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ABSTRACT

In order to remain competitive in the world economy, the United States must develop and improve mathematics and science education. Given that the future workforce in this country will be comprised largely of women and minorities, groups traditionally not entering mathematics and science careers, special recruitment and retention efforts must be developed. Urban community colleges enroll the largest numbers of women and minorities and have a special role to play in these efforts. This collection of articles reviews the status of mathematics-science education, identifies barriers to greater enrollment among women and minorities, examines the growing demand for skilled workers, and prescribes steps to be taken by urban colleges to train a more technical workforce. Included are the following 10 articles: (1) "Implications of the Mathematics-Science Crisis on the U.S. Economy," by Dennis P. Gallon; (2) "Student Participation in Mathematics and Science Programs," by Stelle Feuers; (3) "Federal Government Support for Mathematics and Sciences," by Carl Polowczyk; (4) "Breaking Down Barriers for Women and Minorities in Mathematics and Sciences," by Dianne Halleck; (5) "The Urban Climate and Strategies for Intervention," by Tom Hooe; (6) "Mathematics and Science Crisis: Implications for Educational Leaders of Urban Community Colleges," by Wright L. Lassiter, Jr.; (7) "Mathematics-Science Professors in Community Colleges," by P. M. Commons; (8) "Mandate for Action," by Frank Cerrato; (9) "Needed: An Applied Academics Program," by Dale Parnell; and (10) "Selected Sources and Exemplary Practices in Mathematics and Sciences at Community Colleges," by James Holmberg. (PAA)

REGAINING THE EDGE IN URBAN EDUCATION

MATHEMATICS AND SCIENCES

A Report of the Commission on Urban Community Colleges of the American Association of Community and Junior Colleges

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FOREWORD

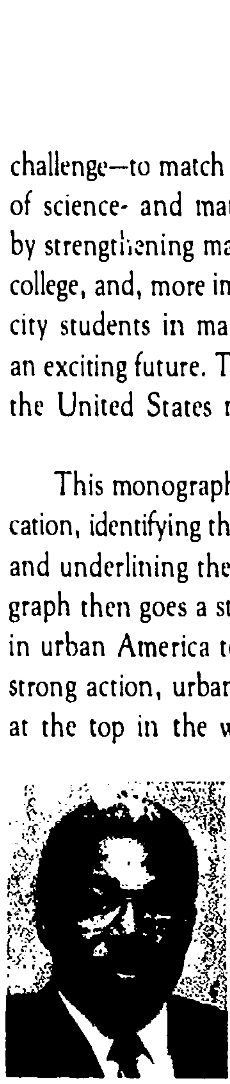
The global arena in which the United States must compete is changing drastically. As the 1990s unfolds, there is a growing recognition that the U.S. leadership position in the world marketplace is being challenged as a consequence of a weakened educated population in mathematics and science and a decline in spending on nondefense research and development. For the first time, the American work force is competing with workers from other countries who are more highly skilled and perhaps more committed to world dominance.

Yet recent social, political, and economic changes around the world also provide the United States with new opportunities to excel in the global expansion. The question is no longer: "Is the U.S. the number one super power?" We are. Rather, the question is "Will the U.S. effectively use all its available assets to keep pace with our European and Asian competitors?" The outcome of that competition will no doubt depend on how we handle the shortage of a well-trained work force in the 1990s. The short-term prognosis for the United States is a decline, not an improvement, in the quality of its work force. To reverse that trend, it is absolutely critical that this country immediately adopt a comprehensive blueprint for creating a national education agenda involving all education institutions, including the urban community college.

The urban community college is the key to U.S. economic strategy because it is the postsecondary institution that attracts those individuals who will make up the largest segment of the future work force: women and minorities. Unfortunately, these groups have traditionally not entered mathematics and science careers.

The Commission on Urban Community Colleges of the American Association of Community and Junior Colleges understands the challenge—to match the workers of the future with the growing number of science- and mathematics-based jobs. This will be accomplished by strengthening mathematics and science offerings in the community college, and, more importantly, by stimulating an interest among inner-city students in math and science courses as their first step toward an exciting future. To remain a dominant voice in the world economy, the United States must solve its mathematics and science crisis.

This monograph examines the status of mathematics-science education, identifying the barriers that have shut out women and minorities and underlining the coming demand for skilled workers. The monograph then goes a step further and prescribes what needs to be done in urban America to train a more technical work force. With swift, strong action, urban community colleges can keep the United States at the top in the world economy.



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PREFACE

As a nation, we are in a serious and uphill struggle to improve our ability to compete in the international economy. Clearly, the foundation of our competitiveness is our strength in science and technology—the ability to create new knowledge and apply it in new products. That ability depends on our human capital, our scientists, mathematicians, and engineers. We cannot take either the quantity or quality of science and math personnel for granted. The nation's community, technical, and junior colleges, the largest arm of American higher education, will play a key role in meeting the challenge of strengthening the nation's mathematics and science personnel pool.

Studies seem to appear weekly pointing to a weakened math and science foundation. Fewer students are choosing to study science and math. The American Council on Education found that from 1966 to 1987 college freshmen planning to major in biological sciences, engineering, physical sciences, and math fell from 21 to 14 percent. Although degrees in computer sciences are on the increase, baccalaureate degrees in math, science, physics, and biology are declining.

International comparisons give little consolation. The United States is graduating one-fifth as many engineers as the USSR. Japan, with half our population, graduated almost as many engineers as the United States. American 13-year-olds score last in math performance when compared to students in many other countries.

With their flexibility to develop instructional programs and their ties to local employment bases, community colleges can respond. Community colleges have a proven record of innovation, especially in addressing education deficits and motivating a diverse student population.

As a nation, we must broaden our perspective beyond our borders. In this increasingly competitive, technological, and international economy, the total education system must respond. Community colleges will play—and must play—a critical role. The chapters by the authorities in this collection provide many thoughtful challenges to the total education system.

U.S. Representative Doug Walgren
D-Pennsylvania

AMERICAN ASSOCIATION OF COMMUNITY AND JUNIOR COLLEGES

COMMISSION ON URBAN COMMUNITY COLLEGES

JULY 1, 1990—JUNE 30, 1991

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I.

IMPLICATIONS OF THE MATHEMATICS-SCIENCE CRISIS ON THE U.S. ECONOMY

BY DENNIS P. GALLON

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Science and technology are indispensable elements needed to assure the economic vitality of any nation. The United States has a long and respected tradition in science and technology; American scientists and engineers invented the technologies contributing the most to 20th century civilization. The telephone, the automobile, and the computer are just a few of America's technological inventions. Today, however, many concede that the United States has lost its competitive edge for innovation to Asia, particularly Japan, and to Europe.

Evidence is indeed mounting that the United States is losing its ability to compete in one market after another. For at least two decades, it has been apparent that the world leadership position in manufacturing once enjoyed by our nation has been on the decline. This country was the steel maker of the world after World War II and once dominated in automobile manufacturing. Today, however, the United States is just another competitor in the world market for automobiles. Occurrences of this nature are increasingly causing concern about our ability to respond to foreign competition that will be with us into the 21st century.

The fact that we have a high standard of living should give us little satisfaction, since we are consuming more than we produce. The trade balance that existed prior to 1980 has not been restored. In less than 10 years, the U.S. position as the world's largest creditor shifted to the world's largest debtor. While some economists predict that the trade deficit will ease slightly in the coming years, the deficit will continue to increase and is predicted to reach an all-time high by the year 2000. These projections will become reality if a large number of American business enterprises are unable to compete in an integrated world economy.

Ironically, all of this will have happened at a time when the United States has more businesses and more scientists and engineers—who, incidentally, have won more Nobel Prizes than any other nation, including Japan—than the rest of the world combined. The paradox becomes more perplexing when one considers that students from all over the world come to this country to obtain advanced training in the sciences and engineering.

So, what does the United States need to regain its economic superiority? Clearly we need to regain our ability to innovate. Most important, however, is the assurance of an educated, skilled, and motivated work force. This country must educate all of its people—especially children—to compete with the foreign work force.

A Decline in the Quality of American Education

Reports document that American pre-college education has been declining since the implementation of the "quick-fix" education strategies in the decade following the 1957 launch of Sputnik. Since the publication of the National Commission on Excellence in Education report, *A Nation at Risk* (1983), warning us about the "rising tide of mediocrity," several subsequent studies have further documented the declining quality of our secondary schools. Our nation is indeed very much at risk.

In 1988 a group of 13-year-olds from five countries and four Canadian provinces (in three cases provinces assessed two languages) participated in a mathematics and science assessment study, "A World of Differences." The students came from

British Columbia	Ontario *(French)*
Ireland	Quebec *(English)*
Korea	Quebec *(French)*
New Brunswick *(English)*	Spain
New Brunswick *(French)*	United Kingdom*
Ontario *(English)*	United States

**The United Kingdom sample was drawn from students in England, Scotland, and Wales.*

The results from this international assessment are quite alarming for the United States. Korear students achieved the highest average, and the U.S. students achieved the lowest and well below the mean score in mathematics. Since mathematics is a prerequisite for science, it is not surprising that the students' performance in this area was not significantly different. The students from Korea performed second to British Columbia, while the U.S. students were in the bottom cluster and ranked ninth. Only Ireland, Ontario (French), and New Brunswick (French) performed worse (Lapointe, Mead, and Phillips, 1988).

Reports from the U.S. Congress Office of Technology Assessment (1988) and the National Research Council (1989) are only two in a long list of publications also concluding that academic standards among U.S. students, particularly in mathematics and science, are extremely low when compared with the performance of students from other advanced countries.

While international comparisons are most alarming, this country's student performance on national assessment tests in other areas, e.g., reading, writing, and geography, is also weak. This decline in academic performance has occurred in spite of claims that the United States spends more on education than Japan, Germany, and other economic competitors. It is projected that over $350 billion will be spent in 1990 to operate our K-12 schools, colleges, and universities. Notwithstanding these expenditures, our educational institutions are failing to educate a superior work force that can help this country meet the challenges of an international competitive environment that will become more intense during the 1990s with the economic integration of Europe.

A National Interest in Mathematics-Science Education

The plea that America produce a more productive work force by immediately implementing educational reforms and investing in human capital has created the current national interest in mathematics and science education. The amount and quality of educational reform around the country have not been uniform. Examples of significant changes, as well as stagnation, can be found within and among many communities.

Increasingly, local, state, and national educational leaders are beginning to evaluate the issues and options linking education policy with present and future economic needs. Perhaps more than ever before, education, business, and political leaders are accepting the position that science and technology are the critical factors driving the world economy, and these leaders support the mandate for more and better mathematics and science education. Consequently, strategies to improve the quality of mathematics-science education are being discussed with a national perspective focused on long-term improvements.

Several states have developed comprehensive master plans outlining broad and ambitious ways to improve mathematics and science education. These states are acutely aware that without such improvements the United States cannot expect to survive in a world that demands technological skills of its workers and scientific literacy of its citizens. Florida is among those states that have implemented curricular reforms requiring that students complete a core of mathematics and science courses before obtaining a high school diploma.

The growing involvement of businesses in education is unprecedented. Many corporations, small enterprises, and civic groups continue to join with schools in mutually productive partnerships. It is generally accepted that education and the decline of America's work force are discussed just as much as, if not more than, the accounting balance sheet in the boardrooms of American businesses. It has been estimated that one out of three major corporations already provides new workers with basic reading, writing, and arithmetic courses. If current demographic and economic trends continue, American businesses will hire a million new people a year who cannot read, write, or count. Teaching employees these basic skills, combined with absorbing the lost productivity while they are learning, could cost industry $25 billion annually (Boyd, 1989).

The fact that corporations are providing their employees with basic skills training and that government, political, and education leaders have an intense desire to improve the quality of education should provide us all with a sense of hope. However, a well-financed, sustained commitment to a clear national agenda must take place if substantial gains are to be achieved. Two major steps are being made in that direction. First, during the past couple of years Congress has responded with legislation that could authorize billions of dollars for instruction and sciences. Educational leaders worry, however, that all of these funds will not be budgeted, causing another "quick-fix" approach resembling that of the Sputnik era.

Second, the executive branch of the government has contributed to the current level of enthusiasm for education in general and mathematics and science education in particular. President George Bush has said he wants to be known as the Education President. The fact that he convened his cabinet and the nation's governors for a summit in Charlottesville, Virginia, in September 1989 to address the critical problems facing American public education demonstrates a commitment to that goal. Not since Franklin Roosevelt's tenure in the Oval Office has a president called the nation's governors together.

While heading FDR's agenda was a search for ways to cope with the Depression, President Bush and the governors grappled with a crisis whose long-range effects could prove no less catastrophic for American economic security and prosperity: the failure of U.S. schools to teach the basic skills needed to keep America productive and competitive.

During the education summit, the President and the governors agreed to

- Establish a process for setting national education goals
- Seek greater flexibility and enhanced accountability in the use of federal resources to meet the goals through regulatory and legislative changes
- Undertake a major state-by-state effort to restructure the education system
- Report annually on progress in achieving the goals

Since the summit, most governors have been working within their states to develop strategies for restructuring their education systems. As a result, many states have developed comprehensive plans. President Bush has made several major speeches, including his State of the Union Address in January 1990, outlining the vulnerability of our economic competitiveness due to a poorly educated work force. In addition, Education Secretary Lauro Cavazos has suggested that sweeping fundamental changes in our education system be made. Other cabinet members, including Secretary of Labor Elizabeth Dole and Secretary of Energy James Watkins, have set into motion several initiatives that will mobilize federal dollars and other resources on behalf of education.

Perhaps the most significant accomplishment since the summit is that the Bush Administration and the National Governors' Association (NGA) have worked collaboratively to develop and recommend a set of national goals. In July 1990, during the NGA's annual meeting in Mobile, Alabama, a document was released, *Educating America: State Strategies for Achieving the National Education Goals*. The report identified the six national goals that are to be accomplished by the year 2000 and listed strategies for accomplishing each one. The goals are

- All children in America will start school ready to learn
- The high school graduation rate will increase to at least 90 percent
- American students will leave grades four, eight, and twelve having demonstrated competency over challenging subjects including English, mathematics, science, history, and geography, and every school in America will ensure that all students learn to use their minds well so they may be prepared for responsible citizenship, further learning, and productive employment in our modern economy
- U.S. students will be first in the world in mathematics and science achievement
- Every American adult will be literate and will possess the knowledge and skills necessary to compete in a global economy and to exercise the rights and responsibilities of citizenship
- Every school in America will be free of drugs and violence and will offer a disciplined environment conducive to learning (National Governors' Association, 1990)

The Bush Administration and the NGA consider these goals to be ambitious and predict that they will set the direction for restructuring our nation's education system for the next decade. However, these goals may also be Utopian. The education summit was convened only about a year ago—it is too early to say precisely if these goals will produce significant impact.

It is not too early, however, to conclude the following: If these goals turn out to be the cornerstone for President Bush's pledge to be the nation's Education President, his administration will not encourage any change in the constitutional authority that education is a state responsibility. Consequently, our nation's schools are not likely to receive any major increases in dollars from the federal level. Further, it is now midpoint in the President's first term of office and, short of rhetoric, he may find it difficult to identify accomplishments in education if he chooses to run for re-election in 1992.

Demographic and Education Skills Attainment Trends

While the inadequacy of our education system has contributed to the mathematics-science crisis, current demographic trends will intensify the magnitude of the problem. First, Americans are growing older. During the next decade a significant number of our scientists and engineers will be lost to retirement without a corresponding pool of applicants to replace them. Second, there is a shortage of White males available to enter the work force. It is estimated that by the turn of the century White males will make up approximately 15 percent of entrants into the nation's work force. And third, most of the new entrants in the work force at the turn of the century and beyond will be minorities, immigrants, and women. These new entrants (Asians not included) have historically participated less in mathematics-science professions.

As the proportion of White males in the population decreases and as fewer of them choose to study science and engineering, the United States will be relying more and more on minorities and women to fill the gap. If current trends continue, it is certain that the needed supply of minority individuals and women with mathematics and science backgrounds will not be available.

A National Assessment of Education Progress (NAEP) longitudinal study concluded that

> Nine-, 13-, and 17-year-old Hispanic and Black students in the U.S. in science and mathematics fall markedly below... their White peers. The NAEP data show that despite recent gains, the average proficiency level in science of 13- and 17-year-old Black and Hispanic students remains at least four years behind that of their White peers. Only about 15 percent of the Black and Hispanic 17-year-olds assessed in 1986 demonstrated the ability to analyze scientific procedures and data, compared to nearly one-half of the White students at this age. While average science proficiency for 9-year-old boys and girls was approximately the same—except in the physical sciences—a performance gap was evident at age 13 and increased by age 17 in most science-content areas. At age 17 roughly one-half of the males but only one-third of the females demonstrated the ability to analyze scientific procedures and data (Mullis and Jenkins, 1988, p. 7).

These data reflect the magnitude of the education problem and, more specifically, the quality and status of mathematics and science education in the United States today. We cannot afford to maintain the status quo if this nation is to remain competitive with other industrialized nations. We urgently need to allocate the necessary resources—economic, human, and physical—to reverse the current situation.

Mathematics-Science Education Pipeline

If this country is serious about increasing the number of mathematics and science professionals, we must be certain that the education pipeline from pre-kindergarten through graduate school meets the needs of those who enter. Strengthening the education pipeline at the pre-college and community college levels is particularly critical. Attention is focused on each of the pre-college levels because the amount and quality of interest students develop in mathematics and science here will strongly determine their interest at the college level. To prepare for college, it is highly recommended that the decision to enter science and engineering careers be made before entering high school. These early years are critical if students are to take the mathematics and science courses that will enable them to see how scientific ideas and processes are connected among and between the various disciplines

To further improve the number of mathematics and science professionals, this country can no longer overlook the existence of minorities, women, and people with learning disabilities, groups that have been previously tapped only for equity reasons in mathematics, science, and engineering professions. Currently minority students, particularly Black males, tend to lose ground at each level of the education pipeline. This is easily documented by the fact that while the number of degrees conferred by colleges and universities increased during the last decade, minorities remain underrepresented in the American education scene. Unfortunately, many of these students begin to lose their competitive skills before they leave elementary school.

This country cannot afford to ignore or even underestimate the contributions that community colleges can make to eliminate the mathematics-science crisis. Community, technical, and junior colleges now form the largest component of higher education in America. More than 10 million students are currently enrolled in credit and non-credit courses at two-year colleges, and the majority of these students are the women and minorities who must be educated and trained if we are to address the mathematics-science crisis in the United States today.

Urban Community Colleges and the Revitalization of Mathematics-Science Education

The student population of today's urban community college is characterized by ethnic, demographic, socioeconomic, and intellectual diversity. These students need support services and a curriculum ladder with every rung in place. Providing these services is essential if these students are to overcome inadequate preparation for college and unfocused education and career objectives.

Admittedly, many students enrolled in two-year postsecondary institutions are totally unprepared for college-level work. Invariably, these students had no college goals when they entered high school and were not exposed to the academic preparation required for any program of study at the collegiate level. It is generally believed that many of these students decided during their final years of high school or later in life that they wanted or needed a college degree.

Before community colleges can begin to provide these students with a heavy emphasis in mathematics and science, they must recognize that a large portion are unprepared for this experience and lack the critical skills necessary to make the successful transition to college work. Moving these students through to graduation further intensifies the challenge facing two-year institutions, particularly the urban community college. In spite of these challenges, however, the community college's "open door" policy has been a success. Flexible and effective delivery systems have helped students develop the skills necessary to obtain the first two years of the baccalaureate degree.

Increasingly, these community college students are going on to universities to complete the master's and Ph.D. degrees in many areas, including science and engineering.

While community colleges have been criticized for trying to be all things to all people, they can almost do that when given adequate economic resources. To perform effectively, however, community colleges need to offer diverse curricula, up-to-date equipment, and an enthusiastic and well-trained faculty. Providing this teaching and learning environment requires that community colleges receive a greater proportion of public funds for education. Currently most states have not come close to providing the resources needed by students served by these two-year institutions, and it is axiomatic that community colleges can benefit in a number of areas from additional funding—two critical areas are faculty development and equipment.

Faculty development funds are needed for faculty preparation and in-service training. This country has a definite shortage of teachers at all levels, particularly in mathematics and science. The shortage can be described as catastrophic when associated with minority teachers. Teacher preparation is an area that the urban community college can readily help to resolve. For example, during the 1988-89 academic year, a majority of the students enrolled in the schools of education in the Florida state university system completed their associate of arts degrees at one of the institutions in the state's community college system (*Associate in Arts Graduates*. . ., 1989). To be most productive in this area, however, funds must be available to recruit and properly train these students. Perhaps equally critical is the need to require that community colleges and universities seek out opportunities to enable these students to complete their program of study as quickly as possible so that they can enter the classroom.

Teacher in-service is just as critical. Many mathematics and science teachers at community colleges have not kept abreast of new research and new teaching techniques in their fields because of heavy teaching workloads. If community colleges are to be successful at educating their heterogeneous student populations, it is essential that they have competent and enthusiastic teachers.

Community colleges have an on-going challenge of providing necessary instructional equipment. Serious deficiencies now exist in both the amount and condition of scientific equipment. Many community colleges in this country were built in the late 1950s and 1960s, and some of the obsolete scientific equipment currently used was purchased back then with construction funds. Given the technological advances of the last 30 to 40 years, it is no small wonder that community colleges often find it difficult to get students excited about science and technology.

Undergraduate mathematics and science education is unquestionably vital to the technological and economic future of this nation. Few will disagree that two-year college students are the largest untapped source for potential mathematicians, scientists, and engineers. Community college leaders have expressed a keen interest in contributing to the reversal of the mathematics-science crisis. These leaders are also acutely aware that reversing this trend means not only preparing their institutions to be more successful at attracting and educating young men and women in the fields of mathematics and science, but also improving the scientific literacy of the general public.

The Commission on Urban Community Colleges of the American Association of Community and Junior Colleges (AACJC) shares the national concerns over the dwindling number of entrants into mathematics-science professions. The Commission is fully aware that the challenge of reversing this trend defies an easy solution; however, it views the contributions of urban community colleges as indispensable for creating a comprehensive national agenda revitalizing mathematics and science education. The chapters that follow will present issues that must be resolved if community colleges are to be a viable component of a national effort to improve our education system and our economy.

About this Book—Current literature is replete with data on the status of mathematics and science education in America. The majority of the literature suggests recommendations to be implemented by secondary schools and universities that will enable these institutions to enhance our mathematics, science, and engineering work force. One of the objectives of this publication is to create a greater awareness of the declining status of mathematics and science education in this country. Another objective is to articulate how the mission and philosophy of the community college makes it ideally suited to significantly influence the academic preparation of those groups traditionally underrepresented in mathematics and science careers.

