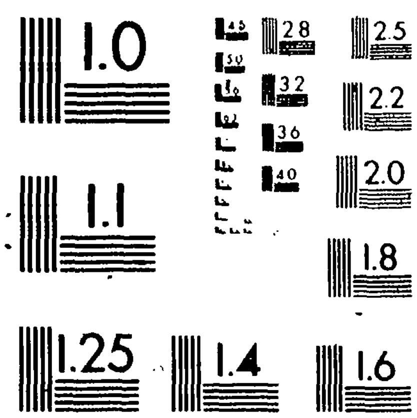
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ABSTRACT

This report includes three papers addressing the issue of technology and education written from the perspectives of business and corporate concerns, educator's concerns, and "collaborative" concerns (labor, business, education, and government). The report includes a commentary by the editor providing an overview of the papers' themes and discussing areas not raised by the papers. In "Forecasting Needs: The High Technology Industry," Robert P. Henderson discusses the conditions that impede the growth of high technology industry and focuses on the lack of proper technical preparation of students in elementary and secondary schools. The second paper, "Improving Math, Science and Technical Education" by Michael W. Kirst, outlines the factors related to modernizing American industry, including public education's need to improve students' technical preparation; also discussed are alternative solutions to the problem. The third paper, "Minnesota Wellspring: Educators as Collaborators in Spurring Technological Innovation" by Donna J. Knight, describes the themes that underpin the Wellspring organization, a collaboration of leaders in labor, business, education, and government. Six appendixes are included. (MD)

THE EDUCATION - ENTERPRISE RELATIONSHIP:

MEETING THE NEEDS OF A PRODUCTIVE SOCIETY

Roberta M. Felker, Ph.D., Editor

April, 1982

National Association of State Boards of Education

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EXCERPTS FROM

THE NATIONAL ASSOCIATION OF STATE BOARDS OF EDUCATION

1981 STANDING RESOLUTIONS:

THE EDUCATION-ENTERPRISE RELATIONSHIP

To promote a free society, educational programs should address the individual needs of each student. Each state board should assume an active leadership role in identifying educational needs, priorities, and plans of implementation for the state.

Educational programs should aid in the development of critical thinking, problem-solving, self-respect, personal values, respect for differences within our pluralistic society, and adaptability to change. Priority should be given to developing proficiency in reading, writing, listening, speaking and mathematics. These skills should be taught throughout the school program to prepare each student for a full, productive life.... .

More specifically:

- Instruction should be provided in awareness of technology for functioning in a technological society.
- Innovative scheduling should be explored to allow for increased experience-based learning, to facilitate the transition from school to the world of work.
- State boards should seek the cooperation of business and industry, using the equipment and personnel, so schools may offer training in evolving technologies.
- State boards should explore the effective use of modern technological systems for classroom and administrative purposes:

ABSTRACT

Technological progress has for some time been considered essential to both our economic growth and national well-being. With this in mind, there has been increasing concern on the part of educational and business interests that: (1) today's students are not being adequately prepared to meet the scientific and technical challenges of the future labor market; and, (2) limited federal investments and policy initiatives will be insufficient to identify, much less remediate, the complex components of this problem.

Recognizing the urgency of these concerns, the National Association of State Boards of Education (NASBE) joined with the National Institute of Education (NIE) to consider selected policy issues and to define a framework for a collaborative "action agenda" for state and local policymakers and private sector corporate leaders.

Three papers were commissioned, representing private, corporate and educational policymaker perspectives. The papers were structured by four questions focusing on the gaps in public school scientific and technical programs, and steps toward remediation of these problems. The authors assumed divergent approaches, highlighting those aspects of the issues central to their varied professional and organizational expertise. The papers raised a number of critical issues that served as springboards for discussion in the overview completed by NASBE. The overview which follows addresses the issues by providing:

- A perspective within which to review the content of the papers
- Common themes addressed by the three authors
- A discussion of additional policy issues stimulated by the papers
- A framework for a Policymaker's Action Agenda

Abstracts for the individual papers are included immediately preceeding each paper.

THE EDUCATION - ENTERPRISE RELATIONSHIP: ADDRESSING THE NEEDS OF A PRODUCTIVE SOCIETY

by

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THE EDUCATION-ENTERPRISE RELATIONSHIP: MEETING THE NEEDS OF A PRODUCTIVE SOCIETY

INTRODUCTION

Technological progress has for some time been considered essential to both our economic growth and national well-being. With this widely accepted belief in mind, there has been increasing concern on the part of educational and business interests that: (1) today's students are not being adequately prepared to meet the scientific and technical challenges of the future work environment; and, (2) limited federal-level investments and policy initiatives will be insufficient to identify, much less remediate, the complex components of this problem.

The National Association of State Boards of Education (NASBE) is a non-profit educational organization representing state-level educational policymakers, members of state boards of education, in 46 states and four U. S. territories. Recognizing the gravity of the aforementioned concerns, and the necessity for beginning to define elements of a collaborative "action agenda" among state and local level educational policymakers and private sector corporate leaders, NASBE joined with the National Institute of Education (NIE) in December, 1981, to give focus to selected issues in the policy arena.

Three papers were commissioned, representing various educational and corporate perspectives. The papers were initially given structure by four questions:

(1) What are the basic gaps in public school scientific and technical programs?

(2) What are the principle obstacles to redressing these deficiencies?

(3) Who is most likely to actively support an aggressive reform effort?

(4) What types of reform strategies are likely to be most effective?

The authors utilized these questions as a framework, highlighting those aspects central to their professional and organizational expertise. A brief description of the three papers follows.

Forecasting Needs: The High Technology Industry

Robert P. Henderson
Chairman and Chief Executive Officer
ITEK Corporation
Lexington, Massachusetts

Henderson begins his discussion with the question: Can the rate of growth of the high technology industry continue in light of conditions such as: (1) high cost of capital; (2) increasing competition from overseas; (3) the ability of the current market to absorb new products; and (4) "the most serious impediment to continued growth...the existing scarcity of engineering and technical help" (Henderson, 1981, p. 29). Focusing the remainder of his paper on the fourth condition, Henderson purports that the primary reason for the shortfall is that elementary and secondary schools are not preparing students willing or capable of continued education or participation in advanced technical areas. He explores the quality of the curriculum, the quality of educators, and non-school factors in this analysis, and concludes that "undertrained, thus under-qualified, teachers along with a soft curriculum have played a major role in the decline of educational standards in this country" (Henderson, 1981, p. 37). The final section of the paper outlines recommendations for corporate involvement with colleges and universities and secondary schools toward helping to resolve the "crisis."

Improving Math, Science and Technical Education

Michael W. Kirst
Professor and Former California State Board of Education Member
Stanford University
Stanford, California

Kirst's paper is grounded in the assumption that American industry must modernize its technological base to respond to the shifting nature of work. He outlines various factors that he perceives as related to public education's diminished capacity to provide adequate technical preparation, including the lack of schools' ability to adapt to change, and the recruitment and retention of teachers. He discusses various alternative solutions such as incentives to attract good teachers and intensive programs of curriculum development, and concludes that, "each government level and the private sector must share the responsibility and the work cooperatively..." (Kirst, 1982, p. 59).

Minnesota Wellspring: Educators as Collaborators in Spurring Technical Innovation

Donna J. Knight
Executive Director
Minnesota Wellspring
St. Paul, Minnesota

"Minnesota Wellspring" is the name of a new organization aimed at expanding Minnesota's technological leadership through the collaboration of leaders in labor, business, education, and government. Knight's paper describes the four themes that underpin the Wellspring vision: (1) the potential for economic growth offered by technology-intensive companies; (2) our continuing evolution to an information-based planet; (3) the emergence of the human mind as a critical resource; and, (4) the necessity for developing new styles of leadership. She then relates this vision to the action areas and accomplishments of Wellspring, including such areas as increasing the responsiveness of educational institutions to the skill and knowledge demands of modern jobs. She concludes with specific initiatives currently underway and Edward Abbey's reminder that, "if enlightenment fails, we have always the traditional solution - disaster - to fall back on."

These summaries indicate the divergent approaches taken by the authors, and the accompanying lack of closure - and even contradictory lines of thought - regarding both the definition of the "the problem," and the nature of "the solution." Review of related literature reveals that this lack of cohesion is reflective of the emerging state of dialogue on this topic, and of the enormous complexity of the issues involved. Clearly, any summative analysis would be premature.

However, the papers individually touch upon a number of issues that can serve as springboards to productive discussion - and collectively draw attention to critical issues that were beyond the scope chosen by the individual authors. The purpose of this commentary, then, is fourfold:

(1) To provide an overview perspective within which to review the content of the papers;

(2) To identify common themes within the papers as guided by the four initial questions;

(3) To discuss issues not raised within the purview of the papers; and,

(4) To cull from both these papers and additional sources a framework for a Policymaker's Action Agenda.

This information is further supplemented by a Resource Bibliography, that can be obtained from NASBE upon request.

It is not expected that this report will resolve the complexities and contradictions inherent in the topic. Rather, it is hoped that these papers and the commentary will serve to inform and stimulate dialogue among educational and corporate policymakers regarding the issues of technical skill preparation and mutual investment in education.

OVERVIEW PERSPECTIVE: THE NEEDS OF THE LABOR FORCE, THE PERFORMANCE OF THE SCHOOLS, AND THE CONTRIBUTION OF TECHNOLOGY

This section is intended to provide background information in three areas integral to an understanding of how the current issues came under discussion:

(1) The projected needs and demands of the labor force;

(2) The current performance of the schools in educating the future labor force; and,

(3) The contribution of educational technology in narrowing the discrepancy between labor force requirements and students' learning.

Labor Force Projections

The Bureau of Labor Statistics has developed three alternative sets of occupational employment projections for the 1980-1990 period, based on three different views of the future economy concerning growth of the labor force, productivity, and other factors (see Carey, 1981; Fullerton, 1980; Kutscher, 1981; Personick, 1981; and Saunders, 1981). The data reported are based on the most conservative estimates provided by the low-trend projections which assume a decline in the rate of labor force expansion, continued high inflation, and modest increases in production and productivity.

Total employment in the low-trend scenario is projected to increase by 17.1 percent or from 102.1 million to 119.6 million between 1980 and 1990. Employment in white-collar occupations is expected to grow proportionately faster than total employment, with a projected rise from 51.4 million in 1980 to 60.8 million in 1990. The number of blue-collar jobs is expected to increase proportionately more slowly than total employment, from 32.4 million in 1980 to 37.5 million in 1990 (Carey, 1981. p. 4).

More specifically, the ten occupations projected to have the largest number of new jobs in the low-trend version are as follows (Carey, 1981, p. 10):

	Occupation	Projected Percent Growth in Employment 1980-1990
1.	Paralegal personnel	108.9%
2.	Data processing machine mechanics	93.2%
3.	Computer operators	71.6%
4.	Computer systems analysts	67.8%
5.	Office machine and cash registers servicers	59.8%
6.	Physical therapists	50.9%
7.	Food service workers	49.6%
8.	Computer programmers	48.9%
9.	Tax preparers	48.6%
10.	Employment interviewers	47.0%

These labor projections are based on assumptions that are obviously vulnerable to real shifts in occupational composition or an industry's product mix. However, at least two probable trends bear mentioning. First, even the low-trend projections support a general upgrading of the labor force. This upgrading will result in an increased demand for what have been called higher order skills such as problem-solving, information analysis and synthesis, and critical thinking. (In fact, four of the top ten projected occupations will demand at least minimal degrees of computer processing and programming knowledge.) Second, and conversely, the data indicate a substantially lower demand (i.e., fewer jobs) for unskilled workers.

When these labor projections are viewed within the context of education, they add credence to the oft-stated need for highly qualified workers in a wide variety of technology-related fields. In the face of current unemployment figures, the data also add a new urgency to the question: are students learning these basic and higher order skills in our schools today?

Student Learning and Performance of the Schools

As the labor projections for the next decade indicate, education is becoming increasingly vital to employment opportunities. However, the definition of what knowledge and skills constitute an education remains an issue. "Basic" skills are not agreed upon, and opinions range from a liberal arts education to life survival skills such as balancing a checkbook. Since there is no general concensus on basics, this summary will utilize the basic skill definitions and data base of the National Assessment of Educational Progress (NAEP) since it is the only national source of survey data describing the educational attainments of today's students.

Examples from recent National Assessment reports on reading, math, and science are provided below (Forbes and Grover Gisi, 1982).

Reading

- While basic reading skills do not appear to be declining, higher-level literacy skills do appear to be dropping. For example, in 1971, 51% of 17-year-olds wrote adequate analyses of given literary passages; in 1980, only 41% were able to do so.

Mathematics

- While lower level mathematics computational skills appear to be remaining stable, the Second National Assessment of Mathematics (1977-78) indicated a 4% decline in mathematical understanding from 1973 to 1978, and another 4% decline in mathematical application during the same time period, with the average percent correct declining from 33% to 29%.

Science

- The 1977 National Assessment of Science revealed that only 46% of the 17-year-olds responded correctly to all science exercises. This can be interpreted as meaning that less than half of these students possess even minimal scientific knowledge.

As with the labor force projections, these data are not definitive and should not be applied *carte blanche* to "prove" the inadequacies of American public school education. They do, however, indicate serious concerns regarding the acquisition of analytical and evaluative skills by many of today's students. The new technological demands of the labor market will continue to add requisite knowledge and skills to the "basic" curricular demands made upon students. However, in addition, the new technologies have also been hailed as at least a partial "solution" to the higher order demands it makes - creating learning experiences embodied in the utilization of the technology itself.

The Contribution of Technology

It may be useful for subsequent analysis to distinguish between educational technology and what Pitts (1982) labels "electronic gadgetry." A perceptive definition developed over ten years ago by the Presidential Commission on Instructional Technology states:

> Educational technology goes beyond any particular medium or device. In this sense, educational technology is more than the sum of its parts. It is a systematic way of designing, carrying out, and evaluating the total process of learning and teaching in terms of specific objectives, based upon research in human learning and communication, and employing a combination of human resources to bring about more effective learning (McMurrin, 1970, p. 8).

Put differently, educational technology involves not only hardware but its human interpretation and application as part of what the 1980 Task Force on Educational Technology referred to as a systematic reordering of the teaching/learning process. Pitts aptly distinguishes this sensitive and intelligent application of machine capability from the indiscriminate application of electronic products in her observation that "the mere application of electronic hardware to educational problems without a sense of the specific purposes it will serve moves that application out of the realm of educational technology and into the realm of "electronic gadgetry" (Pitts, 1982, p. 4).

With increasing acquisition of educational technology by the schools (e.g., in 1980, there were 31,000 microcomputers and 21,000 computer terminals in about half the nation's school districts (NCES, 1980), and increasing demands that schools prepare students to understand and use technological information and equipment as a "basic skill," pressure on the educational system is building. Schools are being asked to respond to occupational projections and declining test scores as part of "the problem," and to incorporate educational technology as part of "the solution." However, the relationships among these variables and their subcomponents are neither clear nor linear (e.g., consider the limited information on the relationship between school achievement and job success).

The three papers examine aspects of these variables in different ways and from different contexts. However, the authors share some common assumptions and give focus to some common themes which may help illuminate the nature of the possible next steps. The following section will focus on these shared assumptions and themes.

COMMON THEMES: PERSPECTIVES FROM A POLICYMAKER, CORPORATE EXECUTIVE AND PRACTITIONER

The following discussion on the shared assumptions and themes of the three papers is structured by the four questions which guided the papers' development:

(1) What are the basic gaps in public school scientific and technical programs?

(2) What are the principle obstacles to redressing these deficiencies?

(3) Who is most likely to actively support an aggressive reform effort?

(4) What types of reform strategies are likely to be most effective?

The purpose of this summary is not to simplify the authors' analyses but rather to illustrate those areas where agreement is indicated, and further, to determine the implications of that agreement.

Public School Gaps

While Knight's focus on the positive aspects of the Wellspring vision and priorities precludes a discussion of "the problem" which Project Wellspring was created to address, both Kirst and Henderson identify at least two elements which they propose comprise major problems with the current system of public schooling. The first of these elements includes what Kirst refers to as "an outmoded curriculum that lacks general introductory courses on technology, physical sciences, and math," (Kirst, 1982, p. 50) and Henderson views as a "soft curriculum," where students "opt for the easy way out" with courses such as "Teenagers and the Law," "Crime and Society," and "Child Behavior" (Henderson, 1981, p. 33). Whether deficient in what it offers or what it fails to offer, Kirst and Henderson identify the school curriculum as a primary contributor to inadequately trained students.

The second problem area of the public school system in meeting the new technological demands of the labor market identified by Kirst and Henderson is the inadequate supply of well trained teaching staff. Kirst, drawing on a paper on teacher supply and demand in California, outlines factors influencing the current shortage, including a decline in the overall ability of those entering the teaching force, lack of rewards for high quality teachers, and the low regard in which teacher education/trainers are held both on college campuses and in society at large. Henderson, while agreeing on the shortage, states, "this shortage is apparently not caused by low salaries but by an inadequate number of teachers trained in these subjects" (Henderson, 1981, p. 35), and goes on to focus on the inadequacy of current certification requirements.

Again, the authors identify the same deficiency area, i.e., the inadequate supply of well trained teachers, but focus on different aspects of the deficiency. In this case, Kirst emphasizes primarily the factors relating to the inadequate teacher supply, while Henderson concentrates heavily on factors relating to inadequate teacher training.

While Henderson confines his remarks primarily to these two areas of inadequate curriculum and teacher supply/training, Kirst gives cursory mention to other factors such as the "lack of school capacity to adjust to change" (Kirst, 1982, p. 50), and the lack of "at least a ten hour inservice workshop in more than ten years" for seventy-nine percent of the veteran technology teachers (Kirst, 1982, p. 51).

In summary, both authors maintain that at least two primary factors are decreasing the capacity of public education to provide a powerful grounding in scientific and technical education:

(1) Outmoded and/or soft curriculum; and,

(2) An inadequate supply of well trained teachers in the scientific/technical fields.

Principal Obstacles to Redressing These Gaps

In the main text of her paper, Knight deals only implicitly with obstacles to redressing gaps in the educational system. It would be through a process of negative deduction that one could imply that the absence of qualities she views as essential to the Wellspring vision (e.g., "the entrepreneurial and collaborative spirit.. and innovation, flexibility, and creativity... " (Knight, 1982, p. 73) would be the principle obstacle to dealing effectively with the inadequacies of a system.

However, in the Appendices, Knight has included a listing of thirteen major obstacles to change in Minnesota's K-12 Schools, including specific data supportive of these obstacles. The obstacles she identifies include:

- Inadequate teacher supply
- Concern for qualifications of teachers
- Inadequate number and uneven quality of teacher inservice programs
- Low salaries
- Lack of universal computer literacy of teachers
- Lack of student interest and motivation
- Declining enrollment makes offerings difficult
- Declining student achievement scores
- Lack of concentrated instruction time or requirements
- Lack of public investment in science/math education
- Lack of coordinated efforts
- Public attitudes
- Sense of impotence, being overwhelmed, resignation

Many of Knight's obstacles to change dovetail with those identified by Kirst and Henderson. Kirst and Henderson do not provide a listing, however, and their obstacles are difficult to differentiate from the "flip-side" of their reform strategies. For example, Kirst mentions that "a logical solution (to the math teacher shortage) is to merely pay all teachers a lot more money and thereby attract enough math teachers" (Kirst, 1982, p. 53). Clearly, the absence of this remuneration can be viewed as an obstacle to redressing the teacher shortage. Henderson, while not dealing with the issue of teacher salaries, recommends a "national engineering policy - an expression of the nation's commitment to that field" (Henderson, 1981, p. 38) - obviously an obstacle to be dealt with in its absence.

In summary, two of the three authors do not enumerate either common or extensive obstacles to redressing the inadequacies they identify. The major content of their remarks will be dealt with under the types of reform strategies they discuss.

Most Likely Reform Supporters

By definition, the leaders in labor, business, education, and government involved in Project Wellspring characterize themselves as reform supporters; in Knight's words, they are a busy and diverse group "who share a vision of the future and intend to work together to act on those beliefs" (Knight, 1982, p. 70).

Kirst's and Henderson's papers do not define such a clear constituency, and one would have to deduce the most likely supporters of reform from their sketches of the actors. This commentary does not reflect such deductions, primarily because generalizations regarding the support or nonsupport of groups of people such as teachers, administrators, college students or corporate professionals necessarily fail to take into account the many contextual factors (e.g., presence or absence of financial support; presence or absence of a change agent) that account for the support or nonsupport of a particular issue.

Types of Reform Strategies Most Likely to Succeed

In general terms, Project Wellspring could be described as a reform strategy that people are betting will work, are committed to make work, and, from the description of the activities, is already working in specific areas. We know very little, however, about what conditions and strategies made the principals in Project Wellspring ("many of whom are adversaries of long-standing..." (Knight, 1982, p. 70) want to become partners in the "marriage of the century," except that it was in their direct interests to join a project designed to "strengthen the economy and thereby benefit the whole" (Knight, 1982, p. 70).

On a more specific basis, all three authors (Knight's strategies are included in the Appendices) address the question of reform strategies, although they did not give specific focus to those "most likely to succeed." The table on the following pages provides an overview of the strategies proposed by each author.

OVERVIEW OF REFORM-STRATEGIES PROPOSED TO REDRESS THE GAPS IN PUBLIC SCHOOL SCIENTIFIC/TECHNICAL EDUCATION

HENDERSON	KIRST	KNIGHT
• Develop a national engineering policy	• Obtain matching federal, state foundation and business support for improving teacher and curriculum quality	• Tap business support and potential
• Tie available funds to specific objectives (e.g., federal standards for curriculum and competency should be established for teacher colleges if they receive federal funds)	• Form consortiums of state governments and private organizations to take the lead in curriculum development	• Make facilities and technology available to community
• Require foreign students to pay full and actual educational costs for higher education	• Pay teachers more money, either across the board or in shortage fields like science and mathematics	• Convene math/science teachers to discuss common problems and solutions
• Extend the 25% tax credit for equipment donations for use in research in the physical sciences to engineering and technical teaching applications	• Retrain teachers presently in surplus areas in the fields of math and science	• Provide special support for math/science teachers (e.g., salary supplements)
• Establish the role of the federal government as coordinator in bringing industry and education together.	• Develop a joint venture between the private sector and public schools whereby private business would allocate some of its employees in order to teach math and science courses	• Increase number of in-service training days dealing with technology for all staff
	• Recognize and reward outstanding teachers through financial incentives (e.g., loan forgiveness programs) and part-time institutes	• Restore interest in science/math and related careers
		• Increase number of minorities in technical fields

OVERVIEW OF REFORM STRATEGIES PROPOSED TO REDRESS THE GAPS IN PUBLIC SCHOOL SCIENTIFIC/TECHNICAL EDUCATION

HENDERSON	KIRST	KNIGHT
	• Retrain guidance counselors to acquaint them with the changing high technology job structure	• Expand use of computers
	• Increase or start inclusion of science in statewide or local standard elementary achievement tests	• Increase math/science requirements
	• Raise state college entrance and graduation requirements in math/science	• Strengthen existing courses - including vocational education
	• Revamp elementary teacher certification requirements to require more units in science, math and technology	• Expand array of co-operative programs
	• Specify the content to be covered in specific courses	• Provide incentives for teachers (e.g., fellowships, summer employment....)
		• Develop strategy for attacking problem on a large scale

At least three points emerge from a comparison of the authors' strategies. First, all three authors refer to a role for the federal government as a stimulator/coordinator/developer of local and state efforts. This development role is congruent with that proposed by other authors (e.g., Melmed, 1982), by federal agencies with direct stake in the outcome of this involvement (e.g., National Science Foundation), and by the OERI FY 83 Technology Initiative (OERI Memorandum, 1982). Second, both Kirst and Knight propose numerous strategies aimed at the teacher quality and curriculum quality issues, which appears to reinforce the importance of these two areas as foci for action. Interestingly, Knight also proposes convening the teachers to utilize their expertise in mapping out strategies for action - a powerful and often underutilized strategy. Third, it is difficult to judge the potential effectiveness of any of the reform strategies listed, since its implementation would necessarily depend on context-specific factors as previously mentioned. A force-field analysis-type ranking of the estimated difficulty of implementation would, however, provide at least a minimal basis for comparison - and for the calculation of potential action.

In summary, the application of the four questions that structured the content of the papers revealed a number of interesting points. First, there was general support for the areas of curriculum and teacher quality as major issues in the public schools today. Second, the obstacles to reform also center on these dual concerns, although both public and student attitudes are also mentioned. Third, the most likely reform leaders include strong state and local level leaders, with some support and guidance from the federal level. Fourth, the list that was generated summarizing the authors' proposed reform strategies revealed concensus for a relatively minor but ongoing role for the federal government, and confirmed the teacher and the curriculum as targets for educational change.

This brief examination of the papers has provided both useful information and a sense of the "vision of problem" as perceived by the three-authors. The next section reflects on a number of broader issues stimulated by the papers in order to focus policymaker concerns.

ADDITIONAL POLICY ISSUES

Both Kirst and Henderson present information based on implicit and explicit assumptions regarding the state of schooling, the ability of the students, and the potential contribution of discrete "solutions" such as increased salaries, and corporation tax credits. Knight's Project Wellspring framework is based on more explicitly stated assumptions and relationships. In order to put such suggestions in a broader context, this section briefly reviews several assumptions which are implicitly imbedded in the issues raised by the authors. In addition, each assumption is accompanied by a policy question that places the issues in a policy context. It is hoped that this review will stimulate additional dialogue regarding the state of the problems and solutions in this critical policy arena, a position supported by Macdonald when he reminds educators not to be "swallowed up by a simplistic, linear, technological problem-solving logic applied to a very complex, multifaceted human situation which demands both flexibility and alternative mental orientations if we are to resolve the inherent concerns we have -- and maintain our humanity in the process" (Macdonald, 1979, p. 9).

Assumption 1: Instructional Certainty
Policy Question 1: What are the desired outcomes of the instructional use of technology?

Many recommendations regarding improved or higher quality curriculum are predicated on the schools' ability to provide the appropriate instructional "know how," and the appropriate instructional resources to correct the learning situation not only for students today - but in the future as well. Melmed is among those who caution that "empirical data on the effectiveness of computer simulation as an educational aid do not exist... " (Melmed, 1982, p. 309). These cautions require thoughtful consideration before assumptions are made about the predictive value of different curricular content or presentation related to the use of technology.

Assumption 2: Schools are Accountable for Learning
Policy Question 2: What changes must be made in the educational system to accomodate effective learning and utilization of technology?

Who is accountable for student learning? Kirst and Henderson give primary attention to the schools; indeed, Henderson states that, "teaching quality, rather than non-school factors (such as home environment and parental expectations) is a leading culprit in the decline in achievement scores... " (Henderson, 1981, p.36). Ultimately, the question of accountability is a complex one and includes multiple factors including quality of teachers; curriculum; and student intelligence, social class, and motivation.

Assumption 3: The Relationship Between Technology and Gadgetry
Policy Question 3: How can we evaluate the success of the use of technology in the schools?

The actual language used to describe technology as well as its place in the world of the future often assume a single, fixed and positive meaning for the electronic equipment and advanced training to be offered to students. As has been mentioned, the complexities and uncertainties of the learning process make any such assumptions vulnerable to the specific situation in which they are implemented. There are as many meanings for the term "educational technology" as there are individuals and schools who operationalize the "gadgetry" - and not all of them are necessarily consensual or positive.

Assumption 4: Only Positive Consequences
Policy Question 4: How can the anticipated resistance to technological innovation be countered most effectively?

We often move, in theory, from the conceptualization of a good idea directly to its implementation, with the best possible consequences. It is easy, in the enthusiasm and optimism generated by new ideas, to assume that all the consequences will be positive, or at least that we will be able to ultimately make them so. It is also easy to succumb to this "wishful thinking" with respect to educational technology, to believe that freed from the boring and repetitive tasks inherent in the teaching, learning, and administrative processes, students and school personnel will pursue higher order learning or other avenues of self-improvement. This may indeed happen, but it is also possible, that, in the case of some teachers, they will be "freed" to find other employment, their acquired skills and knowledge having been taken over by more "stimulating" methods and curriculum in the form of educational technology. Policymakers cannot afford to overlook the concept of resistance to change, and to give serious consideration to these perceptions of the use of technology in schools in determining the methods for introducing technological innovation.

Assumption 5: Policy as Different from Implementation
Policy Question 5: How will the use of educational technology change such things as our understanding of basic skills, the role of the teacher, and the relationship between the business community and the schools?

When issues of policy are considered, it is well to give accompanying consideration to issues of actual classroom implementation. For example, Sheingold's (1981) case studies of three school districts' implementation of educational technology reveal four issues of immediate relevance to policymakers: (1) differential access to the microcomputer according to variables such as sex and social class; (2) the emergence of new roles in response to the microcomputer, including the role of "student expert" which places additional demands on both teachers and curriculum; (3) the lack of integration of microcomputers into elementary classrooms and curriculum, which may separate the application of technology from its content; and, (4) the lack of knowledge about the effects and outcomes of educational technology in the schools. It is critical that educational policymakers consider these factors in determining the efficacy of technology in the schools. In addition, thought should be given to how students may apply this technology to learn those skills necessary to prepare them for their future occupations.

In summary, these examples are not meant to be exhaustive but rather to illustrate the issues which need to be considered for policy action. Others, such as the examination of the role our values play in our choice of technology (and, just as importantly, the influence of technology on our values) will also need careful thought and critical discussion. All the authors stress the imperative of immediate action: the importance of issues such as those mentioned confirms this imperative.

This section has provided examples of the types of complex issues which need to be woven into our vision of joint education-industry ventures. The final section provides a framework for consideration of such issues by policymakers.

A FRAMEWORK FOR A POLICYMAKERS'S ACTION AGENDA

As has been illustrated, there is no dearth of definitions of the problem or proposed solutions to the issue of preparing today's students to meet the scientific and technical challenges of the future work environment. Two priorities seem critical at this point: (1) of the available information, what is most useful? and, (2) how can this information be organized to provide an orientation for action?

This section confronts these concerns through two approaches. First, an outline is provided of projected long and short-term consequences of implementing educational technology in the schools. This "futures" projection provides one way to judge the usefulness of current information in predicting future realities and priorities. Second, an organizational scheme is provided, and the authors' recommendations placed within it in order to give focus to the need for an action orientation. In addition, the Appendices contain examples of suggestions for action which have been generated by another organization. Comparison of these suggestions with those of these authors may prove useful and stimulate creative efforts.

Educational and Social Implications of Technological Innovation

According to Dede, "implementation of the new information technologies in education will create numerous, powerful consequences for society: some direct and deliberate, others indirect and unintended" (Dede, 1981, p. 204). Over the years, research in the field of planned change has revealed that unintended effects of an innovation may frequently be more influential than its deliberate effects. Thus, attempting to anticipate as many as possible of the likely effects of the educational technology movement may be worth doing as policymakers attempt to make judgments about the potential contribution of these technologies to student futures. Dede (1981) proposes a number of illustrative implications which can assist policymakers in these difficult and complex decisions. These implications are summarized on the chart on the following page.

Dede's (1981) projections provide valuable information for policymakers as they attempt to prioritize multiple and often competing demands regarding the implementation of technology in the schools. For example, Dede's first short term effect (independent of implementation strategy) is that a larger proportion of society will have access to instruction (through such devices as "nonformal" home and work computerized learning experiences). A possible long-term effect is the extent to which the advantages of (and not just the access to) educational technology are distributed equally. Policymakers in both the educational and corporate sectors, as they move to greater involvement in non-school learning experiences, need to keep in mind not only concerns with the availability of the hardware devices, but also with the extent to which these devices actually serve to increase individuals' knowledge - and improve their lives. In addition, these implications serve to remind policymakers in all spheres of the importance of staying current and involved in the educational technology movement - and by doing so, retaining their ability to influence its future.

IMPLICATIONS OF THE IMPLEMENTATION OF EDUCATIONAL TECHNOLOGY

EFFECTS LIKELY INDEPENDENT OF METHOD OF IMPLEMENTATION

SHORT TERM (3-10 years)

1. Larger proportion of society will have access to instruction.
2. High initial capital investments in development and delivery systems, followed by reduction in daily operating costs of formal schooling.
3. To realize cost reductions, large numbers of instructional devices must be sold and curricula will have to be centrally produced.
4. Necessity for massive changes in preservice and inservice training.

LONG TERM

1. Differentiation of "education" and "training," with education being done by people and training by machines.
2. Gradual emergence of new definition of intelligence, increasingly centered on analysis, synthesis, and evaluation.
3. Higher overall rate of societal change through both technological innovation and social invention, coupled with an increasing homogenization of different nations and cultures.
4. Evolution of fundamentally different model of teaching and learning.

EFFECTS WHOSE LIKELIHOOD IS DEPENDENT UPON METHOD OF IMPLEMENTATION*

SHORT TERM (3-10 years)

1. Primary initial clientele served will depend on who the major actors are in pioneering large-scale instructional technology usage.
2. The extent to which human interaction is reduced in the learning process will vary.

LONG TERM

1. The extent to which the advantages of the instructional technology are distributed equitably (or inequitably) across the nation will vary.
2. Whether or not a knowledge coordination section is created as a method for national strategic planning will be dependent on many variables, such as the major actors.

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*Dede (1981) proposes four illustrative scenarios whose major actors will be primary determinants of implementation methods: (1) No federal role; (2) Block grant programs; (3) Creation of a distribution system; and, (4) Long-term loans. Further details can be found in the original reference.

A Policymaker's Organizational Framework: One Example

Not only do policymakers need to be future oriented if they are to make decisions which are anticipatory in nature, but they also need ways in which to organize the plethora of information to which they have access. There are many ways in which this organization of information can be accomplished; the example framework on page 24 illustrates one of them. This chart incorporates a number of characteristics that may be useful to policymakers in constructing a state or district specific framework. First, the example conceptual categories for the framework are drawn directly from the information presented by the authors, and from the review of literature. Frameworks should be useful in organizing real information, and not simply a theoretical exercise with no practical application. Second, the information included in the framework is non-duplicative, and coded according to source. This strategy could be used in categorizing suggestions/recommendations by, for example, school district teachers, administrators and parents, or by state board of education and corporation policymakers. While not officially weighting the suggestions, this technique allows the individuals utilizing the framework to consider a maximum amount of information. Third, while not shown here, this type of structure lends itself to a force-field analysis weighting of the difficulty of accomplishing the varying policy alternatives, and thus can be helpful in informing both dialogue and action.

Knight provides a draft of specific examples of strategies to make a framework such as this more practical (complete examples are included in the Appendices). Two sections dealing specifically with the education-business relationship and with support systems for math and science teachers are summarized below to bring more clarity to specific policy action alternatives.

Business Support and Involvement: Actual and Potential

- Much already occurring--e.g.:
  - -- Honeywell, MPS: money, expertise in program development, manpower.
  - -- 3M: recognition of excellence.
- Other forms include:
  - -- Money in targeted education fund: direct cash assistance.
  - -- Computer services.
  - -- Student tours.
  - -- Teacher participation in company-sponsored courses.
  - -- Business people on loan to help school boards in planning and budgeting.
  - -- Find ways to solve problems to mutual advantage.
  - -- Communicate business need for employees.
  - -- Involve high tech companies more in public affairs: but need to prove value of cooperation and need to help shape educational policies.

-- Donate equipment.
-- Allow students to use labs in off-hours.
-- Internships.
-- Work with Junior Achievement.

Provide Special Support for Math/Science Teachers

- Salary supplements.

- Don't lay off.

- Subsidize educators in return for commitment to classroom teaching.

- Professional development and increase resources, e.g.: Science Museum of Minnesota - opportunities in Science Project targeted at Northern Minnesota with Blandin Foundation Support:

  -- Enrichment workshops
  -- Visiting scientists programs
  -- Travelling exhibits
  -- Special summer computing program
  -- Phone hotline on science fairs
  -- Newsletter: The Bog Hopper
  -- Resource Centers

- MPS: to address learning needs of all staff in technology: computers, AV media.

- Minnesota Educational Computing Consortium Workshops - opportunities to "play" with computers, use in creative innovative ways.

Provide Incentives for Teachers

- Fellowships for teachers.

- Inservice.

- Summer employment opportunities.

- Lengthen contract.

- Different salary schedule.

- Increase equipment.

- Design scholarship for post graduate work to strengthen teaching in classroom.

EXAMPLE ORGANIZATIONAL FRAMEWORK FOR EDUCATIONAL TECHNOLOGY

POLICY ISSUES

FINANCE	CURRICULUM	TEACHERS
1. Tie available funds to specific objectives (H) 2. Require foreign students to pay actual costs of higher education (H) 3. Obtain matching federal, state, foundation, and business support for teacher/curriculum 4. Increase teacher salaries either across the board or selectively (K:KN) 5. Tap business support and potential (KN)	1. Form consortia of state governments and private organizations to take the lead in curriculum development (K) 2. Increase or begin inclusion of science in statewide or local standard elementary achievement tests (K) 3. Raise state college entrance and graduation requirements (K) 4. Restore interest in math and science careers (KN) 5. Specify the content to be covered in specific courses (K) 6. Make science/math technology and curriculum available to the community (KN) 7. Expand use of computers (KN) 8. Strengthen existing courses, including vocational education (KN)	1. Retrain teachers in surplus areas in science and mathematics (K) 2. Develop a joint venture between the private sector and schools whereby private business would allocate some of its employees to teach math/science courses 3. Retrain guidance counselors to acquaint them with the changing job structure 4. Convene math/science teachers to discuss common problems and solutions (KN) 5. Increase number of inservice training days dealing with technology (KN)

NOTE: Strategies are coded according to the author(s) who mentioned them:

H=Henderson
K=Kirst
KN=Knight

- Vary length of contract (1-10 months).
- One-time dollar bonus for completion of 5 years of teaching.
- Lab aides.
- Reduction in non-teaching responsibilities.
- Free summer development programs (paid).
- Money for fairs, trips, etc.
- Differential-staffing.

These two tools, anticipatory and organizational frameworks provide one way of moving beyond rhetoric to the challenge and the mandate contained in the papers for collaborative action. The ideas can provide the basis for the cooperative development of other tools that school and business personnel can use to face the challenges and address the problems that technology's entrance into schools and the workplace poses.

CONCLUSION

The state of the art reflected in the papers, and in the schools and the business world is one of complexity and ambiguity. General conditions such as shifting national education priorities, declining financial resources and increased overseas technical competition combine to create new expectations for the schools. We are using labor force predictions, achievement tests results, and futures research to illuminate and direct policies which must guide our country into the time of "future shock."

In times such as this, we tend to turn more and more frequently to "experts" for guidance and perspective. This monograph is an example of such guidance, and the specific ideas provided herein will be useful in stimulating dialogue and debate to assist policymakers to take the "next steps." An appropriate final perspective, both in terms of its implicit reminder of the value of serendipity, and its image of new challenges well met is taken from Frank Baum's classic, The Wizard of Oz:

"Toto, I have a feeling we're not in Kansas anymore."

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FORECASTING NEEDS:
THE HIGH TECHNOLOGY INDUSTRY

by

ROBERT P. HENDERSON

Forecasting Needs: The High Technology Industry

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Henderson begins his discussion with the question: Can the rate of growth of the high technology industry continue in light of conditions such as: (1) high cost of capital; (2) increasing competition from overseas; (3) the ability of the current market to absorb new products; and (4) "the most serious impediment to continued growth...the existing scarcity of engineering and technical help" (Henderson, 1981, p. 29). Focusing the remainder of his paper on the fourth condition, Henderson purports that the primary reason for the shortfall is that elementary and secondary schools are not preparing students willing or capable of continued education or participation in advanced technical areas. He explores the quality of the curriculum, the quality of educators, and non-school factors in this analysis, and concludes that "undertrained, thus under-qualified, teachers along with a soft curriculum have played a major role in the decline of educational standards in this country" (Henderson, 1981, p. 37). The final section of the paper outlines recommendations for corporate involvement with colleges and universities and secondary schools toward helping to resolve the "crisis."

Robert P. Henderson
Chairman and C.E.O.
ITEK Corporation

FORECASTING NEEDS: THE HIGH TECHNOLOGY INDUSTRY

I am testifying today as a member of the high technology industry in Massachusetts. Massachusetts ranks fourth in the nation in high technology employment and first in the number of manufacturing workers engaged in this industry. Fully 28 percent of our industry is classified as high technology.[1]

In the last two years, the high technology industry has created almost 31,000 jobs in Massachusetts[2], in the face of overall declining manufacturing employment. The question today is: Can this rate of growth or any rate of growth continue in light of present conditions?

There are a number of reasons for the question. Among them are the high cost of capital, increasing competition from overseas and the ability of the present market to absorb new products.

The most serious impediment to continued growth, however, is not a market or economic factor. It is the existing scarcity of engineering and technical help. The high tech industry is people poor. There are not enough technically trained people available to meet the requirements of this industry. The United States, unlike other nations, is seemingly unable to produce a sufficient supply of technically educated people. This has prevented many companies from expanding and adding to the economy. Overall, it is hurting our ability to maintain a technological edge in world markets.

Severity of Problem

The shortage is very real. The U.S. Department of Labor estimated that there were 17,000 unfilled entry-level engineering jobs in 1980; other estimates have been as high as 25,000.[3] There is no letup expected in demand over the foreseeable future. According to a recent American Electronics Association's Survey of its membership, representing about one-third of the total U.S. electronics industry, the anticipated demand for engineers in this segment of the high technology industry (Table 1) far exceeds the growth potential for colleges and universities (Table 2).

Much has been said about the reasons for the engineering graduate shortfall. They were discussed in at least two recent hearings before the House Science and Technology Committee.[4] Basically, the reasons given for the shortfall were: inadequate facilities at colleges and universities, facility shortages and the lack of up-to-date equipment for training.

These points need not be restated. It is more important to look at the implications of this shortage. They include the following:

- Shortfall in Employment. The New England Congressional Institute stated that as of June 1980 over 5,900 jobs in Massachusetts high technology industry remained unfilled[5] On an average, for each technical/professional job filled in this industry, an additional three to five support and administrative personnel are required. To this must be added 7.4 jobs in the non-manufacturing sector which are created for each 10 new manufacturing jobs.[6] The total employment shortfall to Massachusetts could have been as high as 40,000 jobs or just under 25 percent of the State's current unemployment figure.

- Economic Impact. The loss in personal income as a result of the Massachusetts employment shortfall is substantially over half a billion dollars.

- Small Business Impact. Small companies create the majority of new jobs. David Burch of M.I.T. determined that 80 percent of all new jobs came from firms with fewer than 500 employees.[7] These firms are today's innovators, yet they suffer most from the engineering shortage (Table 3).

But the shortage causes all high technology companies to suffer. Any company, faced with the necessity to deliver on today's programs and solve today's problems, utilizes maximum human resources to produce what is needed immediately. Therefore, engineers are not available for advanced development or process improvements. Innovation and productivity suffer. The effect causes serious implications for the long term by narrowing the "technology gap" between the U.S. and its international competitors.

Moreover, we reduce our ability to compete against foreign competition. If this state of affairs is allowed to continue, high technology imports will increase and the one bright spot in today's U.S. economy will go the way of automobiles, TV sets and shoes.

Other nations, especially those that are economic and political competitors, are apparently able to graduate more engineers than the United States. It is well known that Russia, with a population just slightly larger than ours, graduates three times as many engineers and that Japan, a nation with half our population, graduates 5,000 more electronic engineers anually than we do.[8]

What is even more telling, however, is that, on a per capita basis, the output of engineers by Czechoslovakia is twice that of the United States; Bulgaria is three times and East Germany is four times our rate (Table 4).

Admittedly, these are not today's industrial competitors. But, based on their proportion of college age people in engineering, they could very well be our competitors in the decades ahead.

The countries that have built up their engineering population have outpaced the United States. Between 1963 and 1977, Japan's share of world trade in manufactured goods (excluding fuel and food) increased from eight to 15 percent while the United States' share fell from 21 to six percent. Between these same years, productivity increased in the manufacturing industries of West Germany by 114 percent, of Japan by 197 percent, and of the United States by only 39 percent.[9] For the last two years, a zero productivity gain has been reported in this country.

If the U.S. had maintained its 1963 productivity rate until the present time, the United States would have been able to afford the Carter Budget, the Reagan tax cuts and been able to give a substantial cash grant to every man, woman and child in the United States.[10]

Duration of Shortfall

The duration of the engineering shortage is disputed. Some sources claim a surplus of Bachelors Degrees in Electrical Engineering (BSEE's) by 1990.[11] Others claim the shortfall will reach 300,000 by that time.[12]

The truth probably lies in between, but the general concensus in the high technology industry is on the side of a continued shortfall even though engineering degrees have increased over the past four years.[13]

There are reasons for this pessimism other than the fact that there is a limit as to how far existing, over utilized colleges and universities can expand without a mass infusion of funds.

The principal reason is the anticipated expansion of the high technology industry. Some examples of this expansion are:

- The dawning of the first VLSI's will herald a new information technology product demand explosion which will equal or exceed the growth curves of the computer industry.

- The marriage of communications and computers will bring forth an entirely new industry to the American scene.

- Increased defense spending, and the need for new, even more sophisticated weapon systems, will significantly add to engineering demand.

- Emerging fields, such as robotics, and the need to increase productivity will create new, specialized engineering fields.

- The increasing complexity of each additional engineering advancement in ongoing technologies will increase the numbers of engineers required to maintain continuing programs and products.

Other reasons for pessimism include the fact that there are indications that there will be a significant decline in the number of degrees granted in the next few years and that the peak we are now experiencing will decline (Table 2).

In addition, an increasing portion of the advanced engineering degrees granted in the United States go to foreign nationals (Table 5), the majority of whom do not remain here after graduation.

As bad as the engineering shortfall is, the situation for technicians (Table 6) and skilled workers is even worse. It has been estimated by 1990 that the country will need over 10,000 tool and die makers, 11,000 drafters, 23,000 engineering technicians, and 58,000 machine service technicians.[14]

Against these needs we are faced with a declining school enrollment (Table 7). A viable supply of engineers, technicians and skilled workers is just not on the horizon.

Concerns with Basic Education

A primary reason for this upcoming shortfall lies in our nation's primary and secondary school systems. This country does not adequately prepare students that are willing or capable of continuing training or education in technical subjects. This is very evident since the ratio of technical degrees to all degrees in most other industrial countries is much higher than ours. (Table 4).

Two reasons can account for this that relate directly to the country's primary and secondary educational process -- the quality of the curriculum and educators.

The declining quality of the curriculum is reflected in the most common measure of academic aptitude. Scholastic Aptitude Test Scores, or SAT's, have been on the decline for over a decade, and the decline has been consistent, regardless of the ever increasing amounts of money, in constant dollars, that the American public has been willing to spend (Figure 1).

Excuses given for the decline include the fact that a greater percentage of students are taking the test or that the expectations of today's parents are not high. Others discount the test as not being meaningful.

There is another more realistic premise. Students leaving our high schools are less prepared in the basics than previous generations of Americans.

Only one-sixth of all high school students take a junior and senior level science course. Only one-half of all U.S. high school students take a math course after grade 10, creating a need for math remediation by one-half of all entering college freshmen. Just 15 percent of all high school students take a course in chemistry -- only seven percent in physics.[15]

The 1980 presidential report on science and engineering education concluded that "more students than ever are dropping out of science and mathematics courses, and this trend shows no sign of abating."[16] We now rank fourth in scientific literacy behind the Soviet Union, West Germany and Japan.[17]

Students opt for the easy way. A listing of the popular courses in a typical Massachusetts high school include such offerings as "Teen-agers and the Law", "Crime and Society", "Personal Consumer Education", and "Child Behavior".[18]

This country simply must challenge its students more. But how? State Boards of Education are no help. To graduate from a Massachusetts high school, state requirements are that a student need pass only four years of English, one year of American History and four years of Physical Education.

And when math and science courses are taught, there are no common standards for evaluation. Local communities can, on their own initiative, vary the passing score on state achievement tests to "improve" the image of competency.[19]

Our national government offers no encouragement, either. To this day there are areas within the Federal Government insisting that declining achievement scores cannot be attributed to a lessening of the study of mathematics and science.[20] What is not said by the U.S. Department of Education is that present day offerings of math courses include such areas of study as "Consumer Math", "Math Review", "General Math" and "Financial Investment",[21] courses unheard of two decades ago.

Our industrial and economic competitors do not make this mistake.

- In Russia, algebra and geometry begin in grades seven and trigonometry is added in grades eight through 10. All Russian students complete five years of physics, four years of chemistry, and one to four years of high school biology.

- In West Germany, biology is introduced in grade three, physics and chemistry in grade five and an increasing advanced math and science course added each year of high school.

- In Japan, 25 percent of all class time in grades seven to nine is spent on math and science, with trigonometry added in grade nine. Thirty-three percent of all Japanese high school students take three natural science courses and four math courses. Japanese 13-year olds have the highest math achievement scores amongst 12 industry countries, including the United States.[22]

The results are evident. Whereas in the United States, 75 percent of our children complete high school, that percentage is 98 percent in Russia and 92 percent in Japan. And, unlike in the United States, there apparently is very little dispute in those two countries over the quality of education.[23, 24]

Another thing happens in our elementary grades where the teaching process plays a role. Until grade six both male and female students score about equally on standardized math tests. From that time on, females take fewer science and math courses than their male counterparts.[25] By the twelfth grade, according to a recent California study, female competency in math has declined to 51 percent of that of their male counterparts.[26] Today, although women make up half of our workforce, only nine percent of the science and engineering workforce is female and most of these are in the sciences.[27]

Whereas a substantially higher ratio of high school graduates in other countries go on to become engineers, our children, because of a dearth in math and science courses, do not even have the choice to major in these fields -- even if they wanted to. Most students do not take the prerequisite courses which would allow them to enter engineering colleges. And even many of those that do take the prerequisites need remedial work.

Michigan Technological University, primarily an engineering school, requires four years of high school math for admission at its School of Engineering. The school gives a math placement test to incoming freshmen, and finds that every year about one-third of the students need remedial algebra, remedial trigonometry, or both, to be able to take calculus, the first-year math course for an engineering major.

Dr. Clyde Work, Dean of the Engineering School who has studied math deficiencies in incoming engineering freshmen, finds that every year nationwide, thirty to forty thousand students enter engineering schools unprepared for calculus.[28]

At Iowa State University, entering students must have graduated in the upper half of their high school class; out-of-state students in the upper quarter. Although their engineering school is selective and overcrowded, only one-third of this year's entering freshmen in engineering qualified on the placement test to take calculus. One-third need a remedial course in algebra; the remaining third need remedial trigonometry and pre-calculus.[29]

Ohio University has complete figures over a period of time on entering freshmen in general undergraduate programs, as opposed to those students who met the University's higher standards for admission to the engineering school. Their Student Advancement Center teaches pre-algebra to about one-third and remedial English to one-sixth of the entering freshmen.[30]

Primary and Secondary Teaching Quality

~~This problem is either caused~~ by and/or aggravated by teaching staff quality.

As there is at the college level, a shortage of math and science teachers and certified instructors also exists in our nation's public schools. A 1981 national study of estimated supply and demand of secondary science and mathematics teachers found that 16 of the 46, or 35%, of state science supervisors responding characterized the mathematics teacher supply situation in their state as a "critical shortage" 16 others said they had some shortage.[31]

Unlike the college level, however, this shortage is apparently not caused by low salaries but by an inadequate number of teachers trained in these subjects. The production of newly-qualified mathematics and science teachers has slowed to a trickle. Last year, for example, Ohio State University, the University of Nebraska, and the University of Minnesota each graduated only one newly-qualified mathematics teacher.[32]

This is not surprising. If a high school student is preparing to enter a teaching college, he or she will not be required to take substantial math courses. In a teacher's college, without this preparation, a math major or minor would require extensive additional courses.

Let me use my state as an example. Massachusetts state colleges offer an education major for prospective elementary school teachers which is centered around courses in pedagogy and child development. Other required courses reflect an attempt to cover basic skills and knowledge, i.e., English composition, but the requirements for math and science are appallingly low. Only the University of Lowell requires two years of general science. Other state colleges require only 15 hours in the math and science area and these can include courses such as "Review of Basic Arithmetic" and "Instructive Geometry". The average SAT's for students for each section in the University of Lowell program is 400; 380 at other state teacher colleges.[33] Certification is almost automatically granted to anyone who graduates. As bad as this is, this certification can be used to teach in middle and junior high schools.

The change from "the basics" to "innovative curriculum" apparently coincided with a decline in teacher qualification. A recent national survey indicated that less than 10 percent of elementary school teachers felt qualified to teach math or science at this low level.[34]

The situation for the secondary teachers is, if anything, worse. Massachusetts state teacher colleges, without exception, require potential secondary teachers to major in a regular field in the liberal arts, involving 30 semester hours concentrated in the major. Education courses, including the practicum, count toward graduation but education is no longer a separate major.

In addition to the liberal arts major, twelve semester hours in education are required plus 18 semester hours (1.5 year-long courses) in the academic field in which the teacher is to be certified, if that certification is to be obtained in a non-liberal arts subject.

These requirements are absurdly minimal. Consider the implications. Any state college graduate with a liberal arts major can receive certification not only for that field but for math merely by taking 18 semester hours of courses in such subjects as a "Review of Basic Arithmetic" and "Instructive Geometry."

Inadequate teacher preparation manifests itself in other areas besides math. Juniors and seniors representing a random mix of all students, tested for enrollment in a Personal Reading Improvement program at Fitchburg State College were found to have reading comprehensive scores equivalent to grade 10.8[35]

The problem is not limited to Massachusetts. To cite one example: A recent study in North Carolina shows that fully 70 percent of their teachers who hold the science certification are certified only in biology. Only 52 percent of the teachers who taught science in grades seven to nine were appropriately certified. Almost 29 percent of the teachers who taught science in grades seven through 12 had no science certification at all.[36]

The situation is apparently getting worse. From 1972 to 1980, the decline in SAT scores for education majors, nationwide, was over twice that of all undergraduates.[37]

Effect of Non-School Factors

That teaching quality, rather than non-school factors, is a leading culprit in the decline in achievement scores seems an unavoidable conclusion.

At the elementary level, where basic skills are taught, a surprising break in the overall national pattern of dropping achievement scores emerges.

Whereas SAT scores, as well as achievement scores in reading and math have declined persistently since the mid-sixties, achievement scores in grades one through three have remained stable.

The implication seems to be that, far from being responsible for dropping achievement, students' home environments and parental expectations sustain them through the early years of schooling. It is during these early years that parental control and influence are undoubtedly strongest.

The national drop in achievement scores does not begin until about the end of the fourth grade. Thereafter, it increases, not only for individual students but persistently and markedly throughout entire grades. Ironically, the highest percentage of loss in achievement occurs in the top 25 percent of students -- those whose home environment would normally be expected to be most favorable to academic success.[38] (Figures 2, 3)

Comparison of absolute raw scores of elementary pupils of the late 1930's with the raw scores of 1950's school children on the same test shows that 1930's school children scored significantly higher (Tables 8, 9); and SAT scores in the 1950's were substantially higher than they were in 1981.

Public school classes of 30 to 40 children were not uncommon in the 1930's and about half of the children in large cities came from non-English-speaking backgrounds. During those depression years, poverty touched many more public school students than it does today's youngsters, even in inner city schools.

The implication here is that today's lower achievement scores cannot be blamed on lack of funds (Figure 1) or class size (Figure 4). Nor, apparently, can they be explained by socio-economic background.

The International Evaluation of Educational Achievement (IEA) is a ten-year study which compared the results of schooling in ninteen countries. "After the socio-economic background of the students has been taken into account, students are still remarkably different in their academic performance, with about 90 percent of the variance in their test scores still remaining to be explained by other factors," the study concluded.[39]

While noting that these other factors may be even more sensitive measures of socio-economic status, even if socio-economic variance were doubled to 20 percent, that would still leave 80 percent unexplained. To quote the study further, "In the IEA studies, school quality variables turned out to have substantial influence on achievement, and some analyses produced the finding that school quality was "of equal or of even greater importance than the home background of the child."[40]

This is not to say that there are not good school systems or good teachers. There are.

It does indicate that undertrained, thus underqualified, teachers, along with a soft curriculum, have played a major role in the decline of educational standards in this country.

Reason for Improved Technical Education

There has been a serious deterioration in the teaching of math and science in our basic educational system. On a very elementary level, this has resulted in today's most common phobia in America, technophobia.[41] At the highest level, it is threatening the economic and political leadership in the United States.

There is a need for everyone to have an educational background in technology so that those who do not become scientists or engineers can make informed decisions about the nation's technological goals and objectives.

And for those who choose not to go to college, the increasing technical complexity of the workplace favors the employment of youth with a firm understanding of math and science. Without this background, it is difficult to enter training programs for technicians and skilled workers.

Those high school graduates wishing to enter engineering schools are finding themselves unqualified. Without a comprehensive background in math and science, they choose careers for which there are no jobs. Thus, our educational system has become a prime cause of this country's employment imbalance. And, without sufficient technical manpower, we will not be able to maintain our slim leadership in worldwide high technology markets or to develop the sophisticated defense systems of the future.

Recommendations

At a time when there is an ongoing debate about the future of the U.S. Department of Education and when funding is being cut and turned over to the states, it is difficult to suggest possible solutions to the engineering crisis that will not increase costs. It is also difficult, at a time when many educators believe that the government has become a surrogate Board of Education, to suggest additional rules or regulations.

However, some of both may be required. A decision has to be made as to what the priorities are for the future well-being of this nation. The engineering and technical manpower crisis deserves a place high on that list. I would offer the following five recommendations.

First, this country should have a national engineering policy -- an expression of the nation's commitment to that field. It should include manpower objectives and a system for measuring against those objectives. It should also address the issues of educational technology standards, information transfer and cooperation between industry and schools.

Second, although funding is being cut back and may be sent to the states for disbursement, the use of available funds should be tied to very specific objectives and quality standards. For example:

- Funds spent for a variety of training activities aimed at teachers and administrators (which totalled about $5 million in 1979) should be directly related to minimum nationally established teacher competency criteria and curriculum requirements.

- Grants to local schools, such as those made under the new Federal Education Consolidation and Improvement Act, should be directed to improvements in basic education at the primary and secondary level. Minimum course requirements and competency tests should be established at the national level.

- Federal standards regarding curriculum and competency should also be established for vocational schools, two-year community and teacher colleges, if they receive federal funding.

- Although quality standards are recommended, it is also suggested that current federal regulations for schools in the non-scholastic area be reviewed for significance and, where found unnecessary, removed.

Third, since almost 70 percent of foreign students learning in this country return to their homeland, federal regulations should require foreign students to pay full and actual educational costs rather than having their education subsidized at the expense of the U.S. taxpayers and students.

Fourth, the recently enacted 25 percent tax credit for equipment donations to universities apparently was restricted to gifts for use in research in the physical sciences. This Act should be extended to include equipment donations for engineering and technical teaching applications.

Finally, the federal government should act as a coordinator in bringing industry and education together to seek common grounds and resolve difficulties. Some of the issues to be addressed might include:

- establishing criteria for industry-sponsored research laboratories and their involvement in commercial products;

- determining methods to supplement facility salaries;

- obtaining agreement on ways to compensate schools for the estimated $1500 in equipment necessary to graduate each student, such as a fee charged for each graduate hired, which would be used to replace equipment.

Other recommendations have been made in Congressional hearings over the past year to correct both the existing engineering shortage and the deterioration in U.S. education. Basically, they are the same problem. Congress is strongly urged to address this issue now.

THE CRISIS IN EDUCATION

Recommendations for Business and Industry -

Grave concerns have been expressed in many quarters about the capabilities and attitudes of our knowledge based industries. For the past two decades, the dynamics of these institutions have shifted away from math and science and weakened the historical relationship that existed between education and the industrial economy. At the college and university level, this has resulted in an insufficient number of scientists and engineers to satisfy the requirements of the nation's high technology companies. It has also resulted in the weakening of the foundation of higher education - our primary and secondary public school systems.

Reversing the dynamics will be a long and difficult process. Complex issues are involved and solutions will be offered from almost as many quarters as have expressed concern. The following are areas where it is believed corporations, both large and small, can play a part in helping to resolve the crisis. Objectives can be set for each area of possible involvement, costs budgeted and controlled, and the results measured.

Colleges and Universities

(1) Corporations can, when possible, endorse the proposal of the American Electronics Association to contribute two percent of their research and development budget to schools of science and engineering. This contribution can be in the form of equipment donations, financial support for specific technical areas or scholarship and financial grants.

(2) A continuing dialogue can be maintained between each company and one particular institution or department within that institution. Areas of discussion could include subjects such as hiring trends, changes occurring in industrial technology and processes, potential joint research programs, the in-plant use of the company's special or high technology equipment to teach about unique or specialized areas and the loaning of adjunct professors to supplement teaching staff in critical areas.

(3) Colleges and corporations should work together to develop and deliver educational programs for employees at the technician, bachelor and masters levels. When necessary, consortiums of companies can join together to insure adequate numbers of students while maintaining acceptable costs. These programs, given at plant sites, can be certificate or degree granting or can be simply retraining or upgrading courses.

(4) Existing or new employee or employee dependent scholarship loan programs can be directed so that recipients who major in science and engineering and work for the sponsoring company for a specified number of years can have all or part of the loan forgiven.

Secondary Schools

(1) Leaders in the business community have been, in the past, most usually associated with the educational process as members of college boards of trustees or of state boards of higher education. These members should actively begin to use their influence to raise the standards for admission to all colleges. This is being done in California and is forcing local school boards to raise the graduation requirements for secondary schools.

(2) Corporations should actively encourage employees to run for election to local boards of education or for appointment to committee positions in local school systems so that they can work to help direct available resources to areas of greatest educational need.

(3) Partnerships should be established between companies and their local high school. Areas of cooperation with the high school can include helping to set curriculum standards for students not planning to enter college, conducting career seminars which highlight the excitement of technology, sponsoring science fairs and offering awards in the companies' name, and supplying, when needed, personnel to augment the school staff.

(4) Supply used equipment for use in science classes and laboratories and provide simple, but interesting, science kits for use at lower class levels.

(5) Start an active program offering company facilities for sponsored programs and tours to students, teachers and guidance counselors to increase their knowledge of, and interest in, technology and technical careers.

(6) Where possible, provide part-time, summer or job sharing programs which will supplement the salaries of highly skilled math and science teachers and which will both help maintain their level of technical knowledge and retain them in their teaching positions.

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IMPROVING MATH, SCIENCE AND TECHNICAL EDUCATION

by

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ABSTRACT

Improving Math, Science and Technical Education

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Kirst's paper is grounded in the assumption that American industry must modernize its technological base to respond to the shifting nature of work. He outlines various factors that he perceives as related to public education's diminished capacity to provide adequate technical preparation, including the lack of schools' ability to adapt to change, and the recruitment and retention of teachers. He discusses various alternative solutions such as incentives to attract good teachers and intensive programs of curriculum development, and concludes that, "each government level and the private sector must share the responsibility and the work cooperatively..." (Kirst, 1982, p. 59).

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IMPROVING MATH, SCIENCE, AND TECHNICAL EDUCATION

At a time when technical requirements for employment, the military and citizenship are increasing, the capacity of public education to provide more preparation is decreasing. Shortages of teachers, outmoded texts, inadequate technical equipment, and unclear academic standards are reinforcing each other. The federal government is decimating its support and leadership while state treasuries are being drained by the recession. Business leadership and funding focuses on the apex of the education system -- prestige universities and engineering -- but the technological infrastructure of ~~lower~~ education erodes. This is a striking contrast to Japan, where government has taken the lead in reinforcing their lead in secondary math achievement and is improving secondary science teaching capacity through teacher upgrading (often using curricula developed by the National Science Foundation (NSF). Local agencies, increasingly tied to state funding and unable to attract teachers, are wringing their hands, but are unable to reverse the negative tide. Meanwhile, the public believes that a teacher surplus still exists! And science consumes less than forty minutes a week at the elementary level, hardly a base for expanding student interest.

There is an interaction effect between the various deficiencies and improvement components discussed above. For example, Zalman Vsiskin, Professor of Education at the University of Chicago, reports the high school experiences of too many students in the recent past have not been positive enough to make them want to teach mathematics.

> Thus, the mathematics curriculum, both the content and the way the content is taught, must be considered a cause of the teacher shortage (Phi Delta Kappan, March 1982, p. 436).

But there are more important reasons for the math teacher shortage, including low salaries and poor working conditions. Unless the United States can attract and retain good teachers, efforts to retrain and upgrade the current staff will merely add to the flight from teaching to other jobs. There will be no quick solution to these basic obstacles to attracting and retaining quality teachers.

Documentation for this situation is widespread, but only the first steps have been proposed. Others will document the crisis, but our task is to prescribe some feasible and affordable methods for school improvement in elementary/secondary science, math, and technology. The dominant strategies of the past two decades (pilot innovative projects and improvement by structural and personnel additions, etc.) probably cannot be financed in the short run. We are in an era of program and specialized personnel contraction. If courses are added, others must be dropped. There is little money for aides or new classes. The concept of seed money through federal or state innovation projects is outmoded because of the lack of local money or teachers to carry on and expand "the exemplary effort." Consequently, we will start with an outline of the major elements of the problem as a basis for proposing specific interventions. The key solution targets should be teachers, curricular content, coverage of this content in class, better textbooks, and use of more efficient teaching technology.

The basic assumption underlying this paper is expressed well by Professor Stan Pogrow of the University of Arizona:[1]

> In an era in which technology is making it possible to replace labor with intelligent machines, and physical distribution systems with communications, a labor intensive approach to production is no longer viable. In order to remain competitive, American industry is being forced to modernize its technological base.
>
> As economic pragmatism fuels the adoption of new technologies, the cumulative impact of these changes will be to alter the nature of work. Specifically, routine and predictable forms of white and blue collar work, such as clerical and welding jobs, will be replaced by the relatively technical work of performing creative and logical operations with electronic forms of data. Most workers, be they artists or machinists, will increasingly have to perform tasks presently associated with science work. The shift in the nature of work will be largely a fait accompli by the time that most of the current elementary school students enter the world of work.

This paper concludes with specific recommendations for future policies. We need more positive rhetoric and orientation about public education. Otherwise, pointing out the challenges in technical education will only reinforce a negative and defeatist cycle about the future potential of public education. Our view on the priorities and first steps is:

1. A sound basic education in math and science is necessary for pupils to take maximum advantage of teaching machines like computers or calculators.

2. It is impossible to provide "literacy" in technical subjects without "literacy" in language and other basic skills.

3. Quality teachers are a precondition for the successful implementation of improved curriculum. The teacher shortage must be addressed first.

4. Improved technical education can only be built on a solid fiscal base for the overall school program. For example, math teachers and programs cannot flourish in an impoverished educational environment.

5. Since improving education is an interrelated enterprise, more public revenue must be devoted to elementary/secondary education than has been spent in the past, or is projected for the future during these difficult economic times.

Role of Various Government or Private Agencies. The key to success in these efforts is cooperation among government and private sources. The federal government should not carry the major burden as it did in the Sputnik era. Federal funds for the purposes described in the last section should be on a matching basis (probably one-third federal) with state governments, foundations, and technology-oriented businesses. Business contributions can be "in kind" such as employing high school math and science teachers during the summer (to supplement their salary) and equipment donations. Foundation and government matching efforts were common for school finance reform (particularly through the Ford Foundation), and similar strategies can focus on teacher retraining. The top priority should be attracting and retaining quality teachers. Without inspired and effective teachers, better curriculum and more teaching machines will not be implemented. Since federal involvement in curriculum development has become so controversial after "Man: A Course of Study" (MACOS), consortia of state governments (Education Commission of the States, National Conference of State Legislatures) and private organizations should take the lead in this area.

New Types of Jobs

Changes in the American culture and economy will create a great deal of pressure on schools. These changes in jobs and culture toward high technology will force a change in education.[2] There will be a radical shift in job content within existing categories such as secretarial, clerk, assembler, etc. These jobs will require interaction with technology to increase and analyze information. Robots or automation will take over many routine jobs while employees will be manipulating the robots. Jobs at the technical level (beyond high school and below A.B.) will grow rapidly and be an area of critical shortage. For example, technicians will be testing, supervising, and repairing production systems that use a great deal of automation and robots. The large change in content and nature of these jobs is obscured by the standard Department of Labor categories such as "crafts and kindred" workers, which do not reflect new work skills.

Computer science degrees are not being produced as fast as demand is growing. We have neither the teachers or equipment at the lower education levels to stimulate and prepare students for computer science careers. Moreover, high economic and employment growth industries are in large part high tech. The California Governor's office, for example, estimates that 25% of new jobs in 1982-1990 will occur from high tech growth, but this expansion is threatened by Japanese competition. By the year 2000, perhaps 50% of the jobs will involve information processing and will use less paper and more electronics or computers. Telecommunications will revolutionize the movement of information and be a major new employment sector. The federal budget increase in defense will require a major expansion in technical manpower of numerous types.

Changes in Culture

Society will be called upon to make all kinds of decisions about the regulations, use, implications, and consequences of technology. An informed electorate is necessary to deal with this, but current curriculums are not oriented to this issue. Computers will be in the home (about 40%) by the year 2000. Moreover, combinations of VTR, video discs, and TVs will be common in home entertainment. This widespread use of technology in culture will put great pressure on the schools to adapt and increase technological instruction. Otherwise, the schools will be viewed as out-of-date and of low quality.

A Lack of School Capacity to Adjust to Change

Schools (except for selective universities) will find it very difficult to adjust and meet these changes in jobs and culture. Indeed, the capacity to respond will not exist if current policies and trends continue. Easiest adjustment will be at Stanford, MIT, and the flagship public campuses which can attract professors, research grants, and facilities. These institutions have the flexibility to institute differential salaries for math and technology teachers. They also can attract industry donations and win research competitions. Many lesser state institutions are not in a favorable situation. Unions will resist differential salaries, and there is less ability to attract research grants and business donations. Yet, the state universities will need to supply most of the technologists.

Community colleges are encountering fiscal stress such as caps on growth of Average Daily Attendance (ADA). They can reallocate priorities from lower priority courses and can attract up-to-date teachers on a part-time basis (often from industry or labor). Community colleges provide many technicians that are in short supply and must improve their attractiveness for business and union donations. The worst problem is in the capacity of elementary/secondary schools (E/S) to supply the basic underpinnings of technical education.

The Dimished Capacity of Elementary/Secondary Schools for Providing Technical Literacy

The shortage of teachers in math, physical science, and computer areas is a critical problem. In each field the supply of new teachers has dropped by 60% over the last decade. About 50% of the teachers are not adequately trained and need upgrading. The basic skills of the teaching force (SAT) is dropping and already appallingly low. In the Pacific states, 94% of the new science and math teachers are not qualified.[3] Solving the teacher shortage is the first priority.

Declining achievement and course taking in advanced science/math areas at the secondary level is turning around. But now that student interest and public pressure are expanding for more technical education, the institutional capacity is not there. One gap is an outmoded curriculum that lacks general introductory courses on technology, physical sciences, and math. Many high tech students are bored, scared, or forced into college sequences that are inappropriate. Advanced placement courses in most schools are threatened with larger class size and loss of senior teachers. Seventy-nine percent of the veteran technology teachers have not completed at least a ten hour inservice workshop in more than ten years.

College standards discourage more math/science because of unweighted grade point average (GPA) admit policy. Students do not elect higher level math and science courses because they fear low grades that jeopardize college admission. In California, only 25% of the students have taken three years of math and two years of science. Changes in college admission standards to increase math and science course taking incentives are urgently needed. At a recent AAAS hearing a math professor at Ohio State reported that half of the Ohio high school juniors had "essen- tially no skills in algebra."

All students will need in-depth experience with a computer during high school. This might involve an in-depth project similar to a term paper. But schools lack computers and teachers to provide each student with a computer project during their school career. Computer software is needed (along with VTR and video discs) for problem solving and more complex exercises and to integrate technology with all classes, rather than merely offering a separate computer course. But NSF support for science and engineering education has declined from 47% of the NSF budget in 1959 to 2% now.

The nature of math is changing from computation and logarithm to estimation and "feel" for numbers (particularly by application), but there is scant teaching personnel or infrastructure to teach or develop this new emphasis. Achievement scores in the U.S. are good in math computation and weak in problem solving. State authorities and local education agencies (LEAs) need to request math textbooks with more problem solving exercises and processes to solve non-routine math problems.

Recruitment, Selection, and Retention of Teachers

A series of economic and demographic changes in the 1960-1975 era tended to obscure the nascent technical teacher shortage. There was a massive increase in college educated workers with a potential to teach. The number of women in the workforce increased dramatically, and the propensity of women to work more continuously and spend less time out of the work force helped the teacher supply. While supply was increasing, two major factors depressed the demand for teachers -- the decline in fertility and a shift in the population away from the frost-belt that created large teacher surpluses in these sections. In part because of the complacency about a surplus, there are major unknowns in projecting teacher demand and supply. We have no good studies of what persons trained as teachers, but not currently teaching, are now doing. Have they dropped out of the labor force? Can this "reserve army" be attracted back to teaching? There is virtually no information on where people go who leave the teaching profession for other occupations. How are the retirement patterns of teachers changing?

Some of the trends that we are tracking are worrisome. Schlechty and Vance in a major review concluded:*

1. A decline in the overall academic ability of those entering teaching in the 1970s compared to the 1960s. Most of the decline occurred among high scoring (on tests) females.

2. Those most likely to leave teaching in the greatest numbers are disproportionately drawn from the most academically able of the teaching population. Again, there is a marked decrease in the retention of high ability females.

3. State legislatures have been mostly concerned with culling out the bottom with little attention to recruiting and retaining the top quality teachers. This legislative focus on the least qualified has further weakened the prestige of teaching by stressing minimum competency and requiring demeaning tests.

4. The low regard with which teacher education and teacher trainers are held on college campuses does little to encourage the brightest students to enter teaching.

5. Teacher reward systems are not well designed to retain teachers. The salary scale is short, and one reaches the top in 10-12 years. All promotions lead away from the classroom to administration.

6. Beginning math teachers in the San Francisco Bay Area earn about $12,700, but industrial salaries start at about $20,000 for a math or science major with an M.A. Among the 1982 entering freshmen at U.C. Berkeley, less than 1% specified an interest in teaching.

The math area as demonstrated is merely a dramatic example of a systematic teacher shortage. The next section focuses on math as an example of the various alternative solutions to increasing the supply of qualified teachers.

Alternative Solutions to Math Teacher Shortage

A past solution was to recruit into teaching the large number of women who possessed teaching credentials but who chose not to enter the work force before they started their families. Once their children were older, many of them could be induced to return to the classroom,

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* Phyllip C. Schlechty and Victor S. Vance, "Recruitment, Selection and Retention: The Shape of the Teaching Force," draft paper prepared for NIE, 1982.

even if on a part-time basis. Changing social and economic conditions have badly eroded this potential supply of teachers. Now that 70 percent of women between the ages of 25 and 65 in the United States are in the work force, schools can no longer count on this pool of potential labor. Also, because women infrequently majored as undergraduates in science and mathematics, the supply of women available to instruct in these fields was never large to begin with.

A second solution has been to hire individuals who either were not prepared in math and science subjects or were very reluctant to become teachers. This "solution" is already being adopted by many school districts to deal with the math and science teacher shortage.

The use of so-called "emergency" credentials has been a big loophole in the licensing structures of several states. It permits unqualified individuals to be employed "temporarily" by school districts. This is clearly not a desirable solution.

A logical solution is to merely pay all teachers a lot more money and thereby attract enough math teachers. Few states can afford a massive salary increase, so another possibility is to pay higher salaries for shortage fields like math. School officials, however, confronted much opposition when they tried to pay one category of instructors more than another. This necessitates saying that teaching science and mathematics is more important than social studies or English. All of these represent subjects that are in the core curriculum. Now school districts ignore supply and demand and pay teacher salaries based on seniority and number of academic years of training. The Houston, Texas, School District provides salary increments for teachers in fields with critical needs, including math and science. Initially, the salary augmentation for science and math teachers is only $1,200 per year. This may not be enough to compete with salaries offered by business and industry. Indeed, Houston still reports a shortage of math and science teachers.

Another solution, and one which would also cost money on the part of the state, would be lengthy retraining of teachers presently in surplus areas such as history and driver training. Only a few "surplus" teachers will have had math or science minors, but most will require much lengthier training. A survey by the National Science Teachers Association found that over half of the elementary school teachers said that their college training did not give them any preparation to teach science. As Guthrie points out,

> ... the majority not only will not have had much mathematics at the college level, but also many of them will be actively afraid of mathematics themselves. Selection among those to be converted to math teachers must be done with extraordinary care. Otherwise, their mathematics aversion all too likely will be subsequently transmitted to their students.[4]

A final alternative is to develop a joint venture between the private sector and public schools whereby private business would be willing to allocate some of its employees, an average of one or two hours a day, in order to teach secondary mathematics and science courses. This would require some short training of these industrial employees who have never faced a classroom of 30 teenagers. But such a program would be in industry's long range interest. It would cause resistance from some teacher organizations, because the part-time teachers would not have credentials.

Solutions: A Long Term Plan to Provide Technical Teachers

The key strategy should be a cooperative effort among government and private sources. Universities, textbook manufacturers, and local school boards must be linked with federal and state authorities. These institutions must be reinforced by business, labor, and foundations. The teacher shortage must be solved systematically as a precondition for better curriculum and increased use of teaching machines. The total number of untrained math and science teachers needs to be measured and forecasted. Intensive inservice programs based on NSF mechanisms in the 1960s should be phased in on a seven year basis--retraining 1/7 of the teachers each year. Costs should be shared: 1/3 federal, 2/3 state with the retrained teachers signing an agreement to teach for a certain number of years after their training. A new federal National Economic Education Act should provide matching grants to states for NSF style summer and short term teacher upgrading institutes. Teachers prepared in these institutes can work with other staff at their schools to upgrade their knowledge in technical subjects.

New teachers must be attracted to technical fields as well as retraining the existing staff. Nationally, between 2000 to 3000 science and math teachers may leave teaching each year for other jobs. Moreover, most of the teaching force in many states is over 45 and will retire in the next 10-15 years. This means several hundred teachers must be prepared each year in California. Financial incentives such as scholarships or loans should be given to academically talented individuals. A loan forgiveness program for teachers could be structured so that all college costs are written off after 10 years of teaching. Salary schedules must have more of a progression, perhaps over a 20 or 30 year period, so that the ceiling is not attained too quickly. Recognition and promotion should be designed so that leaving the classroom is not more attractive. For example, outstanding teachers can be selected for summer or part-time institutes. These teachers can then be designated as leaders for acquainting the rest of the school staff with new developments or techniques. The California Writing Project already has such a design. In fields with urgent and growing teacher shortages such as math, we must use additional measures. In the interim, teachers must be hired on a part-time instructors. Such personnel can be given intensive teaching methods workshops and issued emergency teaching materials.

After inservice training has been completed, many teachers may leave for industry. In order to retain this trained staff, teachers must be satisfied with the conditions in the schools. Income supplementation based on the Exxon program for engineering professors should begin. Since differential salaries for math/science teachers is unlikely, guaranteed summer supplements for jobs in industry, consulting opportunities, and regular paid summer refresher courses are necessary. Science teachers need better lab equipment and math teachers, more calculators.

An Intensive Program of Curriculum Development

Curriculum development in technical education has never regained the momentum of the post-Sputnik era. U.S. science/math specialized students compete favorably with those anywhere in the world. But newer technologies will require curriculum updating. Moreover, it will take new content and courses in such areas as math problem solving and human biology to interest the groups that have shunned the math/science areas in the past. This will take time to develop.

Computers using other communications video (discs) could be used to teach some basic concepts with less teaching time, but we have no curriculum to do this now at the high school level. One focus should be on very good and interesting courses at introductory level (7th-10th grades) to lure more students, and strengthen technical and college oriented electives for those already committed to the area. Introductory science and technology courses need to show students the pleasure of working with science. We have no intro courses in electronics, and little relationship of chemistry to electronics and technology. Curriculum development money should establish new general science courses and advanced electives that "stick" and become part of a long term curriculum.

Some of these new technology courses should be taught by industry people on leave and other low cost delivery mechanisms encouraged. For example, in California, the Lawrence Hall of Science has set up supplementary after-school programs--mobile vans that can reach rural areas and shopping centers with interesting scientific materials. Students could take basic physics on video discs in small school districts with low enrollments. In an era when many students are using outmoded texts in arithmetic, it seems presumptious to discuss new curricula. Consequently, general school funding must increase in tandem with this push for new content.

Federal and state grants are needed to develop courses and tests in:

a. computer experiences, projects, and interactions for elementary and secondary students;

b. increased science in elementary school (now only 40 minutes per week in most schools). Science should be stressed in statewide elementary assessments and tests;

c. values, technology, and society that raise critical public choices and issues facing our nation;

d. an overview, nonspecialist physical science course, 9th or 10th grade, that acquaints terminal science students with chemistry, physics, and technology;

e. electronics, telecommunications, and other technologies -- both junior and senior high school courses should focus on these growth areas;

f. other course development in basic math/science areas, as NSF did in the 1960s -- stress problem solving, applications, etc.

After this course development is finished, we should retrain guidance counselors to acquaint them with the changing high tech job structure. Moreover, professional associations can lead in developing secondary school core curricula that integrate science and technical subjects into other coursework such as history and math. Expanded course availability can be accomplished by merger of community college course offerings with secondary schools through easier dual enrollment with no financial penalty to either school level. States could offer incentive grants for community colleges to teach tech courses on high school campuses. This type of added ADA could get a full state reimbursement.

Comprehensive high schools will not be able to employ enough specialized teachers or aggregate enough tech equipment until the above steps are implemented. As an immediate step, scarce resources of teachers and equipment should be pooled into regional high tech schools that offer technician and college preparation. Such a high school could serve several school districts or be a magent school within a city. Moreover, in order to create a more focused high tech school climate, a school within an existing large comprehensive secondary school could be formed with a high tech focus.

Scarce high tech teacher availability can be partially overcome by replacing routine and drill oriented math/science teaching (e.g., computation practice) with machines. This will free scarce teaching resources from routine drill teaching and focus on creative ones.

Low Cost Incentives for Students to Take More Math/Science and Technology Content

While the proposals outlined above entail considerable cost, there are several incentives that can increase student choice or exposure to technology oriented content.[5] As several studies have shown, an increase in student learning time on particular content will result in higher achievement in these content areas.[6] Some specific ideas are:

- In order to increase current 40 minutes a week in elementary science, increase or start inclusion of science in statewide or local standard elementary achievement tests. Publicity about test results often stimulates LEAs to redistribute their school day. Same policy should be used for secondary schools.

- Reorient existing math tests to stress problem solving and de-emphasize rote computation.

- Raise state college entrance and graduation requirements in math/science which will cause college bound students to alter their college preparation patterns.

- Raise tech requirements for community college A.A. degree to community college transfer to 4 year colleges.

- Revamp elementary teacher certification requirements to require more units in science, math, and technology.

- Increase high school graduation standards for technical education.

This is a complex issue that deserves a separate analysis. All of these ideas, however, require trained teachers to implement them. Incentives for more course taking should be phased in to mesh with teacher supply increases.

Specific Course or Minute Requirements

An inexpensive way to increase content coverage is for the SEA or LEA to require more math and science for high school graduation. But this is a blunt instrument with many implementation uncertainties. It forces a redistribution of existing resources from other subjects to math/science. Any state requirement would be resisted by many LEAs as an unwarranted intrusion on local control. Requirements of specific minutes for science or math in the elementary grades do not meet the historic criteria for leaving a long term impact on schools.[7] Minute requirements are not easily monitored and do not create an active constituency or lobby that can peer behind the classroom door.

Course requirements for college entrace can be more easily enforced and monitored because they have a built-in constituency of the university admissions office. But colleges are never sure what content is included within such titles as "Algebra II." The University of California is proposing to specify what types of content should be covered in each course to mitigate this problem.

The most frequently used way to increase student time is merely to add course requirements for graduation. For example, Governor Brown of California has proposed a statewide standard of 3 years of math and 2 of science. The options to implement such a proposal are listed below:

Options

1. Require it in State Code as a minimum graduation requirement for high school. This can be done by legislation or state board regulations.

2. Require this course pattern for entrance to state universities or as a minimum to complete Community College A.A. degree (for transfer or as a terminal degree). Several community colleges do not require math or science for A.A.

3. Tie it to state matching funds -- school districts that require 3 years/2 years get more teacher retraining or instructional materials from the state. This could either be a matching requirement or a prerequisite before receiving any categorical state money. This prerequisite should not discriminate against low wealth districts and reward the affluent ones.

4. Make statements urging this at all levels of education. Use Governor's position on University Boards to propose it; appoint State Board members committed to it (urge current appointees to do it); schedule speeches before local school boards and administrator groups.

5. Set up a phase-in schedule to reach the goal, given the shortage of teachers and need to reschedule classes/courses. At a large high school (3,000 ADA) about 15 added full-time equivalent (FTE) teachers would be needed. In California, the SEA estimates that only 25% of students take 3 years of math/2 years of science now.

6. Utilize the state mandate for graduation minimum competency to require a specific set of exercises or problems in math and science that would take three years of math or two of science to pass. As of now, the state minimum competency requirement leaves the content and level of the exam to local option. By the state specifying the exam level, the course requirements will follow as necessary preparation.

Discussion of Options

The current California science/math course patterns are:

Students who have completed years of math/science

Math	Science
90% - 1 year	87% - 1 year
58% - 2 years	41% - 2 years
25% - 3 years	13% - 3 years

Most schools have a 9th grade general science course, but few have an introductory physical science course (10th grade) that precedes the college preparatory physics and chemistry. This physical science introductory course could be very useful in general and high technology preparation.

A major issue is what course content can be counted as "math" or "science". There are numerous math courses, ranging from "business math" to calculus. Some LEAs consider home economics a science course. Consequently, there may have to be some definitions of what is "math". Blanket requirements can be softened by allowing local districts variances (approved by the State Board), to develop program substitutes for math/science state requirements and to permit individuals to take "appropriate" substitutes. Could students count psychology and environmental science? Obviously, any state standards must be preceded by a convincing rationale for students as to why they should study these important subjects. Some LEAs will want to count vocational agriculture and applied science in vocational education courses as "science requirements". If the state will accept these, then staffing requirements for teachers will be mitigated.

Less than one-half of U.S. biology teachers have a major in biology. We do not collect such figures for most subjects as far as teacher qualifications are concerned. California uses physics teachers to teach math because of low enrollments in physics. Physics teachers have two-thirds of their teaching load in math, so if science enrollments increase, then math teachers are diverted to teaching science. This would intensify the math teacher shortage.

Concluding thoughts

The most urgent need now is to move beyond documenting the problem to short and long range solutions. Influential parts of the public seem convinced that there is a growing problem. The various levels of government persist in shifting the responsibility. The federal government says it is a state and local responsibility and somehow cutting the NSF and Education Department budget will free up local initiative. The states claim the recession has caused budget deficits so they cannot lead. The local agencies say they cannot raise property taxes, and the problems of teacher training and curricular development transcend boundaries.[8]

Obviously, each government level and the private sector must share the responsibility and work cooperatively on the policy measures covered in this paper. NAF has the legislative authority to provide resources and the new federal EICA provides a flexible state funding mechanism. The spirit of federal involvement must be SEA and LEA capacity building rather than regulation or national direction. The federal government must assist in curriculum development, perhaps through grants to inter-SEA or LEA consortiums.

State government is in a position to play a major leadership role. SEAs set the standards for teacher training, state testing, graduation and college admission. These are powerful regulatory levers that need not cost new money. Local agencies must make teaching conditions more desirable. But all of these policy initiatives are doomed unless we can attract teachers and employ technology to free up teachers from much of their current routine.

FOOTNOTES

1. Stanley Pogrow, "Technological Relevancy and Environmental Collapse," Phi Delta Kappan, forthcoming.

2. For a comprehensive overview, see California Office of Appropriate Technology, The Case for Improving Technological Literacy in California (Sacramento, 1982).

3. These statistics were provided by the President's Commission on Educational Excellence at their public hearing, Stanford, California, March 1982.

4. James Guthrie and Ami Zusman, "Mathematics Teacher Supply and Demand in California," Berkeley, unpublished, 1982. This entire section is derived from their paper.

5. See Michael Kirst, "Loss of Support for Public Schools: Some Causes and Solutions," Daedalus, Vol. 110, No. 3, pp. 53-66.

6. See Decker Walker and Jon Schaffarzick, "Comparing Curriculua," in Review of Educational Research, Vol. 44, No. 1 (1974), pp. 83-112.

7. For these requirements of long term reform impact, see David Tyack, Michael Kirst, and Elizabeth Hansot, "Education Reform: Retrospect and Prospect," Teacher's College Record, Vol. 81, No. 3 (Spring 1980), pp. 253-269.

8. For a fiscal overview, see James Guthrie (ed.), School Finance Policies and Practices: The 1980s -- A Decade of Conflict (Cambridge: Ballinger, 1981).

MINNESOTA WELLSPRING: EDUCATORS AS COLLABORATORS IN SPURRING TECHNOLOGICAL INNOVATION

by

DONNA J. KNIGHT

ABSTRACT

Minnesota Wellspring: Educators as Collaborators in Spurring Technical Innovation

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"Minnesota Wellspring" is the name of a new organization aimed at expanding Minnesota's technological leadership through the collaboration of leaders in labor, business, education, and government. Knight's paper describes the four themes that underpin the Wellspring vision: (1) the potential for economic growth offered by technology-intensive companies; (2) our continuing evolution to an information-based planet; (3) the emergence of the human mind as a critical resource; and, (4) the necessity for developing new styles of leadership. She then relates this vision to the action areas and accomplishments of Wellspring, including such areas as increasing the responsiveness of educational institutions to the skill and knowledge demands of modern jobs. She concludes with specific initiatives currently underway and Edward Abbey's reminder that, "if enlightenment fails, we have always the traditional solution - disaster - to fall back on."

Donna J. Knight
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MINNESOTA WELLSPRING:

Educators as Collaborators in Spurring Technological Innovation

"Minnesota: Wellspring of Science and Technology" was the title of an article commissioned for the October, 1980 issue of Scientific American. It described the growth of Minnesota as a world center for technology, focusing on the synergistic development of computer-related business in the state after World War II. Minnesota, the article implied, has provided a fertile ground for innovative individuals determined to build businesses out of creative ideas.

"Minnesota Wellspring" is now the name of a new organization aimed at expanding Minnesota's technological leadership and thereby increasing the number of new jobs. Twenty-seven leaders in labor, business, education and government created the project and comprise its Board of Directors. The name "Minnesota Wellspring" derives from one of the state's virtues--bountiful, lifegiving water. In a broader sense, the wellspring image represents the element essential to all creative endeavors--the intuitive human mind.

This paper will describe the Minnesota Wellspring project. The Wellspring organization is in its infancy: it's first anniversary will be on September 28, 1982. Since the project is so new--and so creative--the specifics of its agenda are still emerging. Therefore, the emphasis of this narrative is to describe the visionary underpinnings of the effort, including how education fits into the process and content of the group's activities. Minnesota Wellspring is a voluntary and serious collaboration of leaders in labor, business, education, and government who share a vision of the future and intend to work together to act on those beliefs. It is hoped that this paper will serve to illuminate that vision and illustrate those activities.

* * *

The Wellspring Vision

> "The dogmas of the quiet past are inadequate to the stormy present. The occasion is piled high with difficulty and we must rise with the occasion. As our case is new, so we must think anew and act anew."
> -Abraham Lincoln

To understand Minnesota Wellspring is to grasp its vision, a vision portending change in our fundamental understanding of reality. Because the Wellspring project is new, its vision helps provide cohesion among the disparate individuals from labor, business, education, and government involved in its activities. The view of the future espoused by Wellspring is based on four themes: (1) the potential for economic growth offered by technology-intensive companies; (2) our continuing evolution to an information-based planet; (3) the emergence of the human mind as a critical resource; and (4) the necessity for developing new styles of leadership.

* * *

Technology-Intensive Companies and Economic Vitality

> "The potentialities of invention and enterprising individuals are now greater than ever before in human history."
>
> -George Gilder

Entrepreneurial activity is a driving force in America's economy. A 1979 study by David Burch revealed that firms with fewer than 20 employees create 60% of all new jobs.[1] These small companies also tend to produce--rather than use--innovation; in fact, about 74% of all technological innovation occurs in small firms.[2] It is estimated that half of all Americans work in jobs related to information technologies. The number of technology-based jobs in Minnesota has grown two and one-half times more since 1950 than the number of jobs in the manufacturing sector. High-growth companies in pioneering technologies are found in the fields of semi-conductors, software, computers, bioscience, telecommunications, and robotics. All employ engineers, scientists, and technicians in key roles.

High-technology businesses create new markets continuously. They are like an engine gathering momentum, feeding on new knowledge and churning out an ever-expanding mix of innovations. Technology-intensive companies have emerged as unquestioned leaders in the growth of real output, productivity, and employment. Moreover, the innovations spawned by mail businesses offer established companies ways top reduce costs through improved productivity.

Our economic prosperity depends on our ability to innovate. And innovation springs directly from a creative mind seeking a better way.

* * *

Evolution to an Information Age

> "Information is succeeding capital as our major resource."
>
> -Jean Jacques Sevan-Schreiber

We are entering a new era. Information is the organizing principle in this new age. The transformation now occurring is likely to be the biggest shake-up since the Industrial Revolution, in which energy was the organizing principle.

The industrial era was characterized by the physical influence of humans over inanimate objects. The information era, in contrast, features an increase in humanity's power to think and to organize. The information society does not replace--it overlaps--the manufacture and distribution of tangible goods. Its influence helps agriculture and industry progress by doing more with less.

In addition to playing a facilitative role in the economy, information is coming to be regarded as a resource in itself. Information as a resource, however, possesses some very unusual qualities:[3]

1. Information is non-depletive. In fact, it is not only renewable, it is expandable. Information grows as it used.

2. Information is abundant rather than scarce. Time may be scarce, but information is not.

3. An information society is not resource-hungry. The production and distribution of information are comparatively sparing in their requirements for energy and other physical sources.

4. The inherent tendency of information is to leak. Although it is almost impossible to monopolize information, we have tended to treat it as another source of property to be protected and owned. However, the "technologies of leak" are gaining.

5. Information gives rise to sharing transactions rather than exchange transactions. An information-rich environment is a sharing environment. It is not zero-sum in nature.

We live in a world depending less on the allocation of scarce resources than on the sharing of expandable resources. Our conventions, codes, rules, and standards, however, are no longer adequate to accommodate a resource that it neither depletive nor scarce.

* * *

Brainpower as a Resource

"The technology of information is based on people. The first factor of economic development is the development of people."
-Jean Jacques Sevan-Schreiber

The major resource needed to get ahead in the information age is bright, educated, motivated, hardworking people. Technological innovation requires permanent and collective pursuit of knowledge. In fields where advances in hardware are instantly copied and soon surpassed, the use of brain power will separate the leaders from also-rans. The spirit needed for economic growth in the 1980's will require the creation of an environment which stimulates and rewards creativity.

Education plays a major role in the information era, for it can help develop the infinite resource--the creative mind. Public education systems were not developed because the government is generous: schools were established because America needs educated people. Our best investment in the information age is in ourselves--in the capacity of citizens to make ideas prosper. To accomplish this will require a major change in our educational world view. The problem is only partly to upgrade skills that are essential in an innovation-rich society. We must also learn to integrate as well as analyze, to use our intuition as well as our calculators, to seek wisdom as well as facts, and to chop knowledge apart as well as to thread different kinds of knowlege together.

Access to information will become a critical factor in the era of innovation. Herbert Simon maintains that developments in science and information have changed the meaning of the verb "to know" from: "having information stored in one's brain," to: "the process of having access to information".[4] Ignorance of computers will render people functionally illiterate. Computer-literate citizens are as important to an information society as were raw materials and energy in an industrial society.

The problems of the economy, science, education, and information technologies are interdependent. A sound and effective educational system is essential to economic vitality. Science-driven innovations spur the economy and create new jobs. Technologies increase productivity but require a more skilled and professional labor pool with a broad education and a greater familiarity with the tools of science. To wit:

- Much of the knowlege used in developing innovations tends to be based on information received during an entrepreneur's formal education.[5] Therefore, scientific knowledge does not become an available good until it is part of the education curriculum.

- The lack of trained workers already presents a serious obstacle to economic growth. Rising unemployment is even now accompanied by shortages of electronics technicians, computer specialisits, and engineers. This gap between supply and demand is predicted to widen.

- We spend huge sums of public dollars for education and training, yet failed to recognize math and science as fundamental employment requirements, releasing generations of students into the job market ill-prepared for high-demand jobs.

America is at a watershed. To "try harder" is not the answer. Instead, we need to find ways to expand the human capacity to "work smarter". We will meet the challenges of the next few years only by combining capital-intensive technologies with a redeveloped labor force, a recharged entrepreneurial spirit, and a belief that we can achieve what has yet been done.

* * *

The Necessity for Collaborative Leadership

> "I believe that we are here not to negotiate for ourselves, but to seek our benefit in the common good. Only by eliminating all attitudes of specialness will we find a solution. Consequently, I ask that the very word "negotiation" be abandoned."
>
> -Jean Monnet

Openness is a technological imperative. Collaboration and partnership are linked to a universe based on the sharing of expandable resources, rather than on the allocation of scarce goods and services. Industrial society consumes resources; an information society creates material goods and develops human faculties. The move to an innovation- rich planet will not be made by bringing warring factions together to hammer out agreements from separate sides of a negotiating table. Rather, the arbitration method will of necessity yield to new principles consistent with the changed world-view. Conventions of human interaction in tune with the new era will be based on cooperative ventures, sharing transactions, positive-sum solutions, horizontal organizational structures and a long-term perspective.

New conventions are already apparent. "Theory Z" management styles, the quality of work life movement, landmark union-management contract agreements, employee ownership, and the open egalitarian style apparent in many entrepreneurial ventures offer examples of this evolution.

A new urgency, however, is making itself felt. We are at a time in our economic history when we cannot afford division. America's leadership in electronics has eroded. Our automobile industry is under direct assault. U. S. supremacy in information technologies may be in jeopardy. Rigid adherence to old ways is linked to the illusion of an ever-expanding pie to be eternally divided. Converting natural adversarial relationships into destructive attacks are a luxury we can no longer afford. The labor relations cycle, for example, ought to be one of short periods of conflict--limited to the perod of contract negotiation every two to three years--followed by longer periods of significant cooperation. In short, economic growth can no longer be taken for granted. It must be worked for.

John Gardner, in a recent address at the Hubert Humphrey Institute of Public Affairs, discussed the need for the development of new leadership styles:

> "A high proportion of leaders are rewarded for single-minded pursuit of the interests of their group, regardless of the damage it may do the common good. They are rewarded for doing battle, not for compromising. But suppose that the one-segment leader came to be regarded as distinctly inferior to the leader, who, without forgetting the goals of his own group, also worked with others to resolve conflicts and serve the larger good. Wouldn't tnat move us at least a few steps along the road to coherence as a society?"

Leaders in Minnesota Wellspring have made a commitment not only to work for economic improvements, but also to work with each other. They are finding ways to accept responsibility for the common good without losing their constituent affiliation. The challenge for Wellspring principals is to develop a consensus-forming framework through which labor, business, education, and government--without losing their separate identities--can undertake initiatives to strengthen the economy and thereby benefit the whole. Minnesota Wellspring has been called "the marriage of the century." The Wellspring vision calls on all Minnesotans to join forces to ensure economic vitality for generations to come.

* * *

The Wellspring Project

> "First comes the dream and then the reality."
> -Hubert Humphrey

> "You can talk and talk and talk,
> But then you have to do it."
> -William C. Norris

Romanticism is like a military band: it helps you want to go to war, but is useless in the trenches. So too is a vision unaccompanied by accomplishments. Minnesota Wellspring, while based on an almost spiritual vision of the future, is designed to be a catalyst for action. Wellspring principals are doers, creators, risk-takers. They are entrepreneurs in a "why not" organization aimed at making things happen.

Minnesota Wellspring was inaugurated at a premiere dinner on September 28, 1981. The event sold out at 750 participants. Minnesota Wellspring is legally constituted as a non-profit corporation. Wellspring is not a government agency, an industrial development commission, nor a gubernatorial task force, but rather a <u>voluntary collaboration</u> of persons in labor, business, education, and government. Its Board of Directors is comprised of 27 well-known leaders who believe in the information-based vision of the future and in their own capacity work together for the common good. Board members-many of whom are adversaries of long-standing--are firmly committed to demonstrating the viability of Wellspring goals. Clearly, the most unique aspect of the project is that it brings together, under one umbrella, leaders whose economic and political philosophies have often been at odds. Co-chairmen of the project come from labor and business respectively, and the Governor serves as honorary chairman. A roster of the Board of Directors is included in the Appendix.

Funding for Minnesota Wellspring comes from public and private sources. A $70,000 grant from private donors, matched with one of like amount by the Minnesota Department of Energy, Planning and Development, provides seed money and basic operating expenses for fiscal years 1982 and 1983. Additional funding is solicited through the sale of individual and corporate memberships. