense. Given this fact, and the relatively low representation of women in the science and engineering labor force despite the rapid progress that has been made, women still remain the largest pool of talent available for increasing the size and quality of the science and engineering labor force.

2. *Education*

At the high school level, the mean number of years of study of mathematics and the physical sciences for college-bound seniors differs somewhat by sex, with males taking more of these courses than females. In mathematics the difference is about one-third of a year, while in the physical sciences it is closer to one-half of a year.[10] The importance of this difference is difficult to judge without further information. However, better counseling and career information for girls in the elementary and secondary schools, as well as greater encouragement generally to study mathematics and science, would be useful.

One analyst writing on this subject for the current study has suggested that stronger college-entrance requirements in mathematics and science for all students would result in better preparation for women in particular, because of this existing differential in course enrollments.[11]

At the bachelor's level, the figures show a steady increase in the proportion of women in virtually all science and engineering fields over the past decade. At the doctoral level, women made up 10.4 percent of the science and engineering work force in 1977, up from 9.3 percent in 1975 and from 8.5 percent in 1973.[12] Their representation in the various disciplines is significantly different than at the bachelor's level. For example, only about 13 percent of all doctorates in the mathematical sciences go to women—considerably below the 18 percent level for all science and engineering doctorates.

Status of the Physically Handicapped in Science and Engineering

Significant legislation at the national level regarding the physically handicapped has emerged in the past few years. The Vocational Rehabilitation Act of 1973 is intended to do for the handicapped what the Civil Rights Act did for minorities and Title IX did for women. The Education of All Handicapped Children Act of 1975 (P.L. 94-142) is designed to assure that handicapped children have available to them an appropriate free public education.

The major thrust of these statutes with regard to science education is to require mainstreaming of many handicapped students—that is, the accommodation of such students in regular classrooms as much as possible. This, in turn, requires changes in attitudes, correction of architectural barriers, better teacher training, and a variety of other changes on the part of individuals, institutions, professional societies, and agencies of government.

Approximately one percent of the population is severely physically handicapped: blind, deaf, or significantly orthopedically limited. While data are not available regarding the percentage of scientists and engineers who are severely handicapped, it is implausible to assume that it is anywhere near one percent of the 2.7 million persons in the science and engineering work force. Whatever the exact figure, a significant number of handicapped scientists and engineers do exist and can function very effectively. For example, in recent years over 800 disabled scientists have become known to the American Association for the Advancement of Science's (AAAS) Project on the Handicapped in Science.

Publications of the AAAS Project on the Handicapped in Science are recommended for those interested in a fuller discussion of the situation facing the handicapped in science education.

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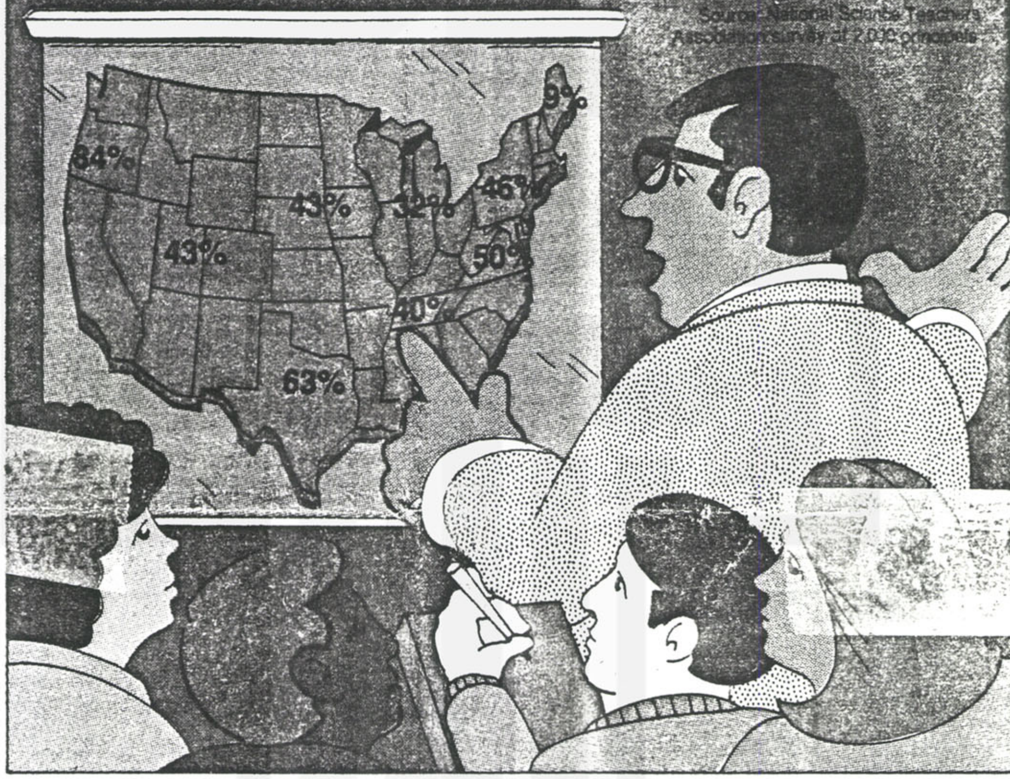
Math teachers don't add up

An estimated 60 percent of those hired to teach math and science in 1981-82 were unqualified under state requirements. Here's a breakdown by regions:

Source: National Science Teachers Association survey of 2,090 principals



Subtracting math teachers

The number of students receiving degrees in mathemathics education has dropped greatly.

Year	Bachelor's	Master's	Doctorates
1971	2,217	782	49
1972	2,425	764	51
1973	2,489	733	52
1974	2,037	828	59
1975	1,938	760	64
1976	1,358	746	55
1977	1,156	663	49
1978	1,048	598	39
1979	850	483	42
1980	762	512	38
1981	798	372	30

Source: National Center for Education Statistics

Student numbers drop

Mathematics scores for the annual Scholastic Aptitude Test have dropped since the mid-1960s.

Year	Score
1970-71	488
1971-72	484
1972-73	481
1973-74	480
1974-75	472
1975-76	472
1976-77	470
1977-78	468
1978-79	467
1979-80	466
1980-81	466
1981-82	467

Source: The College Board

By John Sherlock, USA TOD

COVER STORY

Supply can't meet demand of schools

77% drop in math grads made worse by shifts to higher paying careers

By Richard Whitmire
USA TODAY

The report card is the same nearly everywhere in the nation: There aren't enough math teachers to go around.

Since 1972 the number of secondary math graduates emerging from college-training programs has fallen 77 percent, and the shortage is leading educators to try everything from special recruiting bonuses to retraining gym and English teachers.

Some examples reveal the enormousness of the problem:

■ For the next five years, estimates the Florida Department of Education, its colleges and universities will graduate only 20 math teachers a year — to face an annual need for 325 in the state's schools.

■ Of 1,444 Los Angeles teachers who have at least one period of math daily in grades 7-12, 32 percent have neither a collegiate major nor minor in math.

Please see COVER STORY next page ▶

COVER STORY

Industry salaries lure many

Continued from 1A

■ Houston is offering yearly bonuses beginning at $2,000 to both math and science teachers. In Oklahoma City, new math teachers receive a $500 bonus.

■ The Kentucky Legislature passed a bill to lend up to $2,500 a year to undergraduate math majors who plan to teach — and will forgive the debt if they teach in Kentucky. In 1981 the state's 23 colleges and universities graduated only 50 secondary math teachers — but 114 in 1971.

■ And at Issaquah Junior High in suburban Seattle, not one of the five full-time math teachers has a college major or minor in the subject — including the department chairman, who until this year was teaching elementary students.

Perhaps most painful is the stopgap solution: thousands of unprepared math teachers trying to teach a subject they know little about.

In California, math consultant Joe Hoffman says the State Education Department is issuing emergency math credentials to districts, allowing underqualified teachers to fill in temporarily. "But we suspect they're being badly misused."

In Issaquah, the human dimensions are all too evident as teacher Sally Moore stands before her 27 eighth-graders, struggling to answer questions about the area of trapezoids and parallelograms. She hasn't had a math course since high school geometry in the early 1950s.

A former elementary teacher, she is teaching math for the first time — and in over her head. "I work all the problems the night before class," she says, "but occasionally I get up before class and can't do a problem."

She never had math in college — only math-methods, a "how-to" course for teaching math. And that class was so traumatizing she needed a tutor and a hypnotist to overcome her anxiety.

The national shortage is two-sided.

Potential math teachers are avoiding teaching jobs. Only about 55 percent of the college graduates trained as math teachers are actually taking teaching jobs, says the National Science Teachers Association. And more and more math teachers are quitting — teachers like 31-year-old Dennis Hobbs.

With a masters in math education from the University of Kentucky, Hobbs was teaching calculus and advanced trigonometry in 1981 at Tates Creek Senior High outside Lexington, Ky. But his $16,700 salary was discouraging and five classes a day were a strain, so he answered an ad for computer programmers.

He ended up in an AT&T training class

the classroom, the school board treated him like a nobody.

"A lot of good teachers are leaving," he says. "The ones who can, are getting out."

Almost five times more science and math teachers left teaching in 1981 for industry jobs than retired, reports the National Science Teachers Association.

Compounding the problem are teacher contracts that can prevent the hiring of math teachers who are available. In Issaquah, the district can't hire a new teacher as long as a laid-off district teacher is qualified for the spot.

In Washington state, there is no math certification required for junior high, so when declining enrollments idled elementary teachers like Sally Moore, they were shifted into junior high math jobs.

A partial result: Only 15 of the 37 math teachers in the 7,200-student district have either a major or minor in math.

Most districts cope by shifting math-major teachers into more difficult calculus and trigonometry classes, leaving lower courses to non-math teachers. But consultant Hoffman is wary of the solution:

"We're really concerned that teachers who are not well prepared in math, and who do not understand the big picture of math, tend to fragment the skills. You learn one skill totally out of context with anything else that's learned."

Issaquah math department chairman Ken Ruud expects problems when junior high students reach advanced algebra: "We'll have to spend a lot more time going back and reviewing."

Is all this hurting the students? Educators say yes and point to declining SAT math scores as proof. But that's not the best gauge, cautions Stephen Willoughby, president of the National Council of Teachers of Mathematics. He says the best students still get the best teachers but "the big problem is in the lower levels. It tends to be taught worse and worse."

To swell the ranks of math and science teachers, President Reagan's new budget proposes $75 million, part of it to retrain unemployed college graduates who majored in other fields. But two House bills now in subcommittee would spend more: one proposes $300 million, the second $500 million over five years.

Other suggestions include scholarships for prospective math teachers and tax credits for companies allowing employes to teach part time in high schools. Some districts report success with re-educating teachers in math and science. Last summer Los Angeles started retraining 20 teachers in math.

But there simply aren't enough pro-

SECTION 4

Urban Education: Equity Issues

1. Desegregation of Black and Hispanic Students from 1968-1980
   Gary Orfield

2. School Desegregation Patterns in the States, Large Cities and Metropolitan Areas 1968-1980
   Gary Orfield

3. Civil Rights in the Third Wave
   Alvin Toffler

4. Wanted, Hispanics in the Newsroom
   Charles Ericksen

Joint Center
For
Political Studies

WORKING PAPER: DESEGREGATION OF
BLACK AND HISPANIC STUDENTS
FROM 1968 TO 1980

A Report to the Subcommittee on Civil
and Constitutional Rights of the
Committee on the Judiciary of the
United States House of Representatives

Prepared by
Gary Orfield,
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for the
Joint Center for Political Studies
Washington, D.C. 1982

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BACKGROUND

In the fall of 1981, the House Subcommittee on Civil and Constitutional Rights held extensive hearings on school desegregation. During the course of the hearings, subcommittee members and staff determined that the most recent federal data needed to be examined to learn about progress and problems in school desegregation. What direction had the nation been moving during the seventies? Subcommittee Chairman Don Edwards directed a series of inquiries to the U.S. Department of Education, asking for basic data on the segregation of blacks and Hispanics and the kinds of changes that had occurred between 1968 and 1980, a period which includes all of the controversial urban desegregation orders. The Education Department provided this data in the form of printouts produced by the DBS Corporation under subcontract to Opportunity Systems Inc. in Washington. Chairman Edwards asked the Joint Center for Political Studies to examine the data and report to the subcommittee on the major implications. This report, prepared by Gary Orfield, professor of political science, public policy, and education at the University of Chicago under contract to the Joint Center, responds to that request.

The 1980 national and regional data were first computed for this report and are released here for the first time. For some measures, 1970-1980 comparisons were chosen to permit comparison with data showing changes in overall population between censuses.

THE BASIC TRENDS

Segregation of black students declined significantly in the United States between 1968 and 1980. The most substantial changes, however, were limited to the regions that had been segregated by law before 1954--the 11 states of the South and the 6 border states. Most of this change had been achieved by 1972, and, in fact, the South has recently become slightly more segregated.

During the seventies, all regions of the country except the Northeast reduced black segregation to some degree. The Northeast, by far the nation's most segregated region, became more segregated during the decade. The 1980-1981 school year found almost half of the black students in the Northeast in 90-100 percent minority schools, while fewer than one quarter of the black students in the South were in such schools.

The 1980 data show millions of children in integrated schools, particularly in the South, where segregation had been most severe. But it also shows that 63 percent of black students around the country remain in schools that are predominantly minority and about a third (33.2 percent) are still in intensely segregated schools with 90-100 percent minority enrollment.

The data strongly suggest that the much greater progress in the southern and border states was related to a strong enforcement effort by the federal government and the federal courts, which was primarily directed at southern segregation. When President Kennedy asked Congress to enact a civil rights bill in 1963, 98 percent of black students in the South were in all-black schools and almost all whites attended all-white schools. Enforcement of the 1964 Civil Rights Act and a number of major court decisions on southern segregation cut the number of southern black students in 99-100 percent black schools to 25 percent by 1968. During the 1968-1972 period, when the statistics in Tables 1,2, and 11 show the most dramatic changes recorded during this period, the Supreme Court made two extremely important decisions, in the cases of Alexander v. Holmes and Swann v. Charlotte-Mecklenburg. These decisions required that southern districts desegregate immediately and authorized the use of busing when it was the only way desegregation could be accomplished. These decisions had immediate impacts in hundreds of districts and sharply decreased segregation of black and white students in the South.

Neither the executive branch nor the Supreme Court has issued such clear directives for desegregation policy in the North and West, and progress in these areas has been much slower. By 1970, the South was the least segregated region for blacks, and the gap has grown since then.

The data on Hispanic segregation trends tell a very different story and raise very important research and policy questions. There was no progress on integrating Latino students in public schools in the seventies. In fact, each region of the country has become more segregated for Hispanics as their numbers have rapidly grown in American society. Although the Supreme Court ruled, in the 1973 Denver case, that Hispanics as well as blacks should be desegregated when a school board was ordered to implement a plan, very little has been done to implement this policy, and very few cases have been brought to court.

Hispanics increased rapidly, from about a twentieth of the public school students in 1970 to about a twelfth in 1980. As their numbers grew, so did their separation from whites.* During the seventies, the substantial increase of Hispanic segregation and the gradual decline of black segregation meant that by 1980, the typical Hispanic student attended a school that was more segregated than that of the typical black student (Tables 1-6). The consistent trend toward greater segregation of Hispanics and the acceleration of that trend in the late 1970s suggest that the gap could widen. In 1980, the typical Hispanic student attended a school in which 35.5 percent of the children were white; the typical black student, a school that was very slightly more integrated, 36.2 percent white (Tables 5 and 6). In 1980, 63

*The term "white," as used in this report, should be understood to mean "non-Hispanic white," since Hispanics can be of any racial background and many are all or part white. The term "Anglo" would be more appropriate but is not used here because it is little known outside the Southwest.

percent of black students and 68 percent of Hispanic students were in schools that were predominantly minority. Thirty-three percent of blacks and 29 percent of Hispanics were in intensely segregated schools, with 90-100 percent minority children.

Not only black students but whites as well were far more likely to attend substantially integrated schools in the South than in the North. To be sure, the North and West had far smaller proportions of black students to integrate (27 percent of students in the South were black; 18 percent in the border states; 14 percent in the Northeast; 12 percent in the Midwest; and 7 percent in the West). But even taking these disparities into account, the North and West seem to be doing much less to achieve integration. In the South, the percentage of white public-school students in schools that were 90-100 percent white declined from 71 percent in 1968 to 36 percent in 1980. During the same period, there was virtually no change in the Northeast and a much smaller change in the Midwest (Table 9). Southern white students are growing up in schools where minority students are a major presence, but many white children in the Northeast and Midwest are severely isolated from nonwhite children (Table 7).

BLACK SEGREGATION

The statistics on black segregation trends contain several important messages. Dramatic progress is possible. The decisive changes from 1968-1972 have been consolidated in the southern and border states. But the momentum of increasing integration may be lost unless there are new government initiatives. This is suggested by the small increase in segregation from 1978 to 1980 and the small increase in the South (Tables 1, 2, 11). Third, there are extremely wide regional discrepancies, and the basic problems of black segregation have changed almost beyond recognition since the fifties and sixties.

The problem of segregation for blacks is basically centered in the large older industrial states and in large cities that have experienced major racial change. The Northeast is the most segregated and has become more segregated during the seventies, because black students there are concentrated in large, predominantly nonwhite school districts that have never been ordered to implement a major desegregation plan, even within the central city.

State-by-state data show that intense segregation of black students is now focused in five areas of the United States. In fourteen states and the District of Columbia, at least 30 percent of black students are in schools that have 90-100 percent minority students. The five areas are:

-- Pennsylvania-New Jersey-New York-Connecticut

-- Illinois-Missouri-Indiana-Michigan

-- Washington, D.C.-Maryland

-- Alabama-Mississippi-Louisiana-Texas

-- California

Fourteen other states did have at least 95 percent of their black students in schools with at least 40 percent white students. To be sure, most of these states had relatively few black students at all, but the list does include Kentucky and Delaware, which had severe segregation until the implementation of metropolitan desegregation in their largest cities, Louisville and Wilmington. A number of other states had very modest problems of segregation that could be resolved without major changes.

The most segregated state in the United States for black students in 1980 was Illinois. Some 68 percent of Illinois's black students were in schools that were 90-100 percent minority. (In the District of Columbia, which is not counted as a state, the comparable percentage is 96.) Illinois is followed by New York (56 percent), Michigan (51 percent), New Jersey (50 percent), Pennsylvania (49 percent), Missouri (44 percent), and California (41 percent). All of these industrial states lead all southern states in segregation of black students. The most segregated southern states, Louisiana and Mississippi, had 37 percent of their black students in such intensely segregated schools in 1980. The typical black student in Alabama was in a school with more than twice as high a proportion of white students than his counterpart in Illinois.

Looking at the changes in the composition of the school attended by a typical black student by state during the seventies, the data show dramatic gains in a few states, little change in others, and significant backward movement in a handful. The most striking increases in the white proportion of the student body in schools attended by blacks (in states with at least 5 percent black students) were in Nebraska (a 33 percent increase), Kentucky (25 percent), Delaware (22 percent), Wisconsin (19 percent), Oklahoma (16 percent), and Ohio (15 percent). In all of these states, major court orders affected their largest cities. Two had metropolitan merger orders. The only states to show a substantial decline in the white representation in schools attended by blacks were New York (-6.2 percent) and New Jersey (-6.0 percent). There was a small decline in Connecticut.

The statistics on segregation of blacks show that the nation took a small but important step toward desegregated education in the seventies, and that the southern and border regions have made historic progress. The Northeast has moved against this stream of change, increasing its already intense segregation and operating the nation's most segregated schools.

HISPANIC SEGREGATION

Perhaps the most significant change in public school segregation in the seventies was the clear and sharp increase of segregation of Hispanics. Hispanics are a large and rapidly growing group, which already accounts for about a twelfth of U.S. students. Hispanic children are now more likely than black children to be in predominantly minority schools, though they are less likely to be in schools that are intensely segregated (90-100 percent minority). An indication of this change is the fact that in 1970, Hispanic students in the two least segregated regions of the country--the Midwest and the West--experienced the greatest increases in segregation. Hispanic students in the West and Northeast were far more likely to be in predominantly minority schools in 1980 than black students in the South.

There are a number of possible explanations for the increasing segregation. In the first place, as a group that had been a small minority in a particular area grows and the ethnic composition of the entire local population changes, children tend to be in schools with a higher proportion of minorities even if there is a good desegregation plan. Secondly, Hispanics tend to choose large metropolitan areas as a place of residence to an extraordinary degree--even more so than blacks--and these areas, particularly their central cities, are experiencing rapid increases in their proportion of minority children. The 1980 census showed that 84 percent of Hispanics lived in metropolitan areas and 41 percent lived in central cities of metropolitan areas with more than a million residents. Hispanic families were more than six times as likely as whites to reside in the central cities of the largest metropolitan areas (over three million). It is likely, as well, that discrimination of the type that helped force blacks into ghettos early in the century plays a part in this, as do the problems of language and immigration status.

The long term implications of these trends are unclear. The fact that we have another large, rapidly growing minority that is already by some measures more segregated than blacks and the fact that the trend is toward much greater segregation suggest the need for a serious examination of an urban society where there would be essentially separate systems of schooling not only for blacks and whites but also for Latinos.

As a whole, the West is by far the most important region for Hispanics, and what happens to Hispanic students will have a far larger impact on the West than on any other region. The West has 44 percent of the nation's Latino students, although it has only 19 percent of the nation's students. Thus, almost one fifth of the students in the West's public schools are Hispanic--a far larger proportion than in any other region (Table 10). Outside the West, large Hispanic populations are found in Texas and several large metropolitan areas (New York, Miami, Chicago, etc.). As the Hispanic population continues to grow, particularly in the Southwest, this region may play the role for Hispanics that the South played for blacks. Tables 3,4, and 6 show that Hispanic students in the West now attend schools in which most children are from minority groups--sometimes schools with few non-Hispanic students. Already 63.4 percent of Latino pupils in the West are in predominantly minority schools. If Texas were added to the western region, as it should be for analysis of Hispanic segregation, the level of segregation would be significantly higher.

Hispanics are concentrated in a smaller number of states than blacks, and a good many states have very few Latino students so far and very few signs of segregation. There are 17 states where at least 19 of every 20 Hispanic students are in schools that are 40-100 percent white.

The problems of segregation of Hispanic children are most severe in four states, which have large numbers of Latino chldren in schools that are 90-100 percent minority. New York State leads the list with 57 percent of its Hispanic students in this category, followed by Texas (40 percent), New Jersey (35 percent), and Illinois (32 percent). In 1980, the typical New York State Hispanic student was in a school with only 21 percent white students, the typical Texas Latino pupil in a school with 28 percent whites, the typical New Jersey child in a school with 26 percent whites, and the typical Illinois Latino student in a 36 percent white school. All of these levels of segregation worsened during the seventies. The only states to show any significant improvement were Wyoming, where an influx of whites drawn by the energy boom raised the white proportion and lowered the Hispanic proportion statewide, and Colorado, probably because of the Denver desegregation plan.

IMPLICATIONS

The school statistics show that, as the United States becomes an increasingly multiracial society, racial segregation remains the prevailing pattern in most regions with significant minority populations. Progress in desegregation for blacks in the South is offset by increasing segregation in the North. The large Hispanic population faces increasing educational segregation in the West and in states elsewhere with significant Hispanic populations. Where progress has been made, the changes appear to be related to policies and enforcement efforts by the courts and federal executive agencies. Pressure to enforce desegregation has diminished in recent years, and so has progress. There has been no serious effort to provide integration for Hispanics, and their segregation is rapidly increasing.

A further analysis, examining data from metropolitan areas, would show the degree to which the remaining problems of segregation are really problems of large metropolitan areas in the large states. If the progress achieved in the South is to be emulated in the North and West, clear policies for large metropolitan areas where the entire central-city school district and some older suburbs have become minority institutions must be resolved.

A quarter century after the beginning of significant southern desegregation with the Little Rock court order, the statistics from the South show that once unimaginable change is possible. The data from the North and West and the data for Hispanics from all parts of America show that little can be achieved without clear policies, effectively implemented.

Table 1

PERCENT OF BLACK STUDENTS IN
SCHOOLS WITH MORE THAN HALF MINORITY STUDENTS
BY REGION, 1968-1980

	U.S. TOTAL	SOUTHERN STATES	BORDER STATES	NORTHEAST	MIDWEST	WEST
1968	76.6	80.9	71.6	66.8	77.3	72.2
1972	63.6	55.3	67.2	69.9	75.3	68.1
1976	62.4	54.9	60.1	72.5	70.3	67.4
1980	62.9	57.1	59.2	79.9	69.5	66.8
change 1968 to 1980	-13.7	-23.8	-12.4	+13.1	-7.8	-5.4

Table 2

PERCENT OF BLACK STUDENTS IN
SCHOOLS WITH 90-100 PERCENT MINORITY ENROLLMENTS
BY REGION, 1968-1980

	U.S. TOTAL	SOUTH	BORDER	NORTHEAST	MIDWEST	WEST
1968	64.3	77.8	60.2	42.7	58.0	50.8
1972	38.7	24.7	54.7	46.9	57.4	42.7
1976	35.9	22.4	42.5	51.4	51.1	36.3
1980	33.2	23.0	37.0	48.7	43.6	33.7
change 1968-80	-31.1	-54.8	-23.2	+6.0	-14.4	-17.1

Table 3

PERCENT OF HISPANIC STUDENTS
IN SCHOOLS WITH MORE THAN HALF MINORITY STUDENTS
BY REGION, 1968-1980

	U.S.	SOUTH	BORDER	NORTHEAST	MIDWEST	WEST
1968	54.8	69.6	**	74.8	31.8	42.4
1972	56.6	69.9	**	74.4	34.4	44.7
1976	60.8	70.9	**	74.9	39.3	52.7
1980	68.1	76.0	**	76.3	46.6	63.5
change 1968-1980	+13.3	+6.4	**	+ 1.5	+14.8	+21.1

Table 4

PERCENT OF HISPANIC STUDENTS
IN SCHOOLS WITH 90-100 PERCENT MINORITY STUDENTS
BY REGION, 1968-1980

	U.S.	SOUTH	BORDER	NORTHEAST	MIDWEST	WEST
1968	23.1	33.7	**	44.0	6.8	11.7
1972	23.3	31.4	**	44.1	9.5	11.5
1976	24.8	32.2	**	45.8	14.1	13.3
1980	28.8	37.3	**	45.8	19.6	18.5
change 1968-1980	+5.7	+3.6	**	+1.8	+12.8	+6.8

**Border state figures are not reported because the very small number of Hispanics in this region makes comparison misleading. Among the Hispanics who do reside in this region 2.8% were in 90-100% minority schools in 1980 and 23.2% attend predominantly minority schools.

Table 5

PERCENT WHITE IN
RACIAL COMPOSITION OF
SCHOOL ATTENDED BY TYPICAL BLACK STUDENT,
BY REGION, 1970-1980

	U.S.	SOUTH	BORDER	NORTHEAST	MIDWEST	WEST
1970	32.0	36.7	27.4	31.5	23.6	30.1
1980	36.2	41.2	37.7	27.8	30.6	34.3
CHANGE 1970-1980	+4.2	+4.5	+10.3	-3.7	+7.0	+4.2

Table 6

PERCENT WHITE STUDENTS
IN SCHOOL ATTENDED BY TYPICAL HISPANIC STUDENT
BY REGION, 1970-1980

	U.S.	SOUTH	BORDER*	NORTHEAST	MIDWEST	WEST
1970	43.8	33.4	80.2	27.5	63.6	53.2
1980	35.5	29.5	66.4	27.0	51.9	39.8
CHANGE	-8.3	-3.9	-13.8*	-.5	-11.7	-13.4

(*very few Hispanics live in this region)

Table 7

PERCENT BLACK STUDENTS
IN SCHOOL ATTENDED BY TYPICAL WHITE STUDENT
BY REGION, 1970-1980

	U.S.	SOUTH	BORDER	NORTHEAST	MIDWEST	WEST
1970	6.1	14.9	5.8	4.5	2.8	2.4
1980	8.0	17.5	8.3	4.8	4.5	3.4

Table 8

PERCENT HISPANIC STUDENTS
IN SCHOOL ATTENDED BY TYPICAL WHITE STUDENT
BY REGION, 1970-1980

	U.S.	SOUTH	BORDER	NORTHEAST	MIDWEST	WEST
1970	2.8	2.8	.3	1.4	1.0	8.9
1980	3.9	4.1	.6	2.3	1.4	11.1

Table 9

PERCENT OF WHITE STUDENTS IN SCHOOLS
90-100 PERCENT WHITE, BY REGION,
1968-1980

	U.S.	SOUTH	BORDER	NORTHEAST	MIDWEST	WEST
1968	78.4	70.6	80.0	83.0	89.4	63.0
1972	68.9	38.0	75.9	82.9	87.5	56.0
1976	64.9	34.6	64.8	81.4	84.7	49.9
1980	61.2	35.0	64.1	80.2	81.2	43.3
change 1968-1980	-17.2	-35.6	-15.9	-2.8	-8.2	-19.7

Table 10

RACIAL COMPOSITION OF PUBLIC SCHOOL
ENROLLMENT, NATION AND REGIONS, 1970-1980
DEPT. of EDUCATION SURVEY DATA

	American Indian	Asian	Hispanic	Black	White
1970					
Nation	.4%	.5%	5.1%	15.0%	79.1%
Northeast	.1%	.4%	4.4%	11.9%	83.3%
Border	.8%	.2%	.3%	17.3%	81.4%
South	.2%	.1%	5.5%	27.2%	66.9%
Midwest	.3%	.2%	1.4%	10.4%	87.6%
West	1.1%	1.6%	13.0%	6.3%	77.9%
1980					
Nation	.8%	1.9%	8.0%	16.1%	73.2%
Northeast	.2%	1.4%	6.6%	13.6%	78.3%
Border	1.5%	.8%	.7%	17.5%	79.5%
South	.3%	.7%	8.8%	26.9%	63.3%
Midwest	.6%	.9%	2.3%	12.4%	83.7%
West	1.8%	4.4%	19.0%	6.8%	68.0%

Table 11

BLACK AND HISPANIC ENROLLMENT IN PREDOMINANTLY MINORITY AND 90-100% MINORITY SCHOOLS, 1968-1980

year	predominantly minority		90-100% minority	
	BLACKS	HISPANICS	BLACKS	HISPANICS
1968	76.6%	54.8%	64.3%	23.1%
1970	66.9%	55.8%	44.3%	23.0%
1972	63.6	56.6%	38.7%	23.3%
1974	63.0%	57.9%	37.8%	23.9%
1976	62.4%	60.8%	35.9%	24.8%
1978	61.8%	63.1%	34.2%	25.9%
1980	62.9%	68.1%	33.2%	28.8%

TECHNICAL NOTES

The basic computer work for this report was done by DBS Corporation under subcontract to Opportunity Systems Inc. which prepared data then submitted for analysis by the Joint Center for Political Studies.

The regions used for analysis in this report include the following states:

SOUTH: Alabama, Arkansas, Georgia, Florida, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Texas, Virginia
BORDER: Deleware, District of Columbia, Kentucky, Maryland, Missouri, Oklahoma, West Virginia
NORTHEAST: Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont
MIDWEST: Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin
WEST: Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, Wyoming

EXCLUDED: Hawaii and Alaska, because of unique ethnic composition and distance from other states assigned to regions

Exposure Indices-- the tables reporting the racial average composition of schools attended by blacks, Hispanics, and whites are determined by calculations using the following alegebraic formula, producing a figure commonly called an exposure index:

Exposure Index Showing Typical Exposure of White Students to Blacks in a School District

$$E_{W/B} = \left(\sum_i \frac{W_i}{W_D}\right) X \left(\frac{b_i}{W_i + b_i}\right) \quad X \quad 100$$

W_i is the number of white students in the ith school

W_D is the number of white pupils in the district

b_i is the number of black pupils in the district

Joint Center
For
Political Studies

WORKING PAPER: DESEGREGATION OF
BLACK AND HISPANIC STUDENTS
FROM 1968 TO 1980

A Report to the Subcommittee on Civil and Constitutional Rights of the Committee on the Judiciary of the United States House of Representatives

Prepared by
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for the
Joint Center for Political Studies
Washington, D.C. 1982

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BACKGROUND

In the fall of 1981, the House Subcommittee on Civil and Constitutional Rights held extensive hearings on school desegregation. During the course of the hearings, subcommittee members and staff determined that the most recent federal data needed to be examined to learn about progress and problems in school desegregation. What direction had the nation been moving during the seventies? Subcommittee Chairman Don Edwards directed a series of inquiries to the U.S. Department of Education, asking for basic data on the segregation of blacks and Hispanics and the kinds of changes that had occurred between 1968 and 1980, a period which includes all of the controversial urban desegregation orders. The Education Department provided this data in the form of printouts produced by the DBS Corporation under subcontract to Opportunity Systems Inc. in Washington. Chairman Edwards asked the Joint Center for Political Studies to examine the data and report to the subcommittee on the major implications. This report, prepared by Gary Orfield, professor of political science, public policy, and education at the University of Chicago under contract to the Joint Center, responds to that request.

The 1980 national and regional data were first computed for this report and are released here for the first time. For some measures, 1970-1980 comparisons were chosen to permit comparison with data showing changes in overall population between censuses.

THE BASIC TRENDS

Segregation of black students declined significantly in the United States between 1968 and 1980. The most substantial changes, however, were limited to the regions that had been segregated by law before 1954--the 11 states of the South and the 6 border states. Most of this change had been achieved by 1972, and, in fact, the South has recently become slightly more segregated.

During the seventies, all regions of the country except the Northeast reduced black segregation to some degree. The Northeast, by far the nation's most segregated region, became more segregated during the decade. The 1980-1981 school year found almost half of the black students in the Northeast in 90-100 percent minority schools, while fewer than one quarter of the black students in the South were in such schools.

The 1980 data show millions of children in integrated schools, particularly in the South, where segregation had been most severe. But it also shows that 63 percent of black students around the country remain in schools that are predominantly minority and about a third (33.2 percent) are still in intensely segregated schools with 90-100 percent minority enrollment.

The data strongly suggest that the much greater progress in the southern and border states was related to a strong enforcement effort by the federal government and the federal courts, which was primarily directed at southern segregation. When President Kennedy asked Congress to enact a civil rights bill in 1963, 98 percent of black students in the South were in all-black schools and almost all whites attended all-white schools. Enforcement of the 1964 Civil Rights Act and a number of major court decisions on southern segregation cut the number of southern black students in 99-100 percent black schools to 25 percent by 1968. During the 1968-1972 period, when the statistics in Tables 1,2, and 11 show the most dramatic changes recorded during this period, the Supreme Court made two extremely important decisions, in the cases of Alexander v. Holmes and Swann v. Charlotte-Mecklenburg. These decisions required that southern districts desegregate immediately and authorized the use of busing when it was the only way desegregation could be accomplished. These decisions had immediate impacts in hundreds of districts and sharply decreased segregation of black and white students in the South.

Neither the executive branch nor the Supreme Court has issued such clear directives for desegregation policy in the North and West, and progress in these areas has been much slower. By 1970, the South was the least segregated region for blacks, and the gap has grown since then.

The data on Hispanic segregation trends tell a very different story and raise very important research and policy questions. There was no progress on integrating Latino students in public schools in the seventies. In fact, each region of the country has become more segregated for Hispanics as their numbers have rapidly grown in American society. Although the Supreme Court ruled, in the 1973 Denver case, that Hispanics as well as blacks should be desegregated when a school board was ordered to implement a plan, very little has been done to implement this policy, and very few cases have been brought to court.

Hispanics increased rapidly, from about a twentieth of the public school students in 1970 to about a twelfth in 1980. As their numbers grew, so did their separation from whites.* During the seventies, the substantial increase of Hispanic segregation and the gradual decline of black segregation meant that by 1980, the typical Hispanic student attended a school that was more segregated than that of the typical black student (Tables 1-6). The consistent trend toward greater segregation of Hispanics and the acceleration of that trend in the late 1970s suggest that the gap could widen. In 1980, the typical Hispanic student attended a school in which 35.5 percent of the children were white; the typical black student, a school that was very slightly more integrated, 36.2 percent white (Tables 5 and 6). In 1980, 63

*The term "white," as used in this report, should be understood to mean "non-Hispanic white," since Hispanics can be of any racial background and many are all or part white. The term "Anglo" would be more appropriate but is not used here because it is little known outside the Southwest.