This publication is written for the non-scientist. It is written for policy makers at the national, state, and local levels of government and for people in a position to influence the development of public policy.

This volume is divided into two major sections. The first four chapters focus primarily on the mathematics-science crisis from a macro-perspective. They present some of the national environmental implications that leaders of two-year institutions must understand if their institutions are to effectively contribute to eliminating the mathematics and science crisis. The remaining five chapters discuss the role of community, technical, and junior colleges as providers of new opportunities for women and minorities. The term "minorities" in this publication will include Blacks, Hispanics, Native Americans, Pacific Islanders, and Asians.

This chapter has presented an overview of how a lack of expertise in mathematics and science will weaken the United States as a world leader. This chapter has also discussed the community college as a rung in the education ladder, indispensable in this country's attempt to respond to the mathematics-science crisis.

Chapter Two examines the changing profile of the general population and of undergraduate students in the United States. Major demographic trends and their impact on the availability of well-trained individuals in mathematics and sciences are analyzed.

Practically every state has substantially increased the dollars spent on education over the past five years. Currently state and local governments provide 90 percent of the dollars spent on education. Chapter Three identifies selected federal programs. It also recommends areas where the federal government must provide a substantial infusion of dollars, including community college teacher training, education technology, and research.

Chapter Four identifies the barriers that have kept women and minorities underrepresented in the mathematics and science professions. This chapter investigates strategies for lowering the barriers.

Chapter Five introduces some of the continuing challenges facing the community college as an urban institution. Urban community colleges, more than any other postsecondary institution, have the greatest challenge of providing appropriate instruction for students from diverse backgrounds and varying levels of readiness for learning. Environmental factors within and outside the urban community college, *e.g.*, lack of role models and negative distractions in the community, are also presented.

The title of Chapter Six, "Mathematics and Science Crisis: Implications for Educational Leaders of Urban Community Colleges," indicates its content. The very nature and geographical location of the urban community college will cause it to serve a large percentage of the individuals underrepresented in mathematics and science professions. The leaders of these two-year institutions will determine, to a great extent, if the students enrolled will experience the thrill of discovery and an understanding of the mathematical and scientific principles that govern our world. This chapter also suggests some views that community college leaders must share to help create an effective teaching/learning environment.

Chapter Seven reviews the critical shortage of teachers in American education and the role community colleges can play to help alleviate this problem. Chapter Eight recommends short-term and long-term strategies for community colleges and other agencies to improve the mathematics and scientific literacy of our nation's citizens.

Chapter Nine proposes one solution to the mathematics-science crisis: applied academics and the tech-prep/associate degree program.

Chapter Ten provides a comprehensive review of the literature pertaining to the mathematics-science crisis. Included in this chapter is a descriptive summary of selected exemplary programs located in or associated with community colleges, which are designed to be a catalyst for combating the projected shortage of scientists and engineers.

Acknowledgments—As this volume's editor, I wish to thank all of its contributing authors for their efforts to complete this collaborative project. Thanks are extended to the AACJC staff; Charles Spence, president of Florida Community College at Jacksonville; and other members of the Urban Commission for their advice and assistance. My appreciation is also extended to M. Carolyn Girardeau and Shirley P. Myers for their assistance with editing and to Darbie Hawks for typing several drafts of this publication.

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II.

STUDENT PARTICIPATION IN MATHEMATICS AND SCIENCE PROGRAMS

BY STELLE FEUERS

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Occupational projections by the federal Bureau of Labor Statistics suggest that rapid expansion of high technology will spur job market growth for scientists, engineers, technicians, and computer specialists. They will be needed for the development of high technology products such as computers, scientific and medical instruments, communication equipment, and robots.

Also projected are heavy demands for electrical, industrial, and mechanical engineers as manufacturing industries integrate new technologies into their production systems. In addition, more than a quarter of a million new jobs are expected for engineering professionals, science technicians, and computer programmers. Given current trends, demographers say that the United States will not have enough engineers and scientists in the next century. Business and industry will be searching for men and women with strong scientific skills.

There will be a severe faculty shortage in the sciences in the next two decades unless efforts are taken to strengthen graduate programs, according to Bowen and Sosa (1989). Retirements coupled with projected increases in college enrollment will lead to a low candidate-to-job ratio in mathematics and the physical sciences. Bowen and Sosa's study shows that between 1971 and 1985 the percent of degrees in the arts and sciences dropped from 40 percent to 25 percent of total degrees conferred, while degrees awarded in professional programs such as engineering and business increased. They attribute the change to "a large and continuous flight of students from the arts and sciences over the last 25 years" (p. 46).

The *Digest of Education Statistics 1988* (National Center for Education Statistics) reveals many reasons for this low candidate-to-job ratio:

- Between the years 1970 and 1986, the number of students receiving bachelor's degrees increased by 18 percent, from 839,730 to 987,823. During this period, students receiving bachelor's degrees in engineering increased by 83 percent, from 44,898 to 76,333. By comparison, bachelor's degrees conferred in physical science only increased by 1 percent, and bachelor's degrees in mathematics decreased drastically by 34 percent.

- For the years between 1977 and 1985, enrollment in all graduate programs increased by 21 percent. Engineering programs saw a 45 percent increase during the period. Physical science's enrollment rose 17 percent, and mathematics climbed 13 percent. However, the enrollment numbers do not accurately reflect the number of students who completed the graduate courses.

- The number of master's degrees conferred between 1970 and 1986 increased 25 percent. Master's degrees in engineering did a little better than the average and claimed a total of 29 percent of all master's degrees conferred. Master's degrees in physical science dropped by 7 percent during this period, and master's degrees conferred in mathematics fell 40 percent.

- In 1984-85, there were 32,307 doctoral degrees conferred. Of these, 10 percent were conferred in engineering, 9 percent going to men and 1 percent going to women. Of those who received doctoral degrees, one in every 26 (1,370) was conferred to a White man in the field of engineering, one in every 923 (35) to a Black man in the field of engineering, and one in every 367 (88) to a Hispanic man in the field of engineering. One in every 288 (112) was conferred to a White woman in the field of engineering, one in every 6,461 (five) was conferred to a Black woman in the field of engineering, and one in every 32,307 (one) was conferred to a Hispanic woman in the field of engineering.

- Forty-three percent of the enrollment in U.S. graduate schools of engineering are foreign nationals. More than half of the doctorates in engineering are awarded to students from abroad.

- Of all doctoral degrees conferred in 1984-85, 2 percent were in mathematics, with men in the field of mathematics receiving one in every 56 (581) and women receiving one in every 307 (105). One in every 106 (303) was conferred to a White man in mathematics, one in every 4,615 (seven) to a Black man, and one in every 2,019 (16) to a Hispanic man.

- One in every 468 (69) of all doctoral degrees in mathematics in 1984-85 went to a White woman and one in every 5,804 (six) was conferred on a Hispanic woman. In 1988 across the nation only four Blacks—three men and a woman—received doctorates in mathematics. In the same year, half of doctorates in mathematics and 43 percent in computer sciences were awarded to foreign students.

- Ten percent of all 1984-85 doctorates went to students in the physical sciences, with men receiving nearly 90 percent of them. One in every 16 (2,042) doctoral degrees in the physical sciences was received by a White man; one in every 1,243 (26) was received by a Black man. One in every 83 (389) of all doctoral degrees was conferred on a White woman, one in every 3,590 (nine) was conferred on a Black woman, and one in every 5,384 (six) was conferred on a Hispanic woman in the field of physical science. Foreign students were awarded 32 percent of the doctorates in physical sciences in 1988.

- The total number of jobs is projected to increase by 18 million or 15 percent between now and the year 2000, according to the Bureau of Labor Statistics. Professional specialty occupations are projected to grow more rapidly than the average for total employment through the year 2000—an increase of 24 percent is projected. This growth is due in part to the expected increase in demand for engineers and computer specialists.

To stem the projected shortage of scientists and engineers, women, minorities, and disabled individuals must be encouraged to earn three times as many bachelor's degrees and 10 times as many Ph.D.s in these fields over the next decade (The Task Force on Women..., 1988).

But according to David Reyes-Guerra, director of the Accreditation Board of Engineering and Technology, minorities are more likely to enter technician than engineering programs because the level of mathematics and science skills required is much lower (*Black Issues in Higher Education Special Report*, 1989).

A recent report by the National Science Foundation (1988) reinforces the fact that women, Blacks, and Hispanics remained underrepresented in science and engineering employment in 1986 despite the fact that their employment in those fields had increased. Women and minority underrepresentation reflects their relatively low participation in pre-college science and mathematics courses and in undergraduate and graduate science and engineering education.

The data reveal that despite a significant increase in their numbers, women scientists and engineers continue to report higher unemployment rates and lower annual salaries than their male counterparts. In addition, A fundamental concern for underrepresented minorities continues to be the quality of their pre-college experience.

It is essential that more women and minority youth become committed to technical and scientific studies since they will comprise a major part of the future work force. The largest percentage of minority and women students is found in two-year institutions. Over five million credit students are enrolled in community, technical, and junior colleges in the United States. These include the majority of first-time college freshmen.

Critically needed at the community college level is the improvement of students' scientific literacy. A concerted effort is also needed to increase interest in mathematics and science, thereby increasing the number of students majoring in science, engineering, and technology—particularly among women and minorities. Because mathematics is essential as a foundation to science studies, mathematics curriculum and teaching methodology are in need of examination and improvement.

Two California Mathematics and Science Studies

The Learning Assessment Retention Consortium's (LARC) unique 1989 study shed light on the situation. More than 11,000 ethnically diverse students from 23 California community colleges were studied to determine mathematics outcomes assessment, program evaluation, and accountability. Over half of the students in the sample were 19 years of age or younger; 21 percent were Hispanic; 11 percent Asian; 7 percent Black; and 2.5 percent Philippine American, reflecting the ethnic composition of California community college students (Learning Assessment Retention Consortium, 1989).

Five levels of mathematics courses (arithmetic skills, college arithmetic, beginning algebra, intermediate algebra, and college algebra) were assessed. For each level there were substantial skill gains, from 27 percent to 98 percent higher than corresponding pre-test scores.

A second post-test was administered, enabling a comparison of exit scores to entrance scores at the next highest level.

In relation to skills acquisition, the study indicated that "students. . . showed substantial skill gains within their pre-college remedial mathematics courses, but, on an average, not enough gain to achieve the average entrance skills at the next higher level (with the exception of the arithmetic skills to college arithmetic transition)" (p. 81). Only 32 percent of the college arithmetic students were ready for beginning algebra, only 34 percent of beginning algebra students were ready for intermediate algebra, and only 24 percent of intermediate algebra students were ready for pre-calculus.

The study also measured the proportion of students successfully completing their courses. Of the approximately 10,000 students who took the pre-test, 50 percent completed their courses successfully with a grade of A, B, or C; 19 percent were unsuccessful, receiving grades of D or F; and 31 percent did not complete their courses, having withdrawn or received a grade of incomplete.

A 17-year follow-up study of transfer science students was conducted by Skyline College, California, of the San Mateo Community College District. The study obtained feedback from former science majors in an attempt to determine academic and professional outcomes of science majors at senior institutions from fall 1969 through spring 1986. The study was designed to assess the college's ability to provide quality education and preparation for its students to compete successfully at four-year colleges.

A 23 percent response rate was received from 541 former students. The average science student at Skyline College is a 21-year-old man who completes 72 units in three years with a GPA of 3.03 (Case and Goth, 1987).

Half the respondents indicated they currently were in school and 63 percent were employed (23 percent of the employed respondents were also in school). Respondents were virtually unanimous in indicating that the strong points of science and mathematics instruction at Skyline were the commitment and accessibility of the faculty to students. Small class size also was identified as a major advantage. Laboratory classes were considered a strength because they provided training and experience in modern, well-equipped facilities.

Results of the study suggest that Skyline students were prepared for their transition—69 percent reported that their grade point averages were higher after transferring. Of the students who transferred to a senior institution, 62 percent graduated and 32 percent were undergraduates at the time of the survey. Eighty percent of all employed respondents said their job was related to their program of study. Seventy-five percent of the respondents who were not in school at the time were working in mathematics- or science-related fields.

Math and Science Trends in LACCD

A study of enrollment in mathematics and science and student interests was done by the Office of Research, Planning, and Analysis of the Los Angeles Community College District (LACCD) in January 1990. LACCD is the nation's largest community college district, encompassing one of the largest urban areas. Its enrollment of 108,228 students is 15 percent Asian, 18 percent Black, 26 percent Hispanic, and 38 percent White (Office of Research, Planning, and Analysis, 1990).

The report concluded that over the past decade, student interest in science and mathematics has climbed steadily. In the fall semester of 1979, weekly student contact hours (WSCH) in mathematics, physics, and chemistry classes were 8.9 percent of all instruction. By the fall of 1989, this proportion had increased to 13.3 percent. Because of overall enrollment declines during this period, however, the absolute number of students enrolled in mathematics and science has remained almost constant.

There are some variations in patterns of growth within this grouping. Chemistry has remained a constant proportion throughout the period at roughly 2.1 percent of all instruction. Physics rose from less than 1 percent in 1979 to a peak of 1.5 percent in 1987 and has since declined somewhat. Mathematics has seen a steady climb across the whole period, going from 6 percent of instruction in 1979 to 9.7 percent in 1989. Enrollment in transfer and intermediate-level mathematics classes as a proportion of all WSCH rose from 3.1 percent in 1979 to 5.2 percent in 1984 and then declined slightly to 4.9 percent in 1989. Enrollment in mathematics remedial and occupational classes has grown steadily from 2.9 percent of WSCH in 1979 to 4.7 percent in 1989.

Current enrollment proportions conform to student interests as measured by survey data. The spring 1989 student survey reported that 12 percent of all students had indicated that mathematics and the physical sciences are the study areas of greatest interest to them. Unfortunately, differences in questionnaire wording and the sensitivity of this item to sampling variation—due to its relationship to age and full-time enrollment status—make it impossible to use survey information to gauge change in student interest over time.

Cross-sectional analysis, however, does reveal substantial variation in mathematics and science interest by sex, ethnicity, and age. Men are more than twice as likely as women to show an interest in mathematics or physical science (17.1 percent vs. 8.2 percent). Asian students are roughly twice as likely as Black, Hispanic, or White students to be interested in mathematics or physical science. By age, interest in mathematics and physical science increases from 14.5 percent for those under 20 to 18.1 percent for those in the 20- to 24-year-old group, and then declines somewhat.

The combination of age, sex, and ethnicity variation is most interesting and revealing. For these comparisons, only full-time students will be used since they are a more consistently comparable group. Full-time Asian women under 20 indicate a mathematics-science interest almost as often as do their male counterparts (20.6 percent to 22.6 percent) and one that is higher than that of Black, Hispanic, or White men of any age group. The interest of Asian women in mathematics and science declines consistently with age, so that after age 35 only about 10 percent choose these subjects. Asian men display a high interest across the board, with the proportion of those choosing mathematics and science rising to 30.5 percent for 20- to 24-year-olds and remaining at 25 percent even for those 35 years of age or older.

The mathematics and science interest of young Black women, on the other hand, appears to be particularly lackluster. Those who are full-time students and under 20 are less than one-third as likely as their male counterparts to be interested in mathematics and science (4 percent vs. 14.2 percent). Their choice of mathematics and physical science jumps to 12.7 percent among the 20- to 24-year-olds, but then declines rapidly. For Black men, mathematics and science interest rises to 18.4 percent among the 25- to 35-year-old group and then falls.

Interest in mathematics and physical science is similar among full-time Hispanic and White students. Women of both groups are a little more than half as likely as men to indicate a mathematics and science interest (roughly 11 percent for women and 18 percent for men). Age appears to make little difference for any of these groups.

These data also cannot answer the question of what would be necessary to increase the levels of interest in these subjects. For the survey, students were asked to choose among nine different subject areas. The proportion of those selecting mathematics and science may be low because of the relative attractiveness of one of the other subject areas rather than because the student had no interest in mathematics and science. For young Black women, for example, mathematics and science interest was depressed by a high interest (50 percent) in business and office occupations.

On the other hand, the survey information does suggest that if the lower rates of interest in mathematics and science by women in general were addressed, substantial growth in the technically sophisticated work force could be achieved. Significant increases in the mathematics and science proportion of enrollment have taken place over the last decade, but considerably more could be achieved.

National Findings

A College Board analysis of high school students taking the Scholastic Aptitude Test (SAT) in 1989 revealed that the relationship between the number and type of courses students take and their performance on the SAT continues to be strong ("A College Board Analysis. . .," 1987). Students with seven or 7.5 years of study in academic courses had verbal and mathematics scores well below the national averages. However, two additional years of coursework yielded scores well above the average.

Robert Cameron, College Board research and development analyst, indicates that students who had progressed through calculus in high school had the highest SAT mathematics scores. Students who had taken other than the traditional college preparation mathematics sequence had lower than national average scores in both the verbal and mathematics exams. Fifty-five percent of those students were women.

According to the College Board study, although most ethnic groups demonstrated substantial improvement in the last 10 years, the gap between minority and majority SAT test scores is still large. According to College Board President Donald Stewart, research indicates that "score differences among ethnic groups and between men and women can be traced, in part, to wide disparities in academic preparation—or lack of it" (p. 1).

Among the SAT class of 1989, Asian American men ranked engineering first as their intended college major. All other men had engineering as a second choice. Only 3 percent of the women planned to specialize in engineering, compared to 18 percent of the men. Based on the SAT study, Asian American and Black women represent the largest percentages (6 percent and 5 percent) of all women choosing engineering as a college major. Fourteen percent of Asian American men and 10 percent of Mexican American men said they were interested in the fields of health and allied sciences.

A summary of the major findings of research on the status of natural science, mathematics, and engineering education in community colleges nationwide was completed in 1988 by Cohen. According to the study, characteristics of community college students in the natural sciences, mathematics, and engineering programs and courses reveal that women are overrepresented in the life sciences, while men are overrepresented in the physical sciences, computer sciences, engineering, technologies, and mathematics. Engineering is particularly male-dominated, with men making up 91 percent of enrollment. Furthermore, students who take science courses are somewhat more likely than students in other classes to be enrolled in nine or more units of biological sciences (79 percent), engineering (65 percent), and mathematics (64 percent) (Center for the Study of Community Colleges, 1988).

Courses without prerequisites accounted for 65 percent of the science and 79 percent of the social science enrollment at five large, urban community college districts in the study. In mathematics, 60 percent of the enrollment was in remedial classes; 25 percent in introductory college-level classes; and 14 percent in advanced classes with prerequisites.

On average, students complete 52 percent of the science courses in which they enroll. Most students enrolling in the natural sciences (53 percent) and mathematics (52 percent) do so to prepare for transfer to four-year institutions. On the other hand, 45 percent of the students enroll in engineering to prepare for new jobs while 24 percent prepare for transfer. Students in engineering technology programs generally do not enter four-year colleges.

Approximately 22 percent of all community college students who intend to earn a baccalaureate are majoring in the sciences, including computer science (6 percent), engineering (6 percent), the biological sciences (3 percent), and the physical sciences (1 percent). However, high school seniors entering community colleges in the fall of 1982 elected to major in business, humanities, or vocational studies more frequently than other discipline categories. The disciplines least elected were biological, physical, and engineering sciences.

The study reveals that between 1980 and 1987 the number of community college freshmen planning to major in mathematics remained constant while all other science majors declined: biology from 2.7 percent to 2.4 percent; physical sciences, 1.4 percent to 1.1 percent; engineering, 11.8 percent to 9.3 percent; computer sciences, 2.5 percent to 1.5 percent; and medicine, 1.5 percent to 0.9 percent.

The study further points out that 67 percent of all community college students attended part-time. Almost half of the entering students need remediation in English usage and/or mathematics. Remedial courses account for more than a third of the offerings in English and nearly half in mathematics.

Hodgkinson points out that "by knowing the nature of those coming into first grade in the United States, one can forecast with some precision what the cohort of graduating high school seniors and the entering college class will look like in 12 to 13 years" (1985, p. 10). He predicts that changes in the composition of the group moving through the educational system will change the system faster than any other factor. Given the composition and the number of the groups entering elementary schools, extensive change is needed to develop and provide effective programs and maximum educational gains at all school levels.

Some of the demographic student population changes referred to by Hodgkinson that will heavily impact the educational system in general, and science and mathematics learning in particular, include but are not limited to

- More children entering school from households in poverty
- More children entering school from single-parent households
- More children with teenage mothers
- More children whose parents are not married, now 12 of every 100 births
- More "latch-key" children
- Fewer White, middle-class, suburban children
- A continued drop in the number of minority high school graduates who apply for college
- Increased numbers of Asian American students
- Continuing high drop-out rates among Hispanics, about 40 percent of whom currently complete high school
- A major increase in part-time college students and a decline of about one million in full-time students
- A decline in the number of college graduates who pursue graduate studies in arts and sciences
- A major increase in the number of college students who need both financial and academic assistance

An effective national effort is required to increase this nation's scientific talent pool. Never before has the need for linkages been more evident. No educational delivery system can stand alone; each has a responsibility, but all levels are interdependent. Education must not stand in isolation from government, from legislation, from business, or from society's needs and its counteracting forces. Everyone must be held accountable for what does or does not take place in the schools of this nation.

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III.

FEDERAL GOVERNMENT SUPPORT FOR MATHEMATICS AND SCIENCES

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Community colleges currently receive the majority of their operating and capital outlay budget allocations from state and local governments. The total amount of such funding is determined to a great extent by the tax bases within the states. Consequently, the degree to which these governments adequately allocate the dollars necessary to fund quality programs varies from state to state. It is generally believed, however, that state and local revenues do not enable community colleges to provide the services that are needed by the communities they serve.

The federal government has played a key role in increasing the effectiveness of community colleges by initiating programs to provide economic support to students. Federally funded grants such as the Pell Grants and the Supplemental Education Opportunity Grants, as well as the Guaranteed Student Loan Program, have allowed many students to attend college. The Student Support Services Program is directed at economically disadvantaged students and those who are first in their families to attend college.

These financial aid programs are critical. However, the evolving mission of the community college requires greater financial support. Community college leaders want funding for professional development for teachers, student support programs, and mathematics and science projects, and they want a greater share of the funds distributed by the National Science Foundation (NSF).

What role is the federal government best suited to fill? While that question is posed we also need to address the question of "How can community colleges best benefit from a well-defined federal education policy?" Until some degree of consensus is reached regarding the answers to these questions, community colleges cannot maximize their ability to influence federal policy.

While the federal government has been supportive of postsecondary education in general, its impact on improving the quality of mathematics and science education has been minimized by the reorganization of some federal agencies and the erosion of its overall economic support. For example, the reorganization of the NSF and the Department of Education in 1979-80 brought the Minority Institutions Science Improvement Program into the Department of Education and effectively removed NSF from any role in undergraduate science education.

The federal government is attempting to improve the science and engineering situation. At the education summit in Charlottesville, Virginia, in October 1989, one of the performance goals was to make U.S. students first in the world in science and mathematics achievement by the year 2000. The goal shows how aware the governors and the President are of the problem, yet there has been no new federal money for any of the goals. New NSF initiatives such as the Young Scholars Program and Alliances for Minority Participation and Statewide Initiatives indicate that NSF may return to play a major role in science education. However, recent personnel changes within NSF may prevent any real progress.

The question about which federal agency or agencies will play a role in science education remains unanswered. What is clear is that every institution that has considered the subject of science and mathematics education has recommended an expanded federal role.

Unless science education is supported at the federal level, we will see results similar to the withdrawal of federal support for nursing education through the capitation grant program—a serious shortage of workers in mathematics, science, and engineering.

Two federal a; ncies have increased support for community college mathematics and science education. The Department of Energy makes grants to minority students enrolled in energy-related programs, which are generally science or engineering-related. The National Institutes of Health, a leader in promoting completion of degrees through research initiatives, faculty released time, and student stipends, has developed the Minority Access to Research Careers Program, the Minority Biomedical Research Support Program (MBRS), and the Summer Institute for Undergraduate Faculty. The National Institutes of Health has also developed a network to support students from high school through graduate school by involving the community colleges.

Decline in Interest in Mathematics and Science

The national decline in interest in science and mathematics started after the end of the post-Sputnik infusion of funds into science and engineering. The University of California—Los Angeles Cooperative Institutional Research Program's freshman surveys document the decline of interest since 1966. Interest in the biological sciences has not changed, but interest in the physical sciences and mathematics has declined significantly. The decline in interest in mathematics is alarming; among freshmen it has declined from 4.6 percent in 1966 to 0.6 percent in 1989, while interest in the physical sciences declined from 3.3 percent to 1.5 percent during the same period (Astin and others, 1988).

There will be a shortage of 400,000 scientists and 275,000 engineers by the year 2006 (Holden, 1989). Because minorities and women will make up a large part of the work force of the future, they will have to be attracted to technical careers in unprecedented numbers.

The increasing enrollment in community colleges together with the increased interest in the transfer function places the community college in the best position to attract women and minorities into science and mathematics careers. However, while enrollment expansion has created opportunities for women and minorities, it has also increased the number of at-risk students attending college. These students generally have poor backgrounds in mathematics and science and, therefore, need more nurturing and assistance. Many are the first members of their families to attend college, and they often have little knowledge of the demands of college or an understanding of career opportunities in mathematics and science. Moreover, science education has not been generally viewed as a mission of the community college. Given the severity of the crisis, however, community colleges must become involved. This increased emphasis will require additional financial support for community colleges.

National View of the Problem

The interim report of the Task Force on Women, Minorities, and the Handicapped in Science and Technology (1988) follows the 4 million high school sophomores of 1977, to the 340,000 college freshmen of 1980 with science and engineering interests, to the 206,000 graduates in 1984, to the 9,700 Ph.D. graduates anticipated in 1992. The loss at each educational juncture coincides with an increase in foreign-born graduate students. In 1986 foreign-born students represented 44 percent of the graduate engineering population and 22 percent of graduate science students, and that trend is continuing. Since the United States is a nation of immigrants, the trend may not be undesirable, but the potential brain drain must be recognized.

The task force established national goals that call for quality education from pre-K to twelfth grade to higher education. According to the task force:

> The nation should increase the number and diversity of American students graduating in science and engineering. By the year 2000, we should produce enough professionals in these fields, including more from underrepresented groups, to meet the demand for faculty and for industry and federal personnel (The Task Force on Women..., 1988, p. 32).

The task force points out that federal research and development funds influence the nation's entire science and engineering effort. Funding generates the new knowledge and employs and trains scientists and engineers. These funds should be leveraged to help develop a more diverse, world-class generation of scientific and engineering workers by the year 2000. Another task force goal calls on the entertainment industry and mass media to promote science and engineering, suggesting the need to change role models from people in the entertainment field and sports to those in science and engineering.

As former NSF Director Erich Bloch points out, it will take 20 years to bring about the improvement in pre-college education necessary to supply a solid foundation for minorities and women (Holden, 1989). Programs improving the retention of science and engineering students will give the most immediate pay-off and would probably be the earliest initiative. The retention programs would most likely be coupled with science and engineering facility improvement initiatives.

In the report of the NSF Disciplinary Workshops on Undergraduate Education, the common themes that emerged from representatives of all of the sciences, meeting as separate disciplines, were concern for the condition of undergraduate education, the need for NSF action, and specific recommendations for NSF actions. The workshop reinforced the need for assistance to the community colleges when it pointed out that "...undergraduate education, in particular the lower-division component, suffers from lack of attention, even neglect" (National Science Foundation, 1989, p. 4). Blame is placed primarily on the current emphasis on research rather than on innovative and high quality teaching. This, of course, refers to conditions at universities and four-year institutions, but it is a flawed argument. Research improves teaching, and teaching reinforces research.

Among the exemplary programs discussed in Chapter Ten, the MBRS program demonstrates the inexorable intertwining of research and teaching. To try to drive a wedge between research and teaching, or to assume that the two are mutually exclusive, is not productive. The joint recommendations for NSF actions call for expansion or initiation of assistance in laboratories, courses and curriculum, faculty development, representation of minorities and women, and pre-college preparation of students (National Science Foundation, 1989).

Only the NSF Disciplinary Workshop meetings of biologists, chemists, and computer scientists mentioned community colleges, while engineering, geosciences, mathematics, and physics workshops did not. Community college faculty members were part of the biology and mathematics workshops but did not participate in those involving chemistry, computer sciences, and physics.

Federal inactivity has resulted in some states' recognizing the shortage of scientists and engineers as it affects their ability to maintain or attract technology-based industry. In New York, the legislature has created a Collegiate Science and Technology Entry Program (C-STEP) designed to encourage the pursuit of careers in science, mathematics, or technology by bridging the gap between high school and four- or two-year colleges.

These programs can affect future shortages, but they require time to be effective. In addition to C-STEP, New York has set up a grant program that supports the acquisition and enhancement of technology-based industries in the state by linking together business and education.

Immediate attention to retention and advancement of students has a precedent in terms of private sector intervention and support for students in critical disciplines. The Ford Foundation Upper Division Scholarship Program provided $9.6 million in scholarships to 4,000 minority community college transfer students from 1971 to 1977, with the last funded cohort in 1975. The program was conceived by Fred Crossland of the Ford Foundation and was administered by the College Board under the direction of Stephen White. The College Board's final report in 1978 indicated that 3,878 students had enrolled in four-year institutions and that 63.4 percent of these students had obtained baccalaureate degrees. In follow-up surveys conducted by the Academy for Educational Development (1987), 58 percent of the graduates obtained credits beyond the bachelor's degree, and 33.6 percent obtained the master's degrees. Ninety-five percent of the graduates reported that they were the first members of their families to obtain college degrees.

Recently, inspired in part by the Ford Foundation Urban Community Colleges Transfer Opportunity Program, the National Action Council for Minorities in Engineering has become interested in a community college initiative. Seventy percent of the minority freshmen in engineering school drop out at the end of the freshman year, while 80 percent of community college transfers to engineering schools obtain degrees.

Community Colleges as Research Institutions

The following recommendation is meant to be comprehensive, affecting the institution, faculty, staff, and students. If one accepts the premise that research and scholarship are the bases for growth and success in the sciences and engineering and that hands-on experience is the best way to learn, then a comprehensive federal program must include a research experience. Wherever possible, existing federal programs should be directed toward community colleges to ease the requirement to find "new" money.

The federal government must begin to develop research capability in community colleges. The federal government will have to return to equipment support for undergraduate research and will have to include money for supplies as well as funds to reimburse the institution for released time for faculty. The institutions themselves could recover some indirect costs, which in most instances would improve the entire institutional environment. The following would be key elements in such a program:

- Faculty support to initiate research at the community college
- Support for equipment and supplies to do research at the community college
- Stipends for students to work with faculty on research projects
- Summer salaries for faculty and students to do research
- Requirements for student presentations and attendance at scientific meetings
- Peer review, publication review, and peer assistance
- Establishment of networks of research institutions to facilitate student support and transfer
- Replication of student support at the transfer institutions and continuing into graduate programs for the more capable student

- A requirement that students be tracked so that hard data would be available about the success of the program, showing where students transferred, degrees earned, and employment

The federal government has a role to play in alleviating the national shortage of professionals in science, engineering, and mathematics. Community colleges must be recognized for support by the federal government, as these two-year institutions enroll many women and minorities who are underrepresented in mathematics- and science-related fields.

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IV.

BREAKING DOWN BARRIERS FOR WOMEN AND MINORITIES IN MATHEMATICS AND SCIENCES

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Women and minorities have long been underrepresented in mathematics and science careers. Community, technical, and junior colleges may be in the best position among higher education institutions to change that.

Career choice is a complex balance of at least two major factors: one's interest in the subject and feeling of probable success based on past experiences with some or all of the career's features; and the level of comfort with the identity that the career confers, its social and economic status, and its potential for advancement.

Any profession may best be defined by the characteristics of its present participants. The traditional image of a mathematician, engineer, scientist, or medical doctor has been a white man (this image is evolving to include Asians of either sex).

A metaculture's expectations of its subcultural elements profoundly affect each individual's career choices. Although there is an American cultural paradigm that supports the value of each individual, it may only support an individual in a narrow assortment of activities and occupations. Metacultural bias can be as insidious as "gender-appropriate" choices that women are encouraged to make and as blatant as the growing number of incidents of ethnoviolence reported by the Center for the Study and Prevention of Campus Violence, Towson State University (Clay, 1989).

Students often make choices that preclude mathematics and science careers very early in life, basing them more frequently than not on cultural or subcultural messages already in place in the early grades. Choosing math or science careers is only possible if these careers have not been made unattainable by early school performance. One's capacity to choose these careers also depends heavily on the courses selected in secondary school or supportive counseling. Freedom of choice for the individual is more a national myth than a functioning reality if some critical life decisions take place before the age of 12 and others proceed from them by default.

The Problem of Gender

A historically dominant theme in most elements of American society was that women did not need to be educated, that in fact educating them was a waste of family resources. Typical families might have made sacrifices to educate their sons but usually not their daughters. The traditional role of women was to bear children and maintain family traditions and values.

While these patterns are not as clearly entrenched today, the paradigm continues consciously or unconsciously to bias the opportunity for women to be full and equal participants in the workplace. Women as a group are often perceived as having limited capacity to do analytical work, and they are frequently characterized as emotional and illogical by their male counterparts. Our code of justice, which presumes innocence until proven guilty, tends not to operate in the face of gender bias. Although the status of women has improved, the failure of a majority of states to ratify the Equal Rights Amendment suggests that substantial resistance to the concept of gender equity continues.

Myer (1980) compared the "preferred mode of using minds" in high-school-aged boys and girls. Her results indicate that intuitive and feeling functions are typically more highly developed in girls. The natural mental functioning of girls, as a group, does not suggest that they are less able than their male counterparts, but it does show them to be more sensitive to hidden expectations that society imposes on them.

Societally supported careers of choice for women, in keeping with gender expectations, are teaching from pre-school to secondary school; health occupations, especially nursing; psychology and social work; and a variety of office occupations. These careers share a strong nurturing or male-support component. Women are presently over-represented in all of these careers. An analysis of college majors reported by the National Science Board (NSB) (1989) shows that women continue to preferentially select careers in psychology and social and life sciences.

One of the deeply imbedded myths in our society is that girls are not good in mathematics. The 1981–82 National Assessment of Educational Progress (NAEP) demonstrates that mathematics and science performance levels are not different for girls and boys to the age of 11. However, during adolescence girls begin conforming to the societal expectation that they are not good at mathematics, and by age 17 they score lower than boys on the NAEP (National Center for Education Statistics, 1988). Psychology Professor Jacquelynne Eccles reports that this is self-limitation, most closely related to maternal expectations, and that real ability to solve mathematics problems is less significant than the cultural myth (O'Brien, 1988). Similar performance patterns have been found in girls who have been identified as gifted in mathematics. Significantly fewer gifted girls are identified by the fifth grade than had been identified in earlier grades, although the number of boys gifted in mathematics does not show an equivalent decline.

Survey data collected in conjunction with the NAEP (National Center for Education Statistics, 1988) for 17-year-olds and additional studies reported by Kahle (1985b) and Breakwell (1986) on 13-year-old girls show that girls do not consider careers in science because they believe it to be a male activity. Easlea (1986) reports a survey of college students that shows that all of the physical sciences were perceived as male-identified, and only the life sciences were gender neutral.

Newton (1986) reports that women who have chosen to study engineering, a traditionally male occupation, usually receive support for their choice from both parents, and especially from the father, who is typically in a technical field. Other studies have shown that there is a greater chance that girls will choose college science majors if they can identify with the attitudes and aptitudes of their science teachers. The science role model does not appear to be same-gender related but is related to non-gender-biased encouragement (Frieze, 1978; Granville, 1986; Kahle, 1985a; Smith and Erb, 1986).

Women have equal access to education in science and mathematics but often face major obstacles in making the choice for a career in a scientific, mathematical, or technical field because of the historic lack of societal support for women in these disciplines. Female colleagues and role models are relatively few and often have been handicapped by discrimination in their own careers.

Women who major in mathematics in college will commonly hold a terminal degree at the master's level. NSB statistics (1989) show that women who initially major in scientific disciplines most commonly choose and most frequently complete degrees in biology, the least male-identified of the scientific disciplines. In seeking jobs, scientifically trained women most commonly choose positions at the technician level because it allows them to "stop out" to have children and return to work at a later time with some applicable work experiences. Approaches to increasing the professional status of scientifically trained women, such as job sharing that allows women to work part-time while their children are small, are slowly gaining popularity.

Career advancement potentials for women who enter university teaching are more limited than those of their male counterparts. Women hold positions at the assistant professor level or below after they have been employed for a length of time that is required for their male counterparts to advance to associate or full professorships. Publication is a requirement for advancement in academia, and women's publications are frequently fewer than those of their male counterparts. In addition, nepotism rules have historically kept many highly qualified married women from holding university positions because their husbands were employed by the university and, short of divorce, they could not be (Chamberlain, 1988; Hornig, 1984; Matyas, 1985).

A woman choosing a technical career often risks being viewed as a second-class citizen in her chosen profession as well as in society in general. The perception of risk is a factor in maintaining the status quo and clearly limits career choices for women.

The Problem of Race or Culture

American culture has developed from predominantly Eurocentric roots. Eurocentric values place emphasis on objectivity and individual achievement. Group membership and individual status are established by competition. Black, Native American, Asian, and Hispanic cultures, while not alike in other ways, share a relational cultural heritage. Group membership and status in relational cultures are based on cooperation and contribution to an extended family or community unit. Competition, when it is valued in a relational culture, is at a group level rather than between individuals. Asians are an example of a relational culture that competes well on a group level. Asians presently have twice the percentage of representation in college populations as they have in high school populations (Hoachlander and Brown, 1989).

Children from relational home cultures may experience culture shock when they start school. School culture emphasizes the individual and fosters competition between individuals. It expects greater self-regulation and self-motivation than is typical of many relational cultures. Early childhood experiences of minority children, based on the values of their home cultures, may not include all of the experiences on which the school culture bases its expectations. Pre-school programs and the Head Start program are designed to bridge this gap, but only a small percentage of children participate in these programs. Head Start serves only about 30 percent of eligible children, and pre-schools are only available to families who can afford them.

Children from relational cultures do not define themselves as independent of others. One can but wonder if the reported over-representation of Hispanic and Black children in classes for slow learners does not reflect the difference between home culture and school culture more than it reflects native ability.

The NAEP consistently shows that Hispanic and Black students score below White students in mathematics and science in the primary and elementary grades (Mullis and Jenkins, 1988; National Center for Education Statistics, 1988). Low socioeconomic status, without respect to ethnicity, has also been identified as contributing to substantially lowered performance. Students who start out at a lower performance level may progress at the same rate as all other students, but they never catch up. Minority students do, in fact, progress at a rate equivalent to that of White students on the NAEP until high school, when their percentage gain falls off. Reduced percentage gain at the high school level may be a result of course selection and/or counseling minority students away from a college preparatory curriculum. Numerous reports show that minority students continue to accumulate disadvantages as they progress through school. The sum of these accumulated disadvantages limits or eliminates the possibility of a scientific or technical career because of a lack of mastery of prerequisite knowledge and skills and because of a lack of opportunity for a student to identify these areas as having the potential to be personally rewarding.

When school is not a place of success and acceptance, it becomes a negative environment for children. Attitudes that have been identified in high school drop-outs also have been shown to be present in children as early as in the primary grades. With each transition in school, from primary to elementary to middle school, high school, and college, minority students have a difficult time adjusting to the new environment. With each transition the child moves further from the norm of a relational culture and is increasingly required to assimilate the premises of the Eurocentric model, focused on competition and individual achievement. Society tends to discount or sidetrack those individuals who do not conform to expectations even when, as is currently the case in some large urban school districts, they become the majority. Urban high school drop-out rates for minorities are said to be in excess of 50 percent, and this figure is deceptively low. The figure would be even higher, were it not for the fact that many transient children disappear unnoticed before they even start high school.

Too many minority students do not complete high school and those who do frequently have academic deficiencies that have to be corrected before they can begin college-level work. Minorities who have attained advanced degrees are actively sought by employers in both the public and private sector, but employment and advancement are not necessarily concomitant. The attainment of professional status is as much a factor of networking for minorities as it is for women, and the limits imposed are just as great. College graduation does not in itself lead to employment, as can be attested to by the reported 81,000 college-educated, unemployed Blacks in 1987 (Holmes, 1988). It is not possible to maintain the myth that education has the power to change the socioeconomic status of minorities when minority unemployment rates continue to be excessive.

Lowering Barriers for Minorities and Women

The future of our technological society, based on science and mathematics, is integrally linked to our society and its institutions becoming truly multicultural. The challenge of creating a multicultural educational system has to do with methodological changes, but it also has deep roots in human dignity. The future requires that we come to respect all people and cultures and provide the opportunity for each person to develop in both cognitive and affective domains.

Without effective strategies for intervention that lower barriers and encourage a broader variety of students to enter careers in mathematics, science, and applied technologies, the new work force that will be needed for the year 2000 and beyond simply will not be present. This new work force is projected to be composed largely of women and minorities in addition to immigrants. If they are to become the future work force, both educational and social barriers must be addressed in new ways.

The potential for reducing barriers in mathematics and science while enhancing the school experience by incorporating computers into the educational environment is profound. The computer can be programmed to simulate and model events, and it can be used for individualized tutoring, teaching computer programming and other labor-saving applications. However, Alexander (1987) surveyed the national status of computer use in public education. He found that current usage patterns could lead to the kind of historic gender and minority inequities that have plagued our educational system. There are few safeguards to assure that equity is being monitored or considered.

A number of authors have raised questions about software promoting the kind of bias that disenfranchises the traditionally disenfranchised. In California, where computer literacy is assessed along with general educational prog. ɔs, boys show consistently higher achievement in both the sixth and twelfth grades (Fetler, 1985). Gender equity is a concern with this new tool, but concern should also be expressed for equity for all ethnic backgrounds and all levels of socioeconomic status. Computer access and use can be a very powerful tool for equity, but can also produce a new kind of inequity that may be even more disabling than historic forms.

There are no intrinsic cultural or gender barriers to prevent students from benefiting from computer use in the classroom. The computer has been used to enhance academic performance of girls and all ethnic minorities in mathematics, but the way in which this tool is used and the values that it presents through software will undoubtedly determine its continuing educational value. Children take to computers readily, and research on computer-aided instruction has established that students will spend more time on task with a computer than with more traditional methods of presentation.

Changes are also needed in mathematics teaching to make mathematics skills attainable for more students. The National Research Council speaks to the issue, stating:

> Competition and individualism, ingrained parts of traditional American culture, are reflected in typical mathematics courses where students work alone to solve problem sets. Other cultures, including many which are now a growing part of the American scene, stress teamwork and group problem solving. To the extent that mathematics instruction in the United States continues to stress individualism and competition over cooperation and teamwork, to that extent we continue to introduce unnecessary counterproductive practices for many in our multicultural nation (1989, p. 76).

Martin's (1988) research compares competitive, cooperative, and group competitive teaching strategies in mathematics and has demonstrated that students who perform well in a competitive environment perform equally well in a cooperative one, but that students who do not do well in a competitive environment are more successful in a cooperative or group competitive one.

Teacher-centered methods are currently the most commonly or exclusively used for delivery of mathematics instruction. However, teacher-centered methods are the weakest tools for helping students develop mathematical schema concepts, which each student must construct in order to solve problems. If student success is to be improved, methods must provide an opportunity for students to engage the problem-solving process. If fewer problems are worked by the teacher and more group methods are used, the level of student involvement in problem solving increases.

In adult mathematics instruction, and presumably at any age, small group problem solving or pairs problem solving, which encourages students to talk each other through problems, more directly engages students in developing their mathematics skills. Too often the teacher works solutions but does not provide a model of the decisions that have to be made in the problem-solving process. If mathematics instruction becomes a matter of teacher coaching rather than attempting to impose a specific problem-solving strategy, the greater is the probability that students will arrive at the appropriate strategy for problem solving.

Facilitating improvements in science performance seems to be most closely related to providing more hands-on experience for students and to utilizing a multi-media approach to presenting information. Another pervasive factor is the level at which the student identifies with the attitudes and aptitudes of the teacher. Teachers who are able to create a linkage between themselves and their students help students to recognize their potential for satisfaction and success in the sciences.

The *Science Report Card* (Mullis and Jenkins, 1988) and numerous other studies illustrate a substantial deficiency in the amount of hands-on experience that students receive in elementary school. These experimental omissions are especially handicapping for minority and female students. At all levels of science education, the emphasis needs to be on direct experience of the process and methods of science. Although the history of science is based on the efforts of individuals to discover underlying principles of nature, science has evolved away from the lone researcher and is now based more on the efforts of a research team. Methods of teaching science should reflect the way that higher levels of science are currently being performed.

In college-level science, as in earlier educational levels, the hands-on component is critical to understanding the material. The recently released *Report on NSF Disciplinary Workshops on Undergraduate Education* (National Science Foundation, 1989) identifies the laboratory as the most critical element of instruction and decries the encyclopedic nature of textbooks being produced. The report further identifies that introductory courses in each discipline are the ones most in need of critical review and revision, while laboratory portions of the courses should incorporate new technology (computers and computer-based monitoring) and provide more open-ended experiences. The report calls for science faculty to teach less detail with more challenging experiences that create a sense of excitement about the subject.

In order for minority and female students to choose careers in mathematics, science, and applied technologies, which represent nontraditional occupations for both groups, there must be more than just an improvement in teaching strategies and methods. One of the strongest components in encouraging students to pursue these career areas has been the establishment of mentoring systems and peer networks. A number of projects have demonstrated that a personal support system is a critical element in sustaining interest and progress.

A promising family education model can be found in the National Urban Coalition's YES program in Washington, D.C. and Houston, which focuses on K-6 students and their families. YES is a Saturday program that allows participants, from grandparents to small children, to explore hands-on topics in mathematics and science. Resident academic summer camp programs that provide enrichment activities to extend the mathematics, science, and computer skills of middle school and high school students have been successful in getting students to continue their education and have contributed to their success in college.

Summer bridge programs that bring high school students into college and, with scholarship or work-study support, allow them to take college classes, do research, or prepare for SAT tests are currently being provided by many colleges across the country. Some programs are for gifted students, others for underprepared students, and a few include both. The Dubois Program in New Jersey is a variation that teaches Black culture and leadership skills to gifted Black students.

The Future

The community, technical, or junior college is uniquely placed in the structure of national public education to take a leadership role in increasing the access to careers in science and mathematics for minorities and women. Community colleges are open-entry institutions and are the most common starting point for these groups in higher education. These colleges provide courses that are equivalent to those that students generally do not take in high school, as well as college courses that transfer to four-year institutions. Most community colleges have developmental programs to increase basic skills in reading, mathematics, writing, and science. Of equal importance are the diversity of community colleges' student populations and the lower cost per credit hour.

In addition to the coursework that community colleges can provide directly, they have a unique capacity to establish working partnerships with the public schools to jointly provide new opportunities for students. Through partnerships, some or all of the early "acquired disadvantages" can be reduced. Proactive projects aimed at academic enrichment in elementary and secondary education are as important as developmental education for adults and will increase in importance if their effectiveness is demonstrated.

The future of minorities and women in mathematics and science may be brighter today than it has been in the past, if for no other reason than that we are specifically and deeply concerned about their participation. This concern, if translated to proactive curriculum revision focused to remove barriers and to provide support systems, can produce both a better-informed citizenry and a number of new professionals by the end of this century. It is not sufficient merely to improve either the academic side or the support system, because both are critical for the successful participation of the more relational members of our society in these less humanistically based disciplines. Where choice is involved, human needs have to be addressed. In the case of women and minorities, a large part of that need is for a sense of full membership in scientific and mathematical communities.

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V.
THE URBAN CLIMATE AND STRATEGIES FOR INTERVENTION

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The crisis in mathematics and science offers community colleges a challenge as well as a unique opportunity to provide leadership during this crucial period in which the nation's economic well-being and, some say, ir very existence are threatened. Urban community colleges must not only provide instructional services for students from diverse backgrounds and with varying levels of preparation, but they must also address the issue of women and minority underrepresentation in mathematics and the sciences.

New intervention strategies to improve mathematics and science education must be identified. Strategies should kindle and heighten interest within our students, including those who show little or no interest in these subjects. Educators, business professionals, and political leaders must work together to create programs to support all students, beginning in elementary school, through secondary school, and on to college completion. These graduates will become the nation's next generation of scientists, engineers, and teachers.

Jobs and professions in our cities are changing from manufacturing and heavy industry to information, high-tech, and service occupations. As it has in the past the responsibility for developing the human potential of our cities will rest with the urban community college. But in the future, college programs will need greater structure, with heavy emphasis on mathematics, science, and technology. Universities will continue to provide access to the highly prepared urban high school graduate, but with elevated admission standards and high tuition costs, the "in doors" will be shut to those less-prepared, especially the nontraditional older student looking for high-tech retraining. Minorities and women, who for a variety of reasons have not developed mathematics and science skills, will become a forgotten, unemployed majority unless the community colleges create programs to support, reinforce, and develop their potential.

In a remarkable shift in the 1980s, businesses and industries moved back to urban locations from the suburbs. Corporate leaders found economic benefits in such moves through reduced taxation, proximity to institutional resources, and an unlimited employment pool. This shift places demands on the urban community to provide businesses and industries with workers who are trained with technical skills. Universities will have the responsibility of training professionals for upper-level employment, but the urban community college must train the less well-prepared students for entry into the technical work force. High-tech industries such as biotechnology, telecommunications, computer information systems, and health sciences will demand technician-level employees with well-developed mathematics and science skills.

But community colleges can't be expected to do it all. The poor mathematics preparation of high school graduates, with many needing extensive remedial work in arithmetic and algebra, is ample proof that the crisis in mathematics and science occurs long before students enter the community college. A 1986 Ford Foundation report underlined the seriousness of the dilemma facing our education system, finding that approximately 90 percent of all entering students required some form of remedial mathematics education (Richardson and Bender, 1986). A number of internal and external factors have contributed to the mathematics-science crisis.

Internal Factors: Students and the Community

The characteristics of its students and the community it serves determine much of the nature and program structure of the urban community college. Colleges must constantly assess and monitor their community needs so that they can provide programs, especially in science and mathematics, that meet student academic and employment needs.

At the Community College of Baltimore, minority students are highly represented (making up 71 percent of total enrollment), while surrounding suburban community colleges are comprised of only 16 percent minority students (Maryland State Board for Community Colleges, 1989). A majority of the women enrolled in college are attending community colleges (Hunt, Thomas, and Sears, 1980). In California, minority students constitute 36 percent of the enrollment in all of the colleges in the system (Chancellor's Office, 1985).

The mean age of urban community college students indicates that many students are entering with special mathematics and science learning needs. For example, the mean age of the Maryland community college student population is 27 years (Maryland State Board for Community Colleges, 1989). Many of these students come to the community college for retraining and have large gaps in their educational backgrounds. Their lack of recent educational experience presents great problems to mathematics and science teachers, and special programs are often necessary to teach mathematics and science skills never acquired or to reinstate those lost through years of neglect.

As community colleges approach maturity (30-plus years), a second internal factor also precipitates the mathematics-science crisis: aging facilities and antiquated laboratories. A National Science Board report (1986) states that two-year institutions in the United States are beset by serious deficiencies in the amount and condition of apparatus and equipment. These deficiencies certainly affect curricula in introductory science and mathematics courses, which are the base for developing prospective science and mathematics majors.

In California, for example, 40 percent of all lecture and science laboratory facilities and 42 percent of support facilities are 20 years old. Studies of equipment show that 67 percent are seriously out-of-date, with only 4 percent considered "state-of-the-art" (Chancellor's Office, 1985).

The Community College of Baltimore suffers from the same aging process, with total equipment assets placing it in the lower third of all state community colleges (Maryland State Board for Community Colleges, 1989). Aging laboratories and less than adequate supplies and equipment might also contribute to the low enrollments in natural science, engineering transfer, and computer science programs. Less than 10 percent of all Maryland students elect natural sciences, engineering, and computer science as programs of study (Maryland State Board for Community Colleges, 1989).

The underrepresentation of minority faculty in urban community colleges is also not conducive to the future development of minority scientists and technicians. In Maryland, community college faculties are presently comprised of 90 percent White and 10 percent minority professors. While minority students enrolled in Maryland's community college system exceed 17 percent, the Community College of Baltimore has a 71 percent minority enrollment (Maryland State Board for Community Colleges, 1989). This disparity jeopardizes the educational process since not enough minority faculty are available to serve as role models and mentors for these students.

At present, it doesn't appear that the situation will get better, since the number of prospective minority faculty in the pipeline is low. Blacks earned fewer advanced degrees in 1985 than in 1977, and the number of master's degrees awarded to Blacks was down 34 percent in 1985 (Linthicum, 1989). This phenomenon is even more acute in mathematics and science. Of all the doctorates awarded in mathematics in 1988, only 7 percent went to minority men and women (Leary, 1989).

Teachers themselves might serve as barriers to achievement in science and mathematics due to low standards set for student performance. Many yardsticks are needed to measure effective teaching; however, academic preparation and the ability to present material in a challenging and enthusiastic way cannot be overlooked. Community colleges have a reputation for excellence in teaching due to their receptivity and commitment to satisfying specific student needs. Nevertheless, from time to time students complain about boring lectures, insensitive and unapproachable teachers, and the academic preparation of their teachers. Community colleges must never be guilty of not challenging students in mathematics and science, nor should they be guilty of not advising students into advanced courses in science and mathematics. President Bush supports the idea that if schools are to improve, we must demand higher academic standards for our students and for our parents, teachers, and principals.

Along with the decline in academic preparation of incoming urban community college students, other internal factors also heighten the mathematics-science crisis. Most urban public school students lose interest in studying mathematics and science beginning in junior high school. From the eighth grade on, the number of students taking mathematics decreased by one half for each year of schooling, resulting in fewer and fewer students taking courses important for technical careers (Leary, 1989). In secondary schools, many students do not see the need to study mathematics, or they lose interest and consequently shut themselves off from many careers that demand mathematical skills.

A 1987 survey by the Arkansas Department of Education found that in the state's high schools, Blacks were significantly underrepresented in mathematics beyond Algebra I and in college preparatory science courses (Wavering and Watson, 1987). Furthermore, the survey found that minority students typically take courses in general mathematics and physical science to fulfill requirements for graduation. Unfortunately, these courses do little to enhance mathematics and science preparation.

Current instructional methodology and curricular design in our public schools do little to stimulate study in science and mathematics. In 1986 William Bennett, then Secretary of Education, criticized instructional practices in our schools:

> In three major studies, the National Science Foundation found that most science education follows the traditional practice: "At all grade levels, the predominant method of teaching was recitation (discussion) with the teacher in control, supplementing the lesson with new information (lecturing). The key to the information and basis for reading assignments was the textbook." If science is presented like this, is it any wonder that children's natural curiosity about their physical world turns into boredom by the time they leave grade school—and into dangerous ignorance later on? (Bennett, 1986, p. 27).

While community colleges need to examine their curricula and instructional techniques to ensure that students are prepared to make the transition to college work, encouragement and support for the study of mathematics and science must begin in the public schools.

Only 13 percent of incoming high school students were encouraged by teachers and counselors to take science and mathematics courses in public schools. This small percentage is particularly distressing since students who take more high school science achieve greater success in courses at community colleges (Friedlander, 1981).

The lack of science development in our urban youth begins at an early age. Even though Blacks and Hispanics have shown gains in science proficiency in the past nine years, they are still four years behind their White counterparts. Two-thirds of third-grade students spend less than two hours per week on science study, and the majority of students are not getting experience with hands-on science (Mullins and Jenkins, 1988).

External Factors Influencing the Mathematics-Science Crisis

Urban students are confronted with a number of external factors that hinder their mathematics and science development. These students are typically from lower socioeconomic groups, and there are many cultural and social factors that provide negative reinforcement for scholarship, especially in the areas of mathematics and science. Probably no other factor has greater effect than that of attrition and nonattendance. Whatever the reason, be it early marriage, jobs for family support, or teenage pregnancy, if students do not stay in school, their development will be severely hampered. Minority drop-out rates exceeded 25 percent in a 1987 study (National Science Foundation, 1987).

Parental involvement and the family can have a positive effect on mathematics and science achievement (Mullins and Jenkins, 1988). Time spent in conversation about school significantly influences student success, as does the provision of books and instructional materials. Yet, many urban students are not getting this educational support in the home. Similarly, many urban students do not get parental and family support for considering postsecondary study, and many do not see science or mathematics as important in their educational and occupational futures (National Academy of Science, 1987).

Popular culture, in the form of television, also serves as a detractor from achievement in mathematics and science. Students do not see scientists or mathematicians portrayed in positive roles; they see high technology presented as either evil or laughable. This must have an effect on children not selecting science or mathematics careers (Task Force on Women..., 1988). Television viewing has been shown to be a negative influence on science achievement. Students viewing six hours per day have significantly lower achievement scores in science aptitude (Mullis and Jenkins, 1988).

Interventions for Development and Recovery

Cities and their educational institutions must make a commitment to the development of their human resources, not just for today, but also for tomorrow. Solving the problem of training our people for the high technology of the future does not rest in past academic dogma, but requires a commitment to making logical interventions that will lead to the healthy development of our institutions and our students.

Monaghan (1989) pointed to the global aspect needed to solve our education problems:

> To maintain our country's economic position in an increasingly competitive world, to contribute to the solution of our own domestic problems, and because it is right, we must bring the best, at all levels of education, to all of our citizens (p. A-26).

Urban community colleges can initiate solutions to the mathematics-science crisis since they already have structures and relationships that will expedite the process. Community colleges by their very commitment to undergraduate education can provide the resources necessary to intervene with a diversity of programs.

Bridge programs and 2+2 articulations are already in place and with expansion could supply the early support to secondary students to encourage their persistence in the study of science and mathematics. Most community colleges also have extensive developmental programs in science and mathematics that could be used to support teachers and students in public education.

Community colleges also have been leaders in developing relationships with businesses and corporations for vocational and technical programs. These relationships could be further developed to create pipelines from the junior high schools to secondary schools and on to community colleges for entry into the high-tech work force. The National Science Foundation has recognized the need for financial support of community colleges and has developed recommendations for improving mathematics and science education that will further the community college's ability to address and solve the problem.

For urban minority students to succeed in higher education, they must have access to certain basic components that will ensure their success:

- Early intervention in the public schools to strengthen preparation
- Summer "bridge" programs to accustom minority students to college-level coursework
- Special orientation programs
- Tailored financial aid programs
- Strong academic assessment programs coupled with courses to offset gaps in preparation
- Adequate tutoring services and learning laboratories (Richardson, 1989)

In spite of tight budgetary constraints, urban community colleges must find fiscal resources for the intervention strategies that will solve the mathematics-science crisis. The first strategy includes faculty development, recruitment, and minority representation. Government and institutional programs must be instituted to upgrade professors in urban community colleges. Programs that involve professors in mathematics, science, computer science, technologies with current advancements, and innovative instructional methodologies can ensure that we have the best of the best teaching our urban students. Faculty members must be sensitive to the special needs of their students and should not imitate the style or methods of teaching that most have been exposed to in their education.

Although little research exists that specifically relates to community colleges, several recent studies offer some bright spots. The work of John Roueche and George Baker at the University of Texas at Austin recognizes the unique community college structure, its leaders, and its curricula, and the National Institute for Staff and Organizational Development and the Community College Leadership Program are collecting baseline data. From this beginning, new programs might be developed that could focus on training professors and administrators specifically for community colleges. As recommended in many states, community colleges could develop programs in collaboration with universities to increase the pool of professors. Such a collaborative program might begin in the community college with transfer to a five-year B.A./M.A. program at the university that would also include a year's teaching internship. Articulation with the university for the doctorate would add another dimension.

The development of minority faculty in mathematics and science also needs to be given top priority. Some states have already initiated programs to accomplish this goal, using both short- and long-term strategies. Minority fellowships, summer programs, alliances with Black professional organizations, faculty exchanges, minority job banks, and high school programs are just a few programs needed to increase the numbers of minority faculty in the pipeline.

Colleges need to develop and restructure curricula and instructional design to ensure recruitment and retention in mathematics and science programs. Students must not get turned off early by didactic and irrelevant instruction, but must be involved creatively with their courses and see them as preparation for life experiences and vocations. Traditional instruction must be improved, and new strategies must involve students in study that meets the following criteria: it is competency-based; the courseload is controlled for less-prepared students; and science instruction is integrated with developmental education (Friedlander, 1981).

Teachers, according to Finster (1988), must understand the developmental level of students and involve them with critical thinking exercises, instead of just amassing information. He suggests that good science teaching must challenge the way students think while at the same time providing them with mental and emotional tools to resolve the dilemmas they face.

Researchers believe we are doing a disservice to our less-well-prepared urban science and mathematics students by setting only minimal levels of competence for mathematics and science. Students should be given mathematics problems that challenge the upper level of their competence. This challenge should be followed with instructional strategies that include working in teams, prep time for teachers, and guidance in student personnel interaction (Dancis, 1988).

Urban students need exposure early in life to hands-on exploring and questioning in science, along with learning experiences that maintain a balance between challenge and frustration (Gordon and others, 1986). Outreach programs initiated by urban community colleges must encourage reform in public schools in science and mathematics instruction.

Outreach to secondary schools must also be considered a strategy for intervention to solve the mathematics-science crisis. Whether programs are termed tech-prep, public school articulation, alliances, or collaboration, all must address the issues involved with urban community colleges developing supportive programs with public education. Many universities also have initiated summer programs for high school minorities to attract them to the science and engineering professions (Gordon and others, 1986).

The Ford Foundation has been instrumental in establishing collaborations in 11 cities to bring together high school mathematics teachers with professional mathematicians from higher education and industry. These collaborative efforts enhance the training of public educators in mathematics by involving them in workshops, symposia, and curriculum projects (Romberg and others, 1987). A model for high school and community college articulation that has been structured in Sacramento might be used by other community colleges throughout the nation (Wellsfry and Rosen, 1986).

Outreach activities initiated by community colleges must be expanded and further developed to involve parents, the corporate community, public educators, and state and local governments. Students must not be lost from mathematics and science study early in their educational careers, and only collaborative efforts will ensure that they are not.

All involved with mathematics and science education must ask: Are we accomplishing enough intervention to save the patient? The answer is obvious since many of the end products of our efforts in mathematics and science education are still not where we wish them to be. We must persist in our support for programs to develop faculty, improve instruction, and reinforce outreach. There must be more energy and directed concern for solving this crisis situation in our community colleges.

Burnham (1981) underlined just how important solving this crisis is:

> Without a greater concern for meeting the future head-on in a systematic, comprehensive, humane, and serious manner, contact with the real world and our children and future well-being could be lost (p. 7).

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VI.
MATHEMATICS AND SCIENCE CRISIS: IMPLICATIONS FOR EDUCATIONAL LEADERS OF URBAN COMMUNITY COLLEGES

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Our nation's leadership in science and mathematics is at the heart of the country's economic strength, its national security, and the cultural heritage of its people as explorers and innovators. While the U.S. science and technology enterprise still leads the world, we are losing ground consistently. Moreover, there is no national agenda to reverse the gradual decline.

Vital and challenging questions, however, are being raised that will address our search for ways to make incremental improvements in areas critical to our national economy. The following questions are crucial:

- How will the national needs for science and technology be satisfied for this last decade of the 20th century and beyond?

- Who will produce the higher skills required for most occupations, particularly those that are growing the fastest? Of all the new jobs expected in the 1990s, over half of them will require some education beyond high school, and almost a third will be filled by college graduates.

The answer to both of these questions will be determined by the nature of the contributions made by America's community, technical, and junior colleges. The leaders of these two-year institutions will, to a great extent, shape the quality of their contributions. As has been the case with other postsecondary institution leaders, the urban community college leaders have embraced the mathematics-science crisis in rhetoric and action. Since there is no comprehensive plan to meet the demand for skilled workers, community college leaders are working with business leaders to provide the technical talent that they need to compete. In spite of these collaborative efforts, we need to do more.

Government officials acknowledge the immediate need to improve the quality of education and training of future workers, but also claim that budget pressures prevent an adequate response. In a speech before the Council of Scientific Society Presidents on December 6, 1988, Secretary of Education Lauro Cavazos presented a somber perspective:

> Students in this country are not learning much about science and mathematics. In science, our best high school students—those students who are going on to college, for example—ranked near the bottom of students in 13 countries in chemistry and in physics. In biology, my own field, they were last.
>
> . . . our students don't stack up in international comparisons, nor do they learn much that they can absorb in absolute terms. Fewer than half of them appear to know enough about science to perform jobs that require technical skills or to benefit substantially from specialized, on-the-job training. Fewer than half seem to be adequately prepared in science for informed participation in the nation's civic affairs (1989. p. 108).

The severe underrepresentation of Blacks, Puerto Ricans, Mexican Americans, Native Americans, and women in science- and mathematics-based careers has been documented in many reports and publications.

There are indications that the underrepresentation of this large segment of the U.S. population is a clear threat to the nation's world leadership in the development of sophisticated technology. The need for science and technology manpower, as well as the need for public school, college, and university teachers in those disciplines, can only be met if the United States uses all available human resources. Women and minorities constitute a significant and virtually untapped manpower resource. Therefore, increasing the number of minority scientists, mathematicians, and engineers will greatly enhance the nation's ability to meet future manpower needs.

Call for Leadership from Urban Community College Presidents

It appears we never learn from history. When the Soviet Union put the first Sputnik in orbit, there was an outcry concerning our public schools' mathematics and science programs. The outcry resulted in a national commitment to improvement. Today's setting has many of the same features that were prevalent during the late 1950s.

Additionally, many of the nation's problems require innovative and creative solutions. Since diversity has an enriching effect, the efforts of individuals with varying views and perspectives are more likely to lead to a comprehensive approach to solving complex scientific and technological problems. When one considers improving the human condition, careers in science, mathematics, and engineering are among the most fulfilling and the most lucrative of professions. In a democratic society, all citizens should have an equal opportunity to pursue careers of their choice and to enhance their quality of life by participating in the top professions.

In nearly all of his public presentations, Secretary Cavazos highlights this disturbing trend in our nation:

> Just as there are major education deficits, as relates to science and mathematics, affecting all students regardless of ethnicity, it is more critical for the nation's ethnic minorities. When compared with Anglo juniors in high school, only half as many Black and Hispanic juniors can perform junior-high-level tasks in mathematics, such as calculating the area of a rectangle. The ethnic gap is even wider in science. Only about half of the Anglo juniors can evaluate experiments, interpret text and graphs, and understand basic principles of physical concepts, but fewer than 15 percent of Black students or Hispanic students can do these same things (1989, p. 109).

Something must be done about this alarming dilemma. The approaches must start with a national focus; however, there is a pressing need for a heightened level of educational leadership from all sectors of education. Collaboration is an imperative.

The noted writer Carl Sagan underscores the problem and adds an additional critical dimension: passion and interest on the part of our youth.

> All over America there are smart, even gifted, people who have a built-in passion for science. But that passion is unrequited (1989, p. 43).

He cogently argues from the same pulpit as Cavazos:

> We live in a society exquisitely dependent on science and technology, in which hardly anyone knows anything about science and technology. This is a clear prescription for disaster. It is dangerous and stupid for us to remain ignorant about global warming...or ozone depletion, toxic and radioactive wastes, acid rain. Jobs and wages depend on science and technology. If the United States can manufacture, at high quality and low price, products people want to buy, then industries will drift out of the United States and transfer a little prosperity to another part of the world. Because of the low birth rate in the '60s and '70s, the National Science Foundation projects a shortage of nearly a million professional scientists and engineers by 2010 (p. 44).

Issues of social welfare, national security, and social justice are also introduced by Sagan with the somber question: Where will the needed scientists come from? He asks

> What about fusion, supercomputers, abortion, massive reductions in strategic weapons, addiction, high-resolution TV, airline and airport safety, food additives, animal rights, superconductivity, Midgetman vs. rail-garrison MX missiles, going to Mars, finding cures for AIDS and cancer? How can we decide national policy if we don't understand the underlying issues (p. 44)?

As educators we must articulate the premise that science is much more than a body of knowledge. It is a way of thinking, which is critical to its success. Science invites us to let the facts in. It causes us to consider alternatives. Science also results in the most rigorous, skeptical scrutiny of new ideas as well as established wisdom. As educators our task is not just to train and prepare more scientists, but also to deepen public understanding of science.

Jacquelynne Eccles, professor of psychology at the University of Colorado at Boulder, has conducted interesting research that seeks to provide answers to the question of the gross underrepresentation of women in the sciences. Her research places a major share of the responsibility for the "science gender gap" at the feet of parents. Her studies, coupled with similar studies by Lauren Solzniak of the University of Chicago and Marcia Linn of the University of California at

Berkeley, point to girls being discouraged from pursuing technical studies and, subsequently, technical careers. The research data reveal that girls suffer from a lack of belief in their own ability to perform well in the arena of science and mathematics.

The Rev. Jesse Jackson supports the view of Sagan and the researchers when he argues for "cultivating an appetite for learning." It is his view that the forces of environment are not exclusively to blame for the current disturbing trends. Citing past practices and trends in the pre-integration era, he cites personal instances where, in an environment of lowly circumstances but high expectations, meager supplies but brilliant hopes, his desire to learn was cultivated. This is a major challenge for the educational system of this nation, as well as for the parents of our youth.

Outreach Programs

The state of Texas is acutely aware of the problems associated with the paucity of students pursuing studies and careers in science and technology. Procedures were started two years ago to test incoming college students through the Texas Academic Skills Program, so that they could be identified and placed in remedial courses to bring them up to college level. Yet, that is not enough. There is a resounding call throughout the state for more and earlier intervention.

Community college leaders are asserting that the task must start earlier if we are to graduate more students capable of working in the technological fields of the future. Three areas are identified where institutions of higher learning can help public education and in turn help themselves: reducing the drop-out rate; getting more minorities into college; and recruiting more students into science fields.

In each of these areas a window of opportunity exists for the leaders of urban community colleges. Outreach programs at the high school, middle school, and elementary school levels represent a level of involvement ideally suited for institutions that already have linkages with the public education sector.

A number of Texas institutions have established outreach programs for high school students. One of the most ambitious is the Youth Opportunities Unlimited program, which brings 1,800 minority students to 14 college campuses each summer. Students who have displayed ability but who are considered potential drop-outs participate in a work-study program in which they are taught study and career-planning skills.

The University of North Texas also has pioneered the two-year-old Texas Academy of Mathematics and Science, where gifted students can simultaneously finish the last two years of high school and the first two years of college. The current class has 163 students. Statewide support is needed to help this program reach its projected student body of 400.

It is strongly recommended in Texas that all colleges and universities be held accountable by their governing boards to increase their contacts with public school students and introduce them to the wonders of college and university science laboratories. State legislators are boldly asserting that it is time to get out of the ivory tower and get more Texas youngsters into college in general and into science fields in particular. They further argue that this effort should start in the middle school years and should include minority students who are currently underrepresented in Texas colleges and universities. The encouraging aspect of this development in Texas is that the clarion cry is coming from educational leaders as well as public officials.

The Dallas County Community College District has a program, now in its fourth year, whereby each of the seven colleges has "adopted" a middle school in its respective service area. During the current year, this adoption program has moved to a new level. The district's central city campus, El Centro College, has adopted a largely Hispanic area high school. The thrust of the partnership is to foster an interest in pursuing a college education, thereby deterring drop-outs.

In a collaborative effort with the Dallas Urban League and the Sequoyah Educational Center, El Centro College has begun the second year of the Young Scholars Exploration College. Through funding from the Borden Foundation, El Centro College provided an intensive laboratory-based summer program for 24 Black and Hispanic fourth- and fifth-grade students on the college campus. The students were selected for the program by the science coordinator at the Sequoyah Educational Center, who served as one of the program's instructors. The program, designed to cultivate the study of science by students who had already demonstrated interest and ability, featured a variety of field trips. With increased funding, the second year of the program has been expanded to include third-grade students, bringing the total number of participants to 35.

Texas Christian University, in collaboration with the Fort Worth Independent School District, implemented a week-long Junior University program last year. The initial grant of $25,000 was funded by the Aetna Foundation in Hartford, Connecticut. According to Richard Wachenreuter, program officer of the Aetna Foundation, the early intervention program was designed to increase the college-going rate of minority students. Aetna worked with The College Board's regional office in Austin, which chose Fort Worth as the prototype school district for the program. As a result of the early success of the program, the Aetna Foundation is providing $220,000 for five more programs across the country, including $30,000 for Fort Worth.

The Young Scholars Exploration College program is also part of a national thrust. The Borden Foundation initiated the "Borden Ten Cities Program" in 1988, which provided $10,000 to an educational institution through the auspices of the local Urban League affiliate in each of the 10 cities where the Borden Corporation has a manufacturing unit.

Junior University and Young Scholars Exploration College try to blitz the youngsters with a mind-set that says, "College is right for me." The question is not "Are you going to college?" but "*Where* are you going to college?"

While both programs involved external funding and the use of a college unit to implement the program, each of the educational institutions found it necessary to provide resources to meet the program's objectives. This is a clear implication for institutions who seek to engage in such outreach activities. There is the further implication of the need for a variety of organizations to be involved in such projects in the future, from a funding standpoint.

During the 1987-88 academic year, Springfield Technical Community College, Massachusetts, initiated the Mentorship, Experimentation, and Tutoring Resources for Increasing Competence in Science (METRICS) program in cooperation with the Springfield Public Schools. METRICS attracted 88 students from four Springfield junior high schools in its first year. The program was designed to be an after-school science club for 12 to 15 students at each junior high school to work on science projects with a club adviser for four hours per week during the school year.

Funding for the program was provided by the Springfield Public Schools with the stipulation that METRICS be available to gifted and talented students with an emphasis on girls and minorities. The coordinator of the METRICS program reported that the program was successful in its first year. Evaluation from participating college faculty, club advisers, and parents indicated an overwhelming sense of satisfaction with the program. The commitment on the part of students to participate in an after-school program is a definite indication that there is an interest in science.

Although there has not been the level and intensity of involvement at the National Science Foundation with community colleges or non-research colleges equal to the involvement with research universities, small strides are being made. National Science and Technology Week (NSTW) is the Foundation's most visible effort to reach young students. Each spring NSTW activities bring the wonders of science and technology to thousands of students, their teachers, and their parents.

The personal involvement of a senior official of the National Science Foundation in a unique, one-man Christmas show also speaks well of the agency. For 20 years Bassam Z. Shakhashiri has ushered in the Christmas season with a literal bang. His annual Christmas show, called "Once Upon a Christmas Cheery in the Lab of Shakhashiri," has captivated audiences of up to 600 youths and their parents with demonstrations of "the beauty, the magic, and the adventure" of science, often using ordinary household chemicals found in vinegar, laundry detergent, and disposable diapers.

Shakhashiri, who is a chemistry professor at the University of Wisconsin at Madison and on leave as assistant director of the National Science Foundation, borrowed the idea for the Christmas show from Michael Faraday, the great English chemist and physicist whose Christmas science lectures for children were popular in the 1840s.

In a recent interview, Shakhashiri acknowledged that he is simply trying to share the excitement and joy of hands-on science. His idea is not to overwhelm the young people, but to capture their interest and to fuel their flame of curiosity.

He is disturbed by an NSF estimate that the United States faces a cumulative shortfall of 450,000 native-born college graduates with bachelor's degrees in science, mathematics, and engineering by the year 2000 and a projected shortage of 8,000 scientists with doctorates by 2004. The interest and involvement of a senior official of the National Science Foundation could and should have a positive effect on a national science policy involving the community college.

Future Implications

The demand for increased human resources in science and mathematics has never been greater. The present picture does not inspire confidence. National support for science has rarely been more uncertain than it is today. Among the unanswered questions:

- What is the nation's commitment to science?
- What is our national research plan or strategy?
- What is the nation's plan to attract and cultivate a greater level of involvement on the part of minorities and women in science and mathematics?

The answers to these questions are not as clear as they were 30 or 40 years ago. To bring science back to its proper place in society, we need to bring society back to science. We need a national plan and we need priorities, all of which are developed in conjunction with the key players in the education community. We need clearly articulated goals for science, technology, and education so that American citizens can see that they have a stake in the outcomes. We need to set our fundamental national priorities as they relate to science in the realm of public policy debate and decision making. We are at a critical point in the development of science in this country. The demand for scientific resources has never been greater. The need for results—both scientific and economic—has never been more pressing. The national leadership has never been more lacking. And the role of urban community college leaders in the process of creating a new national consensus has never been more pivotal than it is today.

As part of the national consensus forum, community college leaders can follow the example of Robert Bottoms, president of DePauw University. Bottoms argues that a solution to the undersupply problem is to seek aid from different places. Two years ago he and 47 other presidents of highly competitive liberal arts colleges met at Oberlin College. They discovered that many Ph.D.s from the small research universities did their undergraduate work at small liberal arts schools. He and his colleagues found that at one Midwestern state university there were more Ph.D. candidates in chemistry than undergraduate majors in chemistry.

That finding was significant for two reasons: First, industry and the National Science Foundation have tended to focus on the research institutions, neglecting the contributions of the liberal arts colleges or the role of community colleges in directing high-achieving students to upper-division institutions. Second, while the large universities, with 200 or 300 students in a single class taught by a graduate student, can do an adequate job of teaching to committed students, it is hard for such schools to get young people interested in science or to maintain their interest in science.

Urban community colleges have the potential to improve the quality of life in cities and provide equality of opportunity for their residents, but there is the need for greater coordination and an infusion of governmental and private resources. As efforts are directed to creating a greater level of interest in science and mathematics on the part of minorities and women, the reality is that the urban two-year institution represents the best hope for a generation of Americans that has virtually no other opportunity for education, training, and economic and social survival.

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VII.
MATHEMATICS-SCIENCE PROFESSORS IN COMMUNITY COLLEGES

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As serious and threatening as the U.S. decline in mathematics and the sciences already is, unless effective corrective measures are begun immediately, the situation is going to get considerably worse. At a time when rapidly accelerating technology in almost all fields of employment cries out for increasing technical competence in the work force, a number of different factors, including demographics and lack of interest on the part of American students in pursuing careers in mathematics and the sciences, has resulted in fewer and fewer qualified people to meet the increasing skills needs.

Community college physics teachers were told at the 1989 American Association of Physics Teachers (AAPT) meeting that if all current trends remain essentially the same, this nation will face a shortage of approximately 700,000 scientists and engineers at the outset of the next century. And, as distressing as that prediction may be, it still is but a part of an even greater concern: the problem could become self-perpetuating and increasingly more severe as our already scant supply of well-qualified mathematics and science teachers is further diminished when good teachers retire or leave the profession for lucrative jobs in business and industry.

While the impact of this exodus will be felt at all levels of education, it will probably most severely impact community colleges and secondary schools, where a large pool of relatively poorly paid, postbaccalaureate degree graduates are employed. The "brain drain" on this level of the education system would be catastrophic, affecting not only this generation of students but the next as well, because they would be taught by teachers who may be less qualified. There will be a shortage of teachers even if there were corrective strategies in place right now to solve the problem.

To further compound the problem, our youth have been turned off by the study of science as early as the third grade, and mathematics follows shortly thereafter. The growing shortage of teachers in the sciences and mathematics will exacerbate the problem, as our youth become increasingly disenchanted by subjects presented by teachers who lack the background to deliver meaningful learning experiences. Where are we to get future teachers, let alone the scientists and engineers, who will be needed to solve the problems of increasing population, decreasing natural resources, conservation, and water and air pollution?

Technological changes have led the way for societal changes throughout history. If we are to continue to advance as a society, we must become more scientifically and mathematically literate. We must be knowledgeable enough about the factors that affect our well-being to see and understand the direction in which we are going and to make the necessary corrections to insure our survival. We have chosen in this country a system of education that aspires to bring all of its people up to a level of literacy that will help them, as an educated and informed electorate, to have input on the direction the country chooses to take. We agree that this is the appropriate course of action, but we seem unwilling to assign adequate resources to reach this lofty goal.

What role should the community college play in addressing and trying to solve this problem? Nationally 51 percent of all first-time freshmen college students are in community colleges. Twenty-two percent of the community college population are minorities, and over 50 percent are women. The average age of the community college student is 28.

Traditionally, the White male population has been the primary source of entrants in science and mathematics careers, but it is neither desirable nor feasible to continue this trend. The minority population in this country is increasing, as is the number of people needed for scientific endeavors. It is clear that we can no longer rely on a decreasing segment of the population to supply us with the scientists and engineers of the future. To meet this need, we must, therefore, recruit heavily from the large pool of minorities and women who attend community colleges.

It is also clear that the majority of our student population nationwide is underprepared, for a variety of reasons, to pursue a course of study leading to degrees in mathematics, science, or engineering. How then should we deal with this dichotomy? First of all, we in the community college must more clearly define our role in the educational process, and we should focus primarily on two areas. Because of the number of students we serve, we must play the major role in increasing the scientific literacy of our population. Furthermore, we must play a major role in developing future educators in the sciences and mathematics. We can do this by

- Reaching out to junior and senior high school students, especially those in urban areas, to introduce them to potential careers in the fields of science and mathematics

- Developing curricula to support underprepared students so that they will be able to achieve a level of scientific and numerical literacy that will enable them to pursue careers in private industry or continue their education at a transfer institution

The community college's programs should not be clones of the four-year institution's programs, but must be designed to meet the needs of the community college student. Emphasis on learning and competency should be stressed, not transferability of credit. Greater emphasis must be placed on achieving a level of understanding of the material presented and less emphasis on how long it takes. For example, if it takes three semesters to effectively cover physics with calculus, then so be it. What does it matter that such a course of study receives 10, 11, or 12 credits, other than as a bookkeeping tool?

One ingredient that is often overlooked in any prescription to cure what ails our educational process is teacher effectiveness. While great technological advances have been made in areas outside education, those that are most often employed in the educational community are designed primarily to reduce the burden of grading for the teacher. At the recent AAPT conference for community colleges, a physics teacher from a large community college explained a process in which it was not necessary for him to assess his students' performances in labs. The student simply went to the computer and took a short test that was graded by the computer, and the score was entered in the student's record. When asked about how the teacher assessed the students' ability to express in writing what they had done, he said that he gave an essay question on each of his tests.

The mimeograph machine was a great breakthrough for teachers, enabling them to prepare hand-outs for students and making their grading task easier. Unfortunately, it also relieved students of the responsibility of writing the problem or statement in their own format. They no longer had to decide how to best express the problem. Machine-grading technology has made it possible for teachers to expose more students to material, but are they really teaching better? Machine grading and larger class sizes do not facilitate better teaching. The further removed we as teachers become from our students, the easier it is not to face up to our responsibility to educate them. It is too easy to blame students when they can't answer a series of "simple" multiple-choice questions, because we have documented that they are unable to recall these simple facts.

What we do not, or refuse to, recognize is that the classes are boring and learning is not taking place. Mathematics and science faculty can easily fall into this trap since our subjects are quantifiable and do not deal in opinion.

We in the teaching community, especially at the urban community college level, must be able to relate what we teach to the real world. Our students, most of them underprepared, have not been exposed to the mathematical and scientific relationships that govern our environment and, ultimately, govern us. All too often, we are trying to show the student how to shoe a horse without ever looking at a horse. Can it be that we teach this way because we don't know what a horse looks like either? Unfortunately, most of our students do not possess the formal reasoning skills needed to study science in the abstract.

Formal reasoning is an acquired skill gained from exposure to growth-oriented education, an educational system in which one is called upon to discover and learn. Therefore, our educational process must be one of growth for students and not just a rite of passage to be endured until they reach the age where they can leave school and go to work.

Students themselves must discover the laws of nature. We cannot force them to learn these laws; we can only provide them with the opportunity to form the relationships, both scientific and social, that will help continue their growth outside the classroom.

However, this is not an easy task. It requires more preparation and a higher level of teacher competence and confidence. Therefore, teachers employed at the urban community college should be the best. They face the greatest challenge, and the economic future of our country may depend on how well they succeed in preparing students to function in the 21st century. The task is made even more difficult because of the shortage of qualified teachers and increased class sizes that this shortage necessitates. We must recruit and support highly qualified teachers to work in this environment. Then we must continually search for new approaches to meet the needs of the underprepared student, and we need to limit the number of students in the classroom, even though smaller classes alone are not the answer.

We as teachers must develop new techniques to be used in class. In order to do this, we must be afforded the time to teach without having to sacrifice the quality of current instruction. We must develop more efficient as well as more effective means of presenting our material. Greater use of the computer and peer tutors in entry-level pre-college courses provide only a partial answer to the remediation workload. Technology alone is also not the answer. We have laboratory equipment that would astonish researchers of only two decades ago, but the concepts to be illustrated are often clouded in mystery as the student deals with the complexity of the equipment. For example, the computer can take the data from a scientific experiment, perform the calculations, and plot the graph for the student. It is often argued that these tasks are mundane, so why should we waste time doing them? And yet, we decry our population's inability to evaluate even the simplest set of information. As teachers, we must guard against our fascination with technology and make sure we use it to enhance understanding and not just to make our jobs easier.

The final and most important aspect necessary to bring about a change in our educational system is for us to have the will. Our problems have been a long time in coming, and they cannot be solved by a quick fix. We need to do many things:

- We have a shortage of technically educated people in all walks of life. This problem will persist until becoming (and remaining) a teacher in these fields is seen as a financially, intellectually, and socially rewarding career. To begin to solve the problem, we need qualified teachers and we need them in the classrooms now. We can reduce this immediate need by recruiting those who are ending their careers in industry or in the military and who have experience in technical fields. Their previous experiences will lend credibility to their teaching.

- We should develop more programs on state and national levels that will fund scholarship opportunities for those interested in teaching careers. Such financial incentives could be in the form of student loans, which would not need to be repaid if the student served as a teacher in mathematics or in the sciences for a period of five years.

- Recruiting efforts should begin in junior high school, much the same as we now do for athletics. There isn't a major college coach in the nation who doesn't know who his potential recruits are by the tenth grade, regardless of the sport. Shouldn't we be as interested in the students who will mold the future in the sciences?

- Every analysis of the problem of scientific literacy specifies that we need to devote more time to hands-on learning. However, most high school laboratories are generally poorly equipped, and the exposure is limited to only one period per exercise. The laboratory experience at the community college is seen as less demanding and, therefore, less valuable, from a financial standpoint, for the teachers involved. It is universally accepted in postsecondary education that laboratory hours are worth less credit for both the teacher and the student. Why, then, should a student take courses and a teacher teach in a situation in which they receive credit for one-half the time spent in class? Instead, they will be more inclined to pursue a program of study in which they receive one credit for every one hour spent in class per week per term. Short-sighted though it may be, their focus is on credit received, rather than learning achieved.

- Curriculum development should be undertaken at the state level, with representatives from each level of the education system participating. They should use the outcomes of several of the recent national and state studies, as well as input from national scientific and mathematics professional associations. Their tasks should be to develop a model and implementation strategies, not to study the studies. We are well aware of the problem; we know of the impending shortages. Short-range and long-range planning are needed. As an example, we probably do not need additional laboratory facilities unless we have people in the teaching pipelines to work in them. Buildings don't teach; people do. Limited funding by all levels of government requires us to be efficient in both planning and utilization.

This state-level task force should also take a long look at textbooks. Education in science and mathematics is a growth process, but growth is not achieved by forcing the student to remember a collection of unrelated or seemingly unrelated facts.

Textbooks should foster that growth and not impede it. This provision is almost nonexistent today. *Project 2061*, sponsored by the American Association for the Advancement of Science, in its assessment of the current situation, made the following observation about science textbooks and methods of instruction that are often tied to the textbook: "The present science textbooks and methods of instruction, far from helping, often actually impede progress toward scientific literacy" (1989, p. 14).

Where do we go from here? We who are teaching at the urban community college must make every effort to interest our students in taking a well-rounded course of study that includes mathematics and the sciences, including laboratory experiences. Furthermore, we must try to stress the importance of scientific literacy in our modern society to all students. And most importantly, we must become the most influential source of quality future educators. We need minorities and women with strong education backgrounds to enter the teaching profession. They are beginning their college education with us, and it is up to us to become a positive influence on their future.

If we are to be a positive influence, we must make our product viable, interesting, useful, and understandable. Then we must do the best job we know how to do to prepare our students for success.

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VIII.
MANDATE FOR ACTION

BY FRANK CERRATO

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The American educational system has the potential to improve the general public's scientific literacy as well as to educate competent science and engineering professionals; however, necessary educational reforms implemented during this decade will have a profound impact on our future technological, scientific, and economic competitiveness.

Currently the pipeline of teachers to educate future scientists and engineers is drying up. The education system is underfunded, and demographic trends predict a dramatic change in the profile of new workers by the year 2000. Furthermore, the scientific literacy of the general public needs to be improved. A large number of students are dropping out or passing through the educational system unprepared or underprepared to make the successful transition to college. They lack the skills required for most occupations in our high-tech society.

Notwithstanding the reforms that have been initiated during the last five years to cope with these challenges, it is clear that a high tech and increasingly international economy will require continued restructuring of our educational system. Educational leaders must look for new strategies within and among educational institutions, as well as for joint, mutually beneficial ventures with private industry and government.

Can the urban community college implement reforms that will complement a mandate for change? The answer unequivocally is yes. Urban community colleges are in a unique position to reach out to the community because of their location and comprehensive curriculum.

To be effective, the urban community colleges must provide programs consistent with their mission and not let their fiber be torn by conflicting interest groups. Cooperative efforts must extend into the elementary schools to increase student interest in education. Urban colleges must provide instruction for teacher preparation and enrichment, as well as restructure curriculum to improve mathematical and scientific literacy. They must work with the private sector to encourage political leaders to provide the funds necessary to renovate and build needed facilities in their service areas.

Community college leaders must also assume the responsibility for developing programs that will produce graduates who become productive employees upon entering the job market. To assure the effectiveness of these programs, college leaders need to provide the necessary support services, including counseling, job placement, tutorial, and enabler programs.

Effective mathematics and science programs are needed now more than ever to develop the interdisciplinary thinking process that students must have to act as independently functioning choice makers. Literacy is also needed in these critical areas if one is to work and vote effectively in today's society. Consequently, the nation has come to a crossroads at which the education system must respond to a national mandate for change.

Mandate for Action

1. *Critical to any effective change within our educational system is the establishment of a national educational policy based upon a grass-roots consensus.* An educational "consortium" should provide implementation and evaluation strategies within geographic areas. The consortium should not exist to further analyze or define the problem, but rather to function as an action group with broad goals, reasonable timelines, and specific objectives.

The consortium must include community, political, and business leaders as well as public and private educators from all levels of education. The responsibilities of the consortium would include but not be limited to the following:

- Developing an agenda for improving the quality of mathematics and science education
- Recognizing and rewarding excellence in teaching
- Restructuring curriculum to emphasize mathematics and science in K-12
- Strengthening mathematics, science, and technical education in community colleges
- Establishing linkages between and among educational institutions to prevent isolation of teachers and projects
- Recommending minimum standards for each discipline at each educational level—elementary, secondary, and postsecondary
- Encouraging funding for teacher preparation and professional development
- Developing summer institutes for high school students
- Recommending the allocation of federal funds based upon need and ability to impact change

2. *Increasing the allocation of National Science Foundation (NSF) funds to community, technical, and junior colleges by*

- Broadening NSF program eligibility requirements to include community colleges
- Encouraging joint ventures between two-year and four-year institutions
- Providing funds for laboratory equipment, curriculum development, and research

3. *Improving the scientific literacy of the general public by*

- Developing an understanding and an appreciation of scientific research
- Educating the portion of the American population that is not literate in science

We also recommend the following:

Improving Scientists' Image. Scientists must work to improve the public's understanding of and appreciation for their disciplines. A portion of the general public lacks an understanding of the value of what scientists do and is skeptical of their motives.

Faculty Cooperation. Community college faculty in the biological and physical sciences as well as in mathematics must meet periodically to discuss student preparation and curriculum reform.

Demographic Monitors. There must be continuous monitoring and evaluation of demographic trends and their implications on a declining scientific and engineering work force.

Competitive Salaries. School boards and local, state, and federal governments must work together to make teachers' salaries competitive with the private sector. While this should be accomplished across the board for all academic disciplines, it is imperative in the "hard-to-hire" areas of mathematics and the sciences. The economic impact of living in particular geographic areas should also be a factor; state and federal governments must contribute funds to alleviate the discrepancies between rich and poor districts.

Hiring of Competent Teachers. Leaders at all levels of education must be made aware of the importance of mathematics and science education in the curriculum. They must hire mathematics and science faculty who are competent in these disciplines.

Child Care Service. Providing child care is not a panacea, but the lack of child care is a significant factor in the high drop-out rate at all levels of education. All levels of government and the private sector must become partners with school systems in a national program to provide child care for working parents. This is especially necessary for the urban community colleges, which enroll a great number of single parents.

Intensive Programs in Remedial Education. While our mandate has not changed, a significant part of the community we serve has. The community colleges are seeing greater numbers of students who have never studied. The remedial courses we offer were designed for the traditional "late bloomer," not the student buffeted by the negative distractions of the urban community—drugs, teenage pregnancy, early drop-out, and poverty.

Leaders in education must provide support for special programs to meet the needs of all students unprepared and underprepared for college work. Programs with federal and private funding must be developed and supported with the following objectives: increasing the number of student contact hours; depending heavily on tutors; incorporating how-to-study sessions and study groups; and including career counselors.

Administrators must recognize and be committed to intensive remedial programs that require reduced teaching loads and instructional assistance.

Governance. Each state must re-evaluate its role in the governance of its community colleges. In some states, such as California, where the majority of the operational funds that support community colleges comes from the state, a transfer of governance to the state level should be considered. Outcomes of this change would be to set competitive salaries and criteria for hiring, to establish a standard curriculum, to develop intensive programs in remedial education, to institute innovative faculty development programs, and to remove political influence from local boards.

Resources. The funds to support urban community college programs must come from the public and private sectors. Federal and state governments must support the urban community colleges with grants for specific proposals and with general funds for the colleges to improve their faculty and facilities. G ant funding for specific proposals must have some guarantee of continuance. If funds are granted to start a program or to cover costs for only a year or two, no matter how successful the program is, it will die. It sho::ld be the responsibility of the community college administration to review and evaluate programs to recommend the successful ones for permanent funding.

The private sector must be encouraged to increasingly involve itself in special project grants for students and faculty and for general grants to upgrade obsolete equipment. An excellent example of special funding from industry is the Math Bridge Project at City College of San Francisco funded by Pacific Telesis. This program is designed to increase the number of Black and Hispanic students in mathematics courses who transfer to a university system.

Innovative Programs in Mathematics and Science fo. Faculty Development. The federal government, possibly through the National Science Foundation, must reinstate programs to stimulate and improve instruction in the mathematics-science area. An organization is needed to serve as a clearinghouse of ideas—a national umbrella organization that will support innovative programs, evaluate them, and publish the results of both successful and unsuccessful efforts. It is essential that educators know what's being tried, what's working, what's not working, and what's considered a success.

Innovative Programs—the Private Sector. The private sector has and must continue to provide direction by pointing out the trends in industry that influence community college course content. Programs should be developed whereby private sector representatives receive company-paid released time not only to contribute to curriculum development, but also to instruct or retrain faculty.

The community colleges can strengthen their ties to the private sector by offering special courses designed to upgrade employees of a particular business. Reciprocally, the private sector can provide part-time, on-the-job training and scholarships to encourage continuing education. The more colleges that can link their students to business, the better the students' chances for success.

Linkages with Schools and Universities. Community colleges must reach out to their colleagues in the elementary and secondary schools to achieve a smooth transition through all levels of the educational system. Likewise, the community colleges must articulate their programs with universities to insure, through student follow-up, that their courses are preparing their students not only to enter, but also to succeed at the university level. An across-the-board cooperative effort in the development and coordination of curriculum will facilitate students' passage from one level of education to another.

Another special problem for the urban community college is the number of students from all over the world who enroll to begin or to continue their education. Urban colleges should develop methods of evaluating their past work to insure a smooth transition from the community college to the university system.

Community colleges can only be viewed as one vital part of the entire education system beginning with elementary school and ending with graduate school. As pointed out in 1989 by the National Research Council in *Everybody Counts—A Report to the Nation on the Future of Mathematics Education*, all major components of the educational system—curriculum, teaching, and the assessment of human resources—must be considered as a whole. This cooperative effort of government, education, and business identifies problems, charts a general course for the future, and outlines a national strategy for pursuing that course.

This is the ideal for a long-range solution and the goal we must strive for.

IX.
NEEDED: AN APPLIED ACADEMICS PROGRAM

BY DALE PARNELL

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There are at least four substantial enemies of excellence in the modern school and college mathematics and science curriculum. First, we have allowed the college-prep/baccalaureate-degree curriculum to be the one and only definition of excellence in education. Second, we have allowed the curriculum to become disconnected from real-life issues. The teaching and learning process in formal education is often accomplished outside the context of situations, activities, and real-life problems. Individuals learn best when they are taught in a context of application. Third, scant attention has been given in education to the subject of continuity in learning. American schools and colleges have become a collection of disjointed parts that fail to connect. Fourth, little attention has been given, in defining educational excellence, to the pressing dilemma of how to meet the great range of individual differences among students.

A college-prep/baccalaureate-degree math and science curriculum is certainly the road to excellence for many individuals, and our schools and colleges must help these students prepare for this direction in life better than ever before. Indeed, community colleges are actively pursuing programs to encourage and motivate more community college students to press on to the baccalaureate degree. But educators at all levels must constantly be reminded that the majority of the population will never earn a collegiate-level baccalaureate degree. What about the nonbaccalaureate degree students? What kind of math and science can schools and colleges offer them? These students want and need an excellent education, but one that is applicable to their talents and future. Is the educational crisis of the year 2000 being created today by continuing to insist on one definition of excellence and insist that one kind of educational program be applicable to all students?

Certainly students need more substance and structure in their school and college programs, but do they all need the same dose of theoretical math and science subject matter? This philosophy has motivated other educational leaders into making statements about the quality of education by using the Scholastic Aptitude Test (SAT) as the basis for value judgments, despite the admonitions of the College Board that SAT scores are not to be used to judge the quality of a school. It is a simple fact of life that when "C" students begin taking the SATs, as an increasing number of students have been doing over the past decade, the national average will go down. Based solely upon SAT scores it would be easy to improve math and science education by simply controlling who takes the tests.

No longer can we speak of the liberal arts versus the practical arts as though we live and learn in separate worlds. The students of the future will require both. Have we failed to match in any systematic way the goals of schooling with the real-life needs of individuals living in a knowledge-rich but application-poor society? Young people of today require first-rate mathematics and science curricular alternatives that will prepare them for that next step after high school—whether that step is toward work, an associate degree, or a baccalaureate degree. The learning age demands more quality educational alternatives, and students desperately must understand the "why," or the context, of learning.

A casual observer of math and science instruction in American schools and colleges might conclude that educational excellence can only be achieved by making a majority of students feel like failures unable to cope with modern life. Anything less than a theoretical approach to math and science is viewed as second-rate. Few of the national educational reform studies provide workable solutions to the problem outlined 30 years ago by John W. Gardner (1984 [1961]):

> The importance of education is not limited to the higher orders of talent. A complex society is dependent every hour of every day upon the capacity of its people at every level to read and write, to make difficult judgments, and to act in the light of extensive information.... When there isn't a many-leveled base of trained talent on which to build, modern social and economic developments are simply impossible. And if that base were to disappear suddenly in any complex society, the whole intricate interlocking mechanism would grind to a halt.

The National Commission on Excellence in Education (1983) states our present dilemma in this straightforward way:

> More and more young people emerge from high school ready neither for college nor for work. This predicament becomes more acute as the knowledge base continues its rapid expansion, the number of traditional jobs shrinks, and new jobs demand greater sophistication and preparation.

There is a considerable body of research indicating that people learn best when they are taught in the context of real life issues. Contextual learning as carried out in an applied academics program provides meaning for students and therefore the motivation to learn. The mismatch between what students learn in school and the application of learning has contributed greatly to the poor performance of many students.

Cognitive science research is discovering that intelligence and competence are developed out of the interaction between obtaining knowledge and the application of knowledge. This notion challenges some of the time-honored shibboleths and distinctions in education:

- Head and hand distinctions
- Academic vs. vocational distinctions
- Knowing and doing distinctions
- Education vs. training distinctions
- Theoretical vs. applied knowledge distinctions

Some 535 delegates, including 43 ministers of education, representing 121 countries gathered in 1988 in Geneva, Switzerland under the sponsorship of UNESCO to consider the subject "Diversification of Postsecondary Education in Relation To Employment." The conference participants concluded that postsecondary education in most countries lacks a sufficiently practical focus. These officials voiced great concern that education, in too many instances, does not help students understand the real-life applications of their learning. Shiv Shanker, minister of human resource development in India, observed that in many parts of the world there is a wide chasm between education and the need for it in the world of work.

William Raspberry, columnist for the *Washington Post*, comments in a graphic way about this problem:

> Add one more thing to the list of awful things we are doing to our young people. We are teaching them contempt for manual labor.... We teach all our children as though we expect them to go to college and train for the professions.... We count it an insult to suggest to our children that they might think of a career as an electrician or a plumber or a transmission specialist—not because these jobs don't pay enough (anyone who's had to have his car or his pipes fixed knows better) but because they lack prestige.... And we wonder why so many of them are wasting their lives as small-time hustlers or else killing themselves at such an alarming rate by trafficking in drugs (1984).

When will we learn in this country that we must meet the educational needs of the neglected majority (75 percent in most places) of students who are not likely to earn a college baccalaureate degree? If the sole purpose of math and science education is to prepare students for college baccalaureate degrees and graduate studies, our educational system is a failure by design, leaving the majority of students unprepared for the good technician-level jobs of the future, or even the next step in education.

A few math and science educators are recognizing and enhancing the talents of those students who will be working with their hands as well as their heads. But more, much more must be accomplished. Part of the answer lies in developing first-rate applied academics math and science programs, combining technical education with applied communication, applied physics, applied math, applied biochemistry, and the like. Such programs—drawing upon the shared resources of high schools, community colleges, and industry—can help develop to a higher level a much needed world-class work force in the United States.

Although "learning to know" and "learning to do" in math and science instruction are too often separated, there is little long-lasting learning or understanding without connecting the two. When classroom learning becomes detached from meaningful context, learning becomes only a process of learning rules and isolated facts. The student who experiences an educational program enabling him or her to see the connectedness of things will have an advantage over others.

William Aldridge, executive director of the National Science Teachers Association, comments on the classical subject-by-subject approach to teaching science and the need to better coordinate subject matter learning by helping students understand the connectedness of things:

> The fundamental problem with high school biology, chemistry, and physics courses is that they are not coordinated, are highly abstract and theoretical, do not spend enough time on each subject, and do not use correct pedagogy. In short, we never give students the chance to understand science.... Most people are able to learn physics, chemistry, biology, geology, and other related subjects. People can learn how these subjects apply to their lives and to society's problems. If we teach science to all students in a coordinated way from the concrete to the abstract, with practical applications, our future citizens will be more evidence-oriented. They will know how and when to ask questions, how to think critically, and then how to be able to make important decisions based on reason rather than on emotion or superstition. Science made understandable and accessible to all will also mean more and better scientists and engineers—and a different mix among them, including larger numbers of underrepresented groups such as women and minorities (1989).

One of the disappointing aspects of the major reports on educational reform is the scant attention given to continuity in learning. It is amazing that some students learn as much as they do, given the tremendous gaps in the substance of their learning as a result of irregular class attendance and substantial breaks in learning. There is a close correlation between a loss of continuity in learning and poor grades. In fact, irregular class attendance is an early signal of course failure and eventual dropping out of the school or college. High-school principals report that poor student attendance continues to remain one of the key problems affecting the quality of education in their schools. Yet, this subject has not received much attention in the reform reports. In 1982 the National Center for Education Statistics, on behalf of the National Commission on Excellence, asked 571 school districts which policies or procedures were most important for improving academic achievement. Increased daily class attendance and improved continuity in learning were listed as most important by 66 percent of the sample and 90 percent of the urban school districts.

It is a fairly safe bet that overall student achievement test scores in math and science would improve dramatically in most schools if student attendance patterns improved. On the skill-acquiring levels, continuity in learning is extremely important. If the student misses one or two basic steps, the next steps become increasingly difficult to negotiate. As a consequence, one out of three or more students is constantly endeavoring to catch up. It is sad that most of these students spend the rest of their lives attempting to catch up and never really do.

Fred Hechinger, long-time observer of the American educational scene, has commented on the loss of continuity in learning:

> We are not very good at continuity...as a result of that, American education during the past few decades has become a collection of disjointed parts that in the main fail to connect.... The lack of continuity that plagues American education is something that all of education needs to address. Instead of connecting the separate levels, critics generally compound the spirit of separation by seeking scapegoats instead of remedies.... If we want to reform the schools, two things are essential: continuity, all the way up the line; and understanding the "why" of every single course. Read Bruno Bettelheim on that. Whatever you teach, make the children understand why they are studying it. Don't tell them: "You'll need it later." Later doesn't exist (1984).

There are other important facets to the problem of continuity in learning in math and science education. America is a mobile society, and that very mobility has contributed to a tremendous loss of continuity in learning. An estimated 20 to 30 percent of public school students attend more than one school each year and experience a consequent loss of continuity. Schools by and large operate on the basis of local control and local autonomy. Consequently, the transient student rarely experiences the same curriculum in any two schools. Basically, the American school system still operates as a cottage industry. From school to school, or college to college, instructors approach the curriculum differently and use different textbooks. The student is thrown into a new and often strange environment with a new teacher or teachers and a different curriculum, and told to sink or swim. The teacher will do his or her best to help, but with an abundance of other students needing help he or she has little time to devote to individualized learning. The loss of learning continuity in a highly mobile society remains a significant barrier to achieving excellence in math and science education.

Other gaps cause loss of continuity in learning. How about the gap between high schools and colleges? For some students this gap must seem like the Grand Canyon, rather than a gentle dip. A chasm also exists between high-school and college math and science faculty. Some of this distance can be attributed to structure, which inhibits communication. High school instructors talk with high school instructors, community college instructors talk with community college instructors, and university instructors talk with university instructors. It is only through much effort that the educational communication lines are crossed up and down the ranks.

Unlike European systems, which operate with a central ministry of education, the American education system is highly decentralized. There are 14,140 independent school districts and 1,222 dependent school districts (subject to the fiscal control of county or city government) across America. Responsibility for the actual operation of the schools has been delegated by the various states to local school districts, except Hawaii, which has one statewide school system.

There are 1,211 public and private two-year community, technical, and junior colleges, 1,992 public and private four-year colleges and universities, and an estimated 6,000 proprietary (private) career schools. The private colleges operate in a largely autonomous manner. The public two- and four-year colleges operate under local boards of trustees, as a part of a state university system, or as an independent state system operating one segment of colleges. In addition to that institutional fragmentation, many have observed that there is no organism on earth more autonomous than a professor in a major university. As a consequence of this highly decentralized educational structure, communication among and between the various entities and personnel involved becomes exceedingly difficult. Special efforts are required to improve communication among math and science educators and to improve continuity in learning at all levels of education.

The large challenge facing math and science instructors in secondary schools, and to a significant degree in open-door community colleges, is how to meet the great range of individual differences in every classroom. In desperation, schools have labeled students bluebirds, robins, and meadowlarks, or advanced, terminal, and remedial, and they are still missing the mark.

If we are to become serious about meeting that great range of individual differences in open-door high schools and community colleges, instead of permitting half our students to slip through the "general education" crack, we must cultivate goal-oriented programs to match the diversity of the student body. But educators cannot hope to develop such an appropriate educational diversity unless educational excellence is redefined. We must reject the idea that math and science curricular excellence can be found only in certain university-oriented programs.

John Gardner has distilled some of our best thoughts on the varieties of excellence:

> Though we must make enormous concessions to individual differences in aptitude, we may properly expect that every form of education be such as to stretch the individual to the utmost of his potentialities. And we must expect each student to strive for excellence in terms of the kind of excellence that is within his reach. Here again we must recognize that there may be excellence or shoddiness in every line of human endeavor. We must learn to honor excellence (indeed to demand it) in every socially accepted human activity, however humble the activity, and to scorn shoddiness, however exalted the activity. As I said in another connection: An excellent plumber is infinitely more admirable than an incompetent philosopher. The society which scorns excellence in plumbing because plumbing is a humble activity and tolerates shoddiness in philosophy because it is an exalted activity will have neither good plumbing nor good philosophy. Neither its pipes nor its theories will hold water (1984).

How can educators meet that great range of individual differences among students, whether rich or poor, able or disabled, destined for the university, community college, apprenticeship, military, or a specific job, including homemaking? To that end, we must challenge the assumption that a college baccalaureate degree is the sole road to excellence, respect, and dignity for all people. Social and educational status cannot be confused with equality of opportunity and individual achievement, regardless of the field of study. It will be a sad day indeed if the "excellence movement" becomes a cover for a retreat from equity and opportunity concerns. As stated by the Commission on Pre-College Education in Mathematics, Science, and Technology, "Excellence and elitism are not synonymous" (Coleman and others, 1983). Clearly, American education requires one or two new definitions of excellence in education, definitions that will hold meaning for all students.

What Can Be Done?

Are we creating the crisis of the 1990s by indiscriminately imposing theoretical math and science education standards upon high school graduation requirements for all students? Is this the answer to improving math and science education for the ordinary student? It may motivate some students, but surely it will discourage others. When three out of four of our high school graduates do not complete the college baccalaureate degree program, and 25 percent of those who begin high school do not even finish, one must question the validity of the current educational program for the great mass of individuals in the two middle quartiles of the typical high school student body. What kind of math and science program will meet the needs of these three out of four students? Can these students also experience educational excellence? Will requiring more theoretical physics or theoretical math meet their needs and abilities? Some fundamental shifts must be made in school and college programs if the needs of all students are to be met and the universal education enterprise is to be moved up the road a few more miles.

Students enrolled in technical education programs must meet the same basic skill requirements as other students seeking the high school diploma, but in an applied academics mode. A course in business mathematics can also be rigorous and help students master computing percentages or apply statistical methods. An applied physics course can be rigorous and help students master essential academic knowledge through practical experiences. Connectedness and continuity are key words in reshaping the math and science curriculum to improve the education program for the middle quartiles of students.

Research and experience tell us that students work better with clear goals; indeed, so do we all. Yet there is often a lack of clarity in what some high schools and colleges expect of their students. Furthermore, there is poor communication between these two educational entities. Even more serious, there is a subtle but stubborn provincialism that suggests that program articulation, the careful building of bridges between high schools and colleges, and program evaluation, the careful measure of program success or failure, are extraneous to the primary mission of either group.

National reports on the reform of education have given only cursory attention to the need for application literacy and continuity in learning, forgetting all the dangerous lessons that the business world has learned of late. What happens when the left hand does not really understand what the right is about? The indicators are not difficult to find.

High schools generally do not have a good sense of how the students perform once at college or in the work world, as the colleges and universities, with rare exception, do not keep them informed. Community colleges, which often must deal with students who have failed to reach their own or others' expectations upon high school graduation, are particularly lax in letting high schools know how their former students are doing.

Generally speaking, although the high school math and science courses a student takes do not seem important in getting him or her into a community college, they may be absolutely critical to success once the student is there. Yet, there is precious little communication to high school students from the community, technical, and junior colleges about associate degrees and college exit requirements and the recommended high school math and science preparation.

Clearly, more and more secondary schools and community colleges are waking up to the reality of cooperating in mathematics and science curriculum development to match a new technological world. It is absolutely imperative that high schools and colleges, particularly community, technical, and junior colleges, become aggressive in examining, developing, and sustaining quality educational programs to serve that great host of Americans who keep this country working.

Many academically talented secondary school students have been well served over the years by the college-prep/baccalaureate-degree math and science curriculum, but unfortunately we have allowed this one definition of excellence to dominate the secondary school curriculum. We have attempted to insist that all students must wear one size of educational program shoes. It is clear that one curriculum will not fit the diversity of individual student differences any more than one size of shoe will fit all sizes of feet. In particular, the two middle quartiles of the typical high school student body (the neglected majority) have not been particularly well served by the theoretical college-prep/baccalaureate-degree curriculum; nor have they been well served by the unfocused and watered-down general education curriculum. Further, because of the poor image of vocational education programs, these students by and large have not enrolled in them in large numbers and have therefore not been served at all by vocational education. As a result, some 11 million students out of the 40 million now enrolled in elementary and secondary schools will not even graduate from high school, in part because of the problem of an unfocused smorgasbord type of curriculum.

What can be done? First, high schools would do well to eliminate the unfocused general education program and replace it with a Tech Prep/Associate Degree (TPAD) applied academics program to work alongside the college-prep/baccalaureate-degree program and the high school diploma/vocational education program. The TPAD program targets the two middle quartiles of the typical high school student body in terms of academic talents, learning styles, and interest. Emphasis is placed upon the mid-range of occupations requiring some beyond-high-school education and training, but not necessarily a baccalaureate degree.

The current nationwide 27 percent high school drop-out rate can be reduced if students understand the "why" (the application of their learning) as well as the "what" (the knowledge). This means breaking down the walls between vocational education and academic education and developing a substantive applied academics math and science curricula. The largest volume of high school drop-outs occurs between grades 10 and 11. This volume can be reduced if students see a focused and respected alternative learning opportunity that connects the school and college curriculum with real-life issues.

The four-year TPAD program is intended to run parallel with and not to replace the current college-prep/baccalaureate-degree program. It combines a common core of learning with technical education and rests upon a foundation of basic proficiency development in applied math, applied science, applied communications, and technical education. Beginning with the junior year in high school, students select the TPAD program (even as they now select the college prep program or the high school diploma/vocational education program) and continue for four years in a structured and closely coordinated high school/community or technical college curriculum.

In order to succeed, the TPAD program requires close curricular coordination. Most of all, it requires that high school and community college leaders and faculty members demonstrate mutual respect and cooperate with one another every step of the way.

The TPAD program advocates taking a step beyond the current and usually cosmetic high school/college partnership arrangements into substantive math and science curricular coordination. The program seeks a middle ground that blends the liberal arts with the practical arts. Furthermore, a closely coordinated four-year (grades 11 through 14) applied academics program will provide more room for an elective program than can be achieved in two unconnected years.

The TPAD program targets the two middle quartiles of the typical high school student body in terms of academic talent and interest, and the mid-range of occupations requiring some education beyond high school and some training, but not necessarily a baccalaureate degree.

The TPAD program does not envision taking students out of high school. Rather, TPAD encourages students to stay in high school. They are taught by high school teachers in the first two years, but must also have access to college personnel and facilities when appropriate. Starting with a solid base of applied science, applied math, literacy courses, and technical education systems approaches, the high school portion of the career program is intentionally preparatory in nature. Built around career clusters and technical systems study, the TPAD approach helps students develop broad-based competence in a career field and avoids the pitfalls of more short-term and narrowly delineated job training. It is the responsibility of the high school to open up the world for the student rather than close it down through narrow and specific job training.

The high school or vocational/technical school TPAD program must dovetail with specific math, science, and technical education programs on the postsecondary level. More intense technical specialization is developed at the college level, always in tandem with broad technical competence and broad math and science competence aimed at working in a "wide-technology" society. It is anticipated that one result of this program will be better understanding of the associate degree as it becomes a preferred degree for employers seeking to fill a broad range of mid-level occupations. As a result of increasing employer demand, many students are now seeking the associate degree as a preferred career development goal. Over 450,000 of these degrees were awarded in 1989, and the trend is upward.

The tech prep/associate degree program requires curricular coordination. Most of all, it requires high school, vocational/technical school, college leaders, and faculty members to talk regularly with one another and with employers. The TPAD concept provides a dramatic model for math and science educators wishing to avoid slippage and loss of continuity in learning, bringing program structure and substance to nonbaccalaureate degree students.

Already the program is working: Many high school/college partnerships are being developed. Here is what Richmond, North Carolina, school superintendent Doug James has to say about the program:

> The program has had the greatest impact on secondary education in Richmond County since high school consolidation in 1971. Previous to Tech Prep, 25 percent of our high school students were enrolled in our pre-college program and 75 percent in the general academic/vocational curriculum. Now, over 30 percent are enrolled in the pre-college curriculum and another 30 percent in our Tech Prep program, which involves a more rigorous academic and technological course of study.
>
> Enrollment in Algebra I has increased 42 percent over our 1985-86 enrollment with an associated increase in our average end-of-course test scores. Algebra II enrollment has increased 57 percent with a slight decrease in average end-of-course test scores. A significant increase has also been experienced in student enrollment in more advanced English, social studies, and science courses.... Since the beginning of our Tech Prep program, our average SAT score has increased 46 points, the drop-out rate declined...and the percentage of graduates choosing to attend a community college increased from 24 percent to 46 percent (James, 1988).

Who will win and who will lose in the development of the TPAD program? Frankly, there are no losers, only winners. Most importantly, students will develop sound basic skills and knowledge while obtaining a first-rate technical education. They will develop the competence to be able to cope with a fast-changing modern life, and do that with confidence. Students will be the big winners!

Employers will win by obtaining a better-educated worker than ever before. Furthermore, skilled worker shortages will be alleviated as the TPAD program becomes widely operational across the country in high schools and colleges.

High schools will win because more students will stay in school to complete their high school education, and more students will find satisfaction in their applied academics program. The tone and morale of the high school should improve as more students are engaged in a purposeful and substantial educational program.

Colleges of all kinds will win because entering students will be better prepared. Colleges will spend less on remedial and developmental education programs, allowing those resources to be spent upon increasingly sophisticated technical programs. Also, colleges will better meet the needs of more students with the applied academics program.

Communities and states will win because cooperation at different levels of education will eliminate some program duplication, provide for greater efficiency, and will more fully develop the human resources of each region.

America will certainly win by the development of a world-class work force that will out-work, out-produce, and out-smart the worldwide competition. The greatest resource in our nation, the human resource, will be more fully developed than ever in our history.

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X.
SELECTED SOURCES AND EXEMPLARY PRACTICES IN MATHEMATICS AND SCIENCES AT COMMUNITY COLLEGES

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Community colleges can and must be deeply involved in what could be one of the most crucial joint efforts ever undertaken in this nation. Their accessibility to students, their ability to offer employment training and retraining, and their transfer programs enable two-year institutions to be effective partners with four-year colleges in improving mathematics-science education. The facilities and faculties are already in place. How best do we take advantage of these readily available resources?

The more we know about the mathematics-science crisis and its seemingly endless ramifications, the better we will be able to deal with it. Gathering and understanding information from as many sources as possible will be invaluable in shaping our plan of attack as we devise comprehensive and workable solutions. Some exemplary programs with a variety of funding sources already exist and are proving to be successful.

A cursory review of the ERIC Clearinghouse for Junior Colleges' collection of postsecondary curriculum changes and mathematics and science education-related journals makes it apparent that obtaining a complete listing of recent innovations in mathematics and science teaching is impractical. These sources are replete with responses of researchers and practitioners recommending the development of new approaches to mathematics and science teaching. This chapter is limited to recent discussions of the issues, recommendations for new directions, and exemplary descriptions of classroom success.

This review cannot replace, for the mathematics and science educator, a careful and ongoing reading of the following journals. Each contains many examples of the rapidly expanding literature of learning and teaching strategies. Many, such as the *Journal for Research in Mathematics Education*, provide annual bibliographies of instructional research.

American Biology Teacher
American Educator
Arithmetic Teacher
Chemical and Engineering News
Classroom Computer Learning
College Mathematics Journal
Community/Junior College Quarterly of Research and Practice
Community College Review
Engineering Education
Focus on Learning Problems in Mathematics
For the Learning of Mathematics
Journal for Research in Mathematics Education
Journal of Chemical Education
Journal of College Science Teaching
Journal of Computers in Mathematics and Science Teaching
Journal of Research in Science Teaching
Mathematics and Computer Education
Mathematics Teacher
New Directions for Community Colleges
Physics Teacher

Research in Science and Technological Education
School Science and Mathematics
School Science Review
Science Education
Science Teacher
Technological Horizons in Education

The Dilemma

Our focus on effective community college mathematics and science teaching begins with the evolving mission of the community college. Community colleges are the fastest-growing segment of postsecondary education—a student-centered institutional bridge between a too-often inadequate K-12 education and traditional baccalaureate studies, as well as a provider of training that upgrades skills in the existing work force and prepares students for entry-level jobs that require less than a four-year degree.

The wide-ranging community college mission introduces factors that are beyond the scope of this review and yet set critical parameters for classroom success. Each factor has a rich literature of its own. These include "open-door" access to postsecondary education; the multicultural make-up of the community college; the identification of students who have the "ability to benefit" and those who do not; the need for placement tests and the development of entering and exiting competencies in sequential learning processes; the need to mirror the academic standards set by four-year colleges and universities; and limitations on faculty development as well as the community college's dependence on part-time faculty. A sampling of these concerns can be found in Dodson's "Quality and Accessibility: Are They Mutually Exclusive?" (*Community College Review*, 1987, *14*[4], 56-60) and Frase and Crow's "The Plight of Community College Science Instruction" (*Journal of College Science Teaching*, 1987, *17*[1], 8, 48).

The community college mission creates a dilemma for mathematics and science teachers by pointing them in at least three different directions: (1) they need to respond to past neglect in the K-12 curriculum; (2) they need to parallel the concerns of baccalaureate faculty in four-year colleges or universities; and (3) they need to improve mathematics and science literacy in the workplace. This dilemma is shared by other disciplines in the community college, but it is exacerbated in mathematics and science by the onslaught of technology in the workplace as well as the increasing need for engineers and other mathematics- and science-trained professionals. An interesting perspective on the importance of external influences in determining community college curricula is provided by Wolf and Zoglin in *External Influences on the Curriculum* (New Directions for Community Colleges, no. 64. San Francisco: Jossey-Bass, 1988).

This review focuses on the community college in response to past neglect, which is the largest of the instructional issues facing community colleges. Programs to address this need are major consumers of institutional and faculty resources. Directing the community college educator toward understanding what should have occurred earlier in the learning process, the strategies being developed in the K-12 grades to redress these failures, and the remediation practices that will restore educational opportunity to the lives of disadvantaged community college students is both time-consuming and costly.

The understanding of these sequential and cumulative learning processes is dependent upon recent efforts to develop taxonomies of mathematical and science education. Effective instruction in the community college requires a professional consensus on the appropriate level, timing, and sequence for mathematics and science education. Discipline journals are filled with debate over two recent taxonomies: *Science for All Americans: A Project 2061 Report*, by the American Association for the Advancement of Science (Washington, D.C.: American Association for the Advancement of Science, 1989 [ED 309 060]); and *Curriculum and Evaluation Standards for School Mathematics*, by the National Council of Teachers of Mathematics (Reston, Va.: National Council of Teachers of Mathematics, 1989 [ED 304 336]). The relationship between the two statements has been suggested in Worthy's call for the teaching of mathematics as "the chief language of science" in "Scientific Literacy: Sweeping Changes in Teaching Urged" (*Chemical and Engineering News*, 1989, 67[8], 4).

The five domains of science education—knowing and understanding, exploring and discovering, imagining and creating, feeling and valuing, and using and applying—have been examined by McCormack and Yager in their "A New Taxonomy of Science Education" (*Science Teacher*, 1989, *56*[2], 47-48). This taxonomy is operationalized in their "Assessing Teaching/Learning Successes in Multiple Domains of Science and Science Education" (*Science Education*, 1989, *73*[1], 45-58).

The Committee on Indicators of Precollege Science and Mathematics Education of the Commission on Behavioral and Social Sciences and Education has suggested ways to measure learning progress in its *Improving Indicators of the Quality of Science and Mathematics Education in Grades K-12* (R.J. Murnane and S.A. Raizen [Eds.]. Washington, D.C.: National Academy Press, 1988).

Community college mathematics educators should also be aware of efforts to describe the transition from high school to college, in Lichtenberg's "Summary of the Report of the NCTM-MAA Task Force on the Mathematics Curriculum for Grades 11-13" (*Mathematics Teacher*, 1988, *81*[6], 442-43).

Teaching Community College Mathematics and Science

The student-centered community college mathematics and science classrooms serve students who are prepared for college-level learning and those who are not. Several types of community college students are not prepared for college learning. There are students who successfully mastered inadequate mathematics and science education in high school. These students consider themselves prepared for college and must cope with both their inaccurate perceptions and their misconceptions of mathematics and science knowledge. There are also students whose past experiences have persuaded them that they can learn these subjects only with great difficulty. These students must overcome feelings of inadequacy and poor learning skills. Another group of students did not follow a "college track" in high school and therefore had limited exposure to the necessary preparatory skills and knowledge base. These students may make the easiest transition to the community college classroom, for they bring the least "baggage" with them. And finally, there is a large group of students who did not continue their formal education immediately after high school. Their extended absence from the classroom means that their successful or unsuccessful mathematics and science experiences are remote, and their new connection to these disciplines depends upon revised educational expectations and a new career direction.

Community colleges have led efforts designed to meet the needs of disadvantaged students through formal linkages between the high school and community college classroom. Programs such as that reported at LaGuardia Community College, New York, by Cullen and Moed in "Serving High-Risk Adolescents" (in J. Lieberman [Ed.], *Collaborating with High Schools*. New Directions for Community Colleges, no. 63. San Francisco: Jossey-Bass, 1988) hold out hope that institutional interaction can smooth the transition to successful community college learning. These interactions can and do serve more than remedial needs. The Fast-Paced Mathematics Program at the Community College of Allegheny County's (Pennsylvania) South Campus is a cooperative effort with 71 high schools in 15 counties and Johns Hopkins University to provide college experiences to gifted mathematics students in grades seven and above.

To meet the needs of their students effectively, community college faculty must

- Determine appropriate entry- and exit-points in sequential learning processes
- Learn to assess specific and common handicaps to mathematics and science learning and develop responsive strategies
- Explore a variety of means for providing a mathematics and science education that has relevance to everyday life, career choice, and other learning experiences
- Design and assess effective learning modules and courses
- Learn and practice the most effective instructional strategies

Entry and Exit Testing

The first task for the community college is to assess incoming students to identify common learning groups. Mathematics and science skills do not stand alone in this assessment. Many studies document a strong association among a student's learning skills—studying, reading, writing, listening, reasoning, science, and mathematics. Choice of tests is far less important than the validity of the match that results between levels of student skills and the instructional units that respond to shared deficiencies.

A number of standardized tests are available. These include batteries of tests from the American College Testing Program (ACT) and the Educational Testing Service (ETS) and, in the biology, chemistry, and physics areas, the Sequential Tests of Educational Progress (STEP) series from ETS. Many institutions have developed their own tests, matching student preparation to local learning sequences.

Increasingly, community college educators are concerned about learning outcomes assessment and the development of early warning systems and institutional support services to meet student need. Coupled with effective placement, improvements in these areas could yield an interactive management system that identifies needs, assesses progress, and holds both the student and the college's faculty and staff accountable to the learning process. Many colleges have developed exit tests for their own instructional sequences. Standardized tests, such as the "end of course" tests in the STEP series, permit comparisons between local and national norms. Student tracking systems have been examined in Smittle, LaValle, and Carman's "Computerized Tracking System for Underprepared Students" and Voorhees and Hart's "A Tracking Scheme for Basic Skills Intake Assessment" (both in T.H. Bers [Ed.], *Using Student Tracking Systems Effectively*. New Directions for Community Colleges, no. 66. San Francisco: Jossey-Bass, 1989).

Coping with Handicaps to Learning

The second task for the community college is to encourage instructional strategies for overcoming handicaps to student learning in mathematics and science. Weinstein suggests a comprehensive strategy for addressing the needs of developmental students in "A Metacurriculum for Remediating Deficits in Learning Strategies of Academically Underprepared Students" (in Noel and Levitz [Eds.], *How to Succeed with Academically Underprepared Students: A Catalog of Successful Practices*. Iowa City, Iowa: American College Testing Program, 1982). She reviews the strategies of successful learners and suggests that "by using instructional methods that demonstrate, cue, and reinforce the use of learning strategies, college teachers can implement a learning strategies metacurriculum" that reaches beyond the basic skills classroom. This ACT publication also contains a useful resource bibliography.

In "Teaching College and College-Bound Biology Students," Uno has outlined four difficulties students have learning college science (*American Biology Teacher*, 1988, *50*[4], 213–16). These include the lack of a solid science background, negative or indifferent attitudes toward science, the lack of self-discipline and study skills, and the inability to think critically. In a helpful discussion of learning styles, Lawson holds that students improve their ability to reason scientifically in the cognitive conflict between prior misconceptions about science and tests of alternative constructs. In "A Better Way to Teach Biology" (*American Biology Teacher*, 1988, *50*[5], 266–78), Lawson describes descriptive, empirical-deductive, and hypothetical-deductive learning cycles, which differ in the degree to which students gather data in a descriptive fashion or set out to test alternative conceptions.

Specific handicaps to learning have been addressed in other articles. Learning anxieties about science and mathematics direct the student's attention away from the learning task. Strauss and Clarke have discussed strategies for overcoming science anxiety in "Fear and Trembling in the Examination Hour" (*Journal of College Science Teaching*, 1989, *18*[4], 223–35). Kogelman, Forman, and Asch have proposed ways of coping with mathematics anxiety in "Math Anxiety" (*American Educator*, 1981, *5*[3], 30–32).

Attitudes constitute another variable in the learning process. The literature suggests that while attitudes may or may not affect classroom performance, classroom success does affect future attitudes toward learning. At the College of DuPage, Eldersveld and Baughman found no statistical relationship between student attitudes or perceptions of ability and classroom success in their "Attitudes and Student Perceptions: Their Measure and Relationship to Performance in Elementary Algebra, Intermediate Algebra, College Algebra, and Technical Mathematics" (*Community/Junior College Quarterly of Research and Practice*, 1986, *1*[illegible]–17). On the other hand, Yager and Penich found student attitudes [illegible]ard science improved in exemplary science programs in "An Exemplary Program Pay-Off" (*Science Teacher*, 1989, *56*[1], 51–58).

The issues associated with extended absences from formal learning have been explored by Prather and Shrum in "Science Education for Out-of-School Adults: A Critical Challenge in Lifelong Science Education" (*Science Education*, 1987, *71*[5], 691-99). Adult learners with low self-esteem and poor learning skills were found to benefit more from mastery-based instruction in Dolan's "Affective Characteristics of the Adult Learner: A Study of Mastery-Based Instruction" (*Community/Junior College Quarterly of Research and Practice*, 1983, *7*[4], 367–78).

Cultural issues pertaining to Hispanic students are explored in Rendon's "Basic Skills: Responding to the Task with Effective Innovative Programs" (paper presented to the National Policy Conference on Urban Community Colleges in Transition. Detroit, Mich., March 7-9, 1981 [ED 213 460]).

A variety of strategies for teaching learning-disabled students are presented in Corn's "Teaching Remedial Mathematics to Learning-Disabled Community College Students" (*Journal of Reading, Writing, and Learning Disabilities International*, 1987, *3*[1], 93–102). Meyers and Burton discuss instructional responses to kinesthetic deficits and reasoning and visual and audio-processing disorders in "Yes You Can... Plan Appropriate Instruction for Learning-Disabled Students" (*Arithmetic Teacher*, 1989, *36*[7], 46–50).

Structuring Developmental Education

The third task for the community college is to design a developmental curriculum that responds to the assessment of student needs, identifies skills to be learned, provides needed support services to both students and faculty, and possesses a rationale that ties it to the overall institutional program.

Developmental needs and institutional responses have been reviewed in Ahrendt's (Ed.), *Teaching the Developmental Education Student* (New Directions for Community Colleges, no. 57. San Francisco: Jossey-Bass, 1987). A useful bibliography is provided in this volume in Zwemer's "Sources and Information: Developmental Education at the Community College." A review of earlier studies can be found in Lombardi's "Developmental Education: An Expanding Function—An ERIC Review" (*Community College Review*, 1979. *7*[1], 65–72).

Developmental science and mathematics education are treated separately in Ahrendt's New Directions for Community Colleges volume. In "Science and Developmental Education," Craven suggests broadening the traditional definition of basic skills to include science education. Successful science instructors, he argues, are those who "understand that developmental education students are likely to be field-dependent learners at the concrete level of cognitive development." In "Mathematics and Developmental Education," Stowbridge suggests that successful skill development in mathematics follows a process that begins with "massed practice" or intense drill over short periods of time and leads to "spaced practice," which is less intense and spread over longer periods. This process also includes "plateaus," where instructors should expect little improvement in speed or accuracy and students should be encouraged to consolidate and integrate their knowledge. He underscores the importance of review and the development of a skill maintenance program during which skills learned are applied under a variety of different circumstances. Student and teacher interaction is essential to each stage in this process.

Useful reviews of remedial mathematics programs include Ajose's "A Review of Research on the Effectiveness of Remedial Mathematics Programs in Two-Year Colleges" (paper presented at the annual meeting of the American Mathematical Association of Two-Year Colleges, Houston, Texas, Oct. 10-14, 1978 [ED 164 017]); Akst's

"Reflections on Basic Math Programs in the Two-Year College" (paper presented at the Sloan Foundation Conference on New Directions in Two-Year College Mathematics, Atherton, Calif., July 11-14, 1984 [ED 246 925]); and his "Remedial Mathematics at Manhattan Community College" (*MATYC Journal*, 1977, *11*[1], 10-11).

The fragmentation of mathematical knowledge is a handicap to learning. For the suggestion that developmental mathematics instruction should be focused around a theme such as the "search for and use of coherent generalizations" or "means of simplifying quantifiable phenomena to improve understanding," see Pace's "Thematic Teaching in Remedial Mathematics" (paper presented at the National Conference on Remedial and Developmental Mathematics in College: Issues and Innovations, New York, April 9-11, 1981 [ED 203 935]).

Other devices for ordering mathematical information for more effective learning can be found in Covington and Tiballi's "Using Bloom's Taxonomy for Precision Planning and Creative Teaching in the Developmental Math Classroom" (paper presented at the Western College Reading Association Convention, San Diego, Calif., April 3, 1982 [ED 221 253]), and Bishop's "Review of Research on Visualization in Mathematics Education" (*Focus on Learning Problems in Mathematics*, 1989, *11*[1-2], 7-16). This issue is devoted to the process of visualization.

McClure describes a three-phase developmental, transitional, and "spanning for success" approach in use at Midlands Technical College in her *Science Mastery: A Design for High-Risk Student Success* (Columbia, S.C.: Midlands Technical College, 1984 [ED 259 785]). In this approach students are introduced gradually to the college curriculum. They begin with tightly structured mastery learning, move to more independent developmental instruction coupled with auditing experiences in mainstream classes, and finally to mainstream class enrollment augmented by tutorial assistance. This instructional design has improved student success rates.

Cherim has described a focus on the importance of learning chemistry in the modern world, coupled with instructor-driven behavior modification in "A Philosophy for Teaching Preparatory Chemistry" (paper presented at the Annual Two-Year College Chemistry Conference, Atlanta, Ga., March 27-28, 1981 [ED 203 937]). A similar concern is addressed in Bond's "In Pursuit of Chemical Literacy: A Place for Chemical Reactions" (*Journal of Chemical Education*, 1989, *66*[2], 157-60).

Thematic approaches have been suggested for the teaching of science. Rhodes and Schaible describe science as a form of thinking that leads to a "more consistent, coherent, and comprehensive picture of nature" in their "Fact, Law, and Theory: Ways of Thinking in Science and Literature" (*Journal of College Science Teaching*, 1989, *18*[4], 228-32, 288). Yager has described the value of teaching science-related issues that confront society in "Research and Teaching: Approaching Scientific Literacy Goals in General Education Science Courses" (*Journal of College Science Teaching*, 1989, *18*[4], 273-75).

Other developmental educators have emphasized the co-dependence of basic skills and the need to confront the learning needs of the whole student. Korn has described a method for identifying students with cognitive skills inadequate to succeed in biology and has suggested ways of improving these in basic skills classes in "Improving Reasoning Skills in Nonmajor Biology Classes" (*Community College Frontiers*, 1978, 6[4], 36-40). Erlich and Lynch-Kennedy have outlined the Ithaca College, New York, program that teaches basic skills in content courses in nine disciplines in "Skills and Content: Coordinating the Classroom" (*Journal of Developmental and Remedial Education*, 1983, 6[3], 24-27). For mathematics, see Smith's "Liberal Arts Mathematics: Cornerstone or Dinosaur?" (paper presented at Sloan Foundation Conference on New Directions in Two-Year College Mathematics, Atherton, Calif., July 11-14, 1984 [ED 245 721]).

The co-dependency of learning skills is also recognized in programs that block-schedule basic skills classes. In such programs, students are scheduled into common discrete basic skills courses, given a counseling and content focus, and monitored through instructor interaction. A variety of block programs at the Community College of Allegheny County's Allegheny Campus has yielded improved student retention and success. The pilot program is reported in McHugh and others, "A Report on Project Block: Fall Term 1977 and Follow-Up Study Spring 1978." While the pilot clustered basic skills courses around a beginning psychology course, subsequent programs have included courses in history, the humanities, and a seminar in critical thinking skills. See, for example, Holmberg's "The Teaching of History to Developmental Students: A Block Project" (*Community College Social Science Journal*, 1980-81, *3*[2], 44-61). In addition, blocking programs have been specified to women, minorities, the learning disabled, as well as dislocated workers at comparable skill levels.

This blocking effort has been expanded to "learning communities" in McCartan's "Helping Students Learn" (in J.E. Lieberman [Ed.], *Collaborating with High Schools*. New Directions for Community Colleges, no. 63. San Francisco: Jossey-Bass, 1988). These "learning communities" include repeated contact within the peer group, active engagement in the learning process, introduction of a counselor to deal with particular needs, increased interaction between the student and teacher, and the integration of basic skills instruction across the curriculum. As in the case of Ithaca College above, basic skills are taught more successfully within content courses.

Other efforts at integrated skills learning include reading, writing, and thinking across the college curriculum. Such efforts are discussed in Livingston's "Reading into the Subject of Science" (*Science Teacher*, 1989, 56[2], 9-10) and Soriano's "Thinking Through Writing"

(*Science Teacher*, 1989, *56*[3], 70-73). An example of an integrated program for accelerated students is provided by Worthy in "Exclusive Undergraduate Program Provides Depth, Breadth in Sciences" (*Chemical and Engineering News*, 1989, *67*[9], 22-24).

Designing the Developmental Course

The fourth task for the community college teacher is to design the developmental course. This course must meet the student's need to develop skills and progress within the curriculum. Reducing student failure means spotting the problem and acting to remediate in a timely fashion. Mann reports on an early-warning formula for predicting midterm grades in general chemistry in his *Predicting Midterm Grades, Phase II* (Perkinston, Miss.: Mississippi Gulf Coast Junior College, 1977 [ED 151 043]). The formula is available in ED 125 730.

In an effort to cope with potential failures from fundamental algebra, a number of community colleges, including the Community College of Allegheny County, have experimented with "math restart" programs. In these programs, the remedial course is divided into modules and unsuccessful students are encouraged at mid-term to withdraw from their original course and to re-enroll in the module they have failed. This practice has yielded significant improvements in retention and grade success.

Kleinstein and Kleinstein describe the topics included in a first remedial mathematics course in "Some Considerations in Curriculum Development: A New Math Course for New York City Open Admissions Students" (*MATYC Journal*, 1976, *10*[3], 150-54). Clements and Del Campo explore learning modes in "Linking Verbal Knowledge, Visual Images, and Episodes for Mathematical Learning" (*Focus on Learning Problems in Mathematics*, 1989, *11*[1-2], 25-33). Merchant designs a competency-based mathematics course for career students in "A New Approach to Teaching Business-Oriented Students" (*Community College Review*, 1980, *7*[4], 36-39).

Successful developmental instruction requires a laddering of concepts to be learned and linkages to college-level work. O'Hara specifies the objectives of developmental biology in "Biology Course Innovations: Remedial Science and Biology-at-Home" (in F.B. Brawer [Ed.], *Teaching the Sciences*. New Directions for Community Colleges, no. 31. San Francisco: Jossey-Bass, 1980). A similar discussion is available for chemistry in Ozsogomonyan and Clinkscales "The Chemistry Preparatory Course in Community Colleges: A Case Study" (unpublished paper, 1977 [ED 148 450]). Worthy reports on an American Chemical Society conference on the goals and appropriate levels of chemistry education in "Educators Propose Refocusing General Chemistry Curriculum" (*Chemical and Engineering News*, 1988, 66[42], 25-26).

Kreiser describes Rhode Island Junior College's response to developmental chemistry needs in "Basic Skills for Chemistry: A Pre-Chemistry Course" (*Journal of Chemical Education*, 1981, *58*[8], 636). Sevenair and others describe a course for pre-health majors in "A Nontraditional Organic Chemistry Course" (*Journal of College Science Teaching*, 1989, *18*[4], 236-39).

Practicing Effective Instructional Strategies

The final task for community colleges is to identify and practice effective teaching strategies in the developmental classroom. More effective classroom instruction can be obtained by modifying the teacher's approach to the classroom. Friedman and Stomper, in their "Effective College Instruction in Basic Mathematics" (*Journal for Research in Mathematics Education*, 1988, *19*[2], 169-74) have compared more and less effective mathematics instructors as measured by student success. More effective instructors used interrogative methods, responded in neutral ways to student answers, repeated correct answers and asked questions in ways that elicited correct answers, spent more time on new materials rather than homework, and provided immediate feedback to ongoing materials.

Cohen has summarized mathematics instruction in the community college. See his "Mathematics Instruction at the Two-Year College: An ERIC Review" (*Community College Review*, 1985, *12*[4], 54-61) and "Mathematics in Today's Community College" (paper presented at the Sloan Foundation Conference on New Directions in Two-Year College Mathematics, Atherton, Calif., July 11-14, 1984 [ED 244 656]). See also Cohen and Diamond's *A Study of Remedial Algebra Courses Taught at Queensborough Community College: Spring and Fall 1973* (Bayside, N.Y.: Queensborough Community College, 1975 [ED 144 654]).

For a similar discussion of science education in Australia, see Tobin, Treagust, and Fraser, "An Investigation of Exemplary Biology Teaching" (*American Biology Teacher*, 1988, *50*[3], 142-47).

For the developmental student whose reading abilities are limited, careful attention should be paid to the selection of a textbook. The use of the Fogg Readability Index is described in Holabaugh's "Textbook Selection: Clearing the Fog" (*Journal of College Science Teaching*, 1989, *18*[5], 327-29). Harder describes the criteria for selecting a textbook, including its comprehensibility, in "Attitudes Toward Reading Science Textbooks" (*American Biology Teacher*, 1989, *51*[4], 208-12). McIntosh has described augmenting the textbook for more effective learning in his "The Expanded Syllabus as an Aid for the Underprepared Science Student" (*Journal of College Science Teaching*, 1987, *17*[2], 137-38). McIntosh includes in his syllabus "general strategies for effective study," how to use the SQ3R technique in studying the textbook, and how to take effective notes. In

"How-to-Do-It: A Biology Composite Guidebook" (*American Biology Teacher*, 1989, *51*[2], 103-04), Stencel describes the development of a supplemental course guide in biology.

Effective laboratory instruction engages the student in inquiry, encourages the student to manipulate experimental materials, and provides for the experiential teaching of specific scientific concepts. These practices are explored in Leonard's "Research and Teaching: Ten Years of Research in Investigative Laboratory Instruction Categories" (*Journal of College Science Teaching*, 1989, *18*[5], 304-06). Kandel has described "Grading to Motivate Desired Student Performance in a Descriptive Laboratory Course" (*Journal of College Science Teaching*, 1989, *18*[4], 249-51).

Chang Ping-Tung has explored the use of small study groups in "Small Group Instruction: A Study in Remedial Mathematics" (*MATYC Journal*, 1977, *11*[2], 72-76, 77).

Programmed, competency-based instruction has been used to effectively augment other forms of learning. Brase and Brase describe its use to augment traditional lectures in "Basic Algebra in a Balanced Lecture-Program Format" (*Two-Year College Mathematics Journal*, 1976, *7*[7], 13-17). Petricig has determined that use of a mathematics laboratory and programmed instruction increased the student success rate in "Combining Individualized Instruction with the Traditional Lecture Method in a College Algebra Course" (*Mathematics Teacher*, 1988, *81*[5], 385-87).

Programmed instruction has been reviewed as a stand-alone instructional technique in Hector's "A Mastery Approach to Mathematical Literacy" (*Two-Year College Mathematics Journal*, 1975, 6[2], 22-27) and Orman's "Programmed Instruction in Mathematics" (*MATYC Journal*, 1977, *11*[1], 13-15).

Morman has compared instructional methods in "An Audio-Tutorial Method of Instruction vs. the Traditional Lecture-Discussion Method" (*Two-Year College Mathematics Journal*, 1973, 4[3], 56-61). Three methods of teaching remedial mathematics have been compared in Corn and Behr's "A Comparison of Three Methods of Teaching Remedial Mathematics as Measured by Results in a Follow-Up Course" (*MATYC Journal*, 1975, 9[1], 1-13). Moore and Griffin found no significant difference between the methods used in "Analysis of Teaching Techniques: Individualized Instruction-Programmed Instruction vs. Programmed Instruction Supplemented by Video Tape Presentations" (graduate seminar paper, Virginia Polytechnic Institute and State University, 1977 [ED 171 344]).

Use of mathematics laboratories and learning center support services has been explored in Spangler and Stevens's "Mathematics K-14" (*Community and Junior College Journal*, 1979, 49[7], 28-30); Palow's discussion of Miami-Dade Community College's (Florida) activities in "Technology in Teaching Mathematics: A Computer-Managed, Multimedia Mathematics Learning Center" (paper presented at the annual meeting of the National Council of Teachers of Mathematics, Boston, Mass., April 1979 [ED 184 609]); Williams and Mick's "The Philosophy and Application of an Audiovisual Laboratory in Teaching Basic Mathematics" (*MATYC Journal*, 1976, *10*[3], 167-72).

Rapid changes in computer hardware and software have given rise to a rich and abundant literature on automated classroom support systems. Here it is possible only to suggest the types of help available. Bialo and Silvin review the advantages of this technology in the developmental classroom in "Computers and At-Risk Youth: Software and Hardware that Can Help" (*Classroom Computer Learning*, 1989, 9[5], 48-55). The use of computers for simulation and modeling, drill and practice, computation and data analysis, data management, and word processing in the teaching of the sciences is reviewed in Spraggs's "Microcomputers in Science Instruction" (in D.A. Dellow and L.H. Poole [Eds.], *Microcomputer Applications in Administration and Instruction*. New Directions in Community Colleges, no. 47. San Francisco: Jossey-Bass, 1984). A classroom philosophy, two years of experience, and nine laboratory procedures are described in Collings and Greenslade's "Using the Computer as a Laboratory Instrument" (*Physics Teacher*, 1989, *27*[2], 76-84). Computers combined with interactive videodiscs are described in Jones and Smith's "Lights, Camera, Reaction! The Interactive Videodisc: A Tool for Teaching Chemistry" (*Technological Horizons in Education*, 1989, *16*[7], 78-85).

Exemplary Mathematics and Science Programs Involving the Community College Student

1989 Prefreshman Summer Basic Skills Program. LaGuardia Community College, New York. Arthur Greenberg. To enable its students to make a smoother transition bet een their high school and college experience, LaGuardia Community College, New York, developed a Prefreshman Summer Basic Skills program.

The summer program offers courses in mathematics, writing, reading, English as a Second Language, library skills, and counseling. In addition to the obvious motivational benefits of getting an instructional "boost," the program introduces an instructional component ("Strategies for Math Success," "Strategies for Writing Success," and so on), which will provide newly admitted students with an opportunity to learn the strategies that promote success in an academic setting. In this way, the program provides pre-freshmen with an orientation to college life, focusing on the importance of basic skills acquisition. The "strategies" sessions are designed to give entry-level students a head start learning those classroom behaviors that lead to increased academic motivation and success in a basic skills setting.

The LaGuardia Basic Skills Program. LaGuardia Community College, New York. Arthur Greenberg. To meet the diversified and profound needs of their students, LaGuardia Community College designed a multi-tiered, multifaceted approach to basic skills development in the areas of reading, writing, mathematics, and English as a Second L· -guage (ESL).

There are four levels of classes in reading and ESL, and the mathematics program is comprised of two levels. Students are placed in the appropriate level based on the results of the Freshman Skills Assessment Program. The basic skills program takes many approaches in attempting to address student needs. In addition to the conventional approach of teacher-led instruction, students can take advantage of tutors, tutor-counselors, computer-aided instruction, sequenced courses, combinations of paired skills and subject content courses, and "Express" courses, which, through intensive and innovative use of computers and special LaGuardia-designed courseware, permit students to dramatically improve their skills in a very short time.

The English 099 Express Course, for example, meets for one week, from 9 a.m. to 5 p.m. (40 hours) and creates an environment in which students are immersed in the learning and practice of standard written English.

Analytical Reasoning Skills Project. Florida Community College at Jacksonville. M. Carolyn Girardeau. Funded by the Program for Excellence in Mathematics, Science, and Computer Education, Florida Department of Education and Florida Community College at Jacksonville. In fall 1986, five full-time professors representing chemistry, microbiology, physics, college preparatory mathematics, and college algebra participated in a faculty development and instructional research project. Participants selected demonstrated the ability to conduct classroom research and a willingness to modify instructional materials and delivery systems while maintaining established course standards. Grant funds provided faculty released time, in-service workshop consultants, short-course training, attendance at professional meetings, and a four-week summer student assistant training program.

Project design included

- Review and synthesis of current literature concerning recent findings related to memory and learning research
- Assessment of innovations (process and products) developed by the Science Education Research Group of Xavier University, Louisiana
- Learning to Learn Thinking Improvement System training for three instructors at Syracuse University, New York

The four-week summer pilot program was extremely successful. Content and instructional delivery incorporated the philosophies and strategies of the SOAR and LTL models. Pre- and post-test results on the WASI documented that Black males achieved the greatest percentage of improvement in problem solving and comprehension as compared to other participants.

Scholars in Residence—A Faculty-Directed Mathematics and Science Education Articulation Model. Florida Community College at Jacksonville. M. Carolyn Girardeau. Funded by Florida Community College at Jacksonville and Title II—Education for Economic Security. The Scholars in Residence Program provided curriculum development on the Learning to Learn Thinking Improvement System for a core of middle school faculty. The Learning to Learn system is designed to provide students with a set of analytical thinking skills that result in significant long-term improvements in grade point average, retention, and overall academic achievement. Learning to Learn was introduced at Florida Community College at Jacksonville in 1987 as a student success project.

The middle school faculty of Ribault Junior High School were provided in-service training on using the Learning to Learn skills of notetaking, task management, reading books, problem solving, information mapping, paragraph writing, and integrative learning. Teachers were given curriculum assistance for a six-month period while they developed and implemented ways to introduce the Learning to Learn skills to eighth- and ninth-grade students in English, mathematics, social studies, and science classes.

The Scholars in Residence Program proved to be an effective faculty-led articulation model with excellent potential as a middle school or high school learning-teaching strategy.

Collegiate Science Technology Entry Program (C-STEP). John M. Montgomery. Funded by the New York State Education Department. The Collegiate Science and Technology Entry Program is designed to increase the enrollment and retention of economically disadvantaged or minority students historically underrepresented in programs that lead to professional licensure and to employment in scientific, technical, and health-related fields.

The program, in place at two-year and four-year colleges throughout New York, supports screening, testing, counseling, tutoring, and teaching of students in curricula that lead to professional licensure or a career in the health, science, or technical areas. A staff of educational specialists is available to assist students in nursing, computer science, mathematics, English, and biology, and a host of other services are available to the students.

The Minority Biomedical Research Support (MBRS). This program is housed at the National Institutes of Health. Its goal is to address the underrepresentation of ethnic minorities in biomedical research and to increase the pool of minority biomedical scientists through student development and participation in research at underdeveloped minority institutions. The MBRS program has grown from 38 institutions, 282 undergraduate students, 44 graduate students, and 199 faculty positions in 1972 to 1,095 students, 407 graduate students, and 772 faculty supported at 87 institutions in 1988. Since its beginning, 21,017 students have participated.

The program supplies equipment to start research and awards incentives for faculty to do research, including released time and summer salaries. For students, the program provides stipends to work with faculty on research projects on and off campus. An MBRS network extends from the community college to graduates and medical schools.

The National Action Council for Minorities in Engineering (NACME). The NACME program allows high school students who have an interest in science, engineering, and the technologies to participate in summer work-study educational programs. After science and mathematics skills are developed, students are introduced to engineering by NACME volunteers who are engineers. NACME stipends are awarded to students upon high school graduation, upon enrollment at a community college, and upon transfer to engineering schools.

The Community College Summer Research Program. Occidental College, California. The Community College Summer Research Program brings students, mostly minorities, to Occidental College for an opportunity to work with top faculty members as well as undergraduate and graduate students in chemistry, biology, and geology. Students are encouraged to participate in research and to continue their studies at a four-year institution. Of the 30 community college students who have participated so far, all have completed their degrees either at Occidental or at other four-year schools. Some are now pursuing graduate work.

Ventures in Sciences: A Collaborative Approach to Encouraging Mathematics and Sciences Careers Among Limited English Proficient and Other Minority Populations. Ruth Burgos-Sasscer. Truman College, Illinois. The purpose of this project is threefold: to identify and recognize the undiscovered academic potential of minority students in the public schools who are viewed as average; to encourage them to pursue careers in science, mathematics, and engineering, particularly as teachers; and to provide them with the kind of long-term, comprehensive, coordinated support that will motivate them to stay in school, enter college, and ultimately establish careers in those disciplines. The program will exhibit an uncommon focus on the special needs of students with limited English proficiency through establishment of a bilingual track.

During the spring of 1991, following a six- or seven-month planning period, 160 students, 60 with limited English proficiency, will be identified for participation in the project. The first recruitment effort will identify students from each high school level; that is, students from the ninth through twelfth grades will be represented. Following the initial year, however, students will be identified in the eighth grade as freshmen and each group will advance a year, with a new group of participants entering as freshmen every year thereafter. Once in the program, participants will remain there throughout their high school careers. Attrition will be handled by choosing new participants at the level from which a given student withdrew.

One distinguishing feature of the project is its two-track design—one track for minority students in general, and the second for Hispanic students with limited English proficiency. The second track will be taught primarily in Spanish, with an ESL component, for the first two years. In the third year, English will be gradually increased, and by the fourth year the two tracks will merge.

Academy for Mathematics and Science Teachers in Chicago. Gordon Berry. Illinois Institute of Technology. The Academy will begin improving the quality of mathematics and science teaching using programs during the school year and summers, evenings, and weekends. Programs for both current teachers and new teachers will be offered.

The scale of this ambitious project is measured by the need to serve over 15,000 teachers and 410,000 inner-city children. The Chicago Academy proposal addresses a constituency that is 88 percent minority, the group most underrepresented in the technological work force, from the technician to the Ph.D. scientist.

The mandate of the Academy is to improve the quality of mathematics and science instruction offered to all students. The Academy will be the contact point for Argonne National Laboratory and Fermi National Accelerator Laboratory (Fermilab) area universities and colleges, private sector experts in management and research, and museums to join the effort to assist and support CPS educators. The initial Academy programs will be drawn from those activities that are already well established in the Chicago area and that emphasize integrated mathematics and science skills and use a hands-on mode of learning and teaching.

Conclusion

This brief review of curriculum innovation in mathematics and science education and exemplary mathematics and science programs involving the community college has attempted to describe the magnitude of the tasks ahead for the classroom teacher. In recent years the literature records a healthy growth in creative concepts and serious research. The institutional challenge, however, is great. Community colleges pride themselves on teaching excellence and have moved reluctantly to support research activities that assess student outcomes. The challenge for the '90s will be to examine existing classroom practices, to implement the process that will bring innovative knowledge to the attention of the classroom teacher, and to provide the institutional support that will encourage the adoption of new and more effective instructional strategies.

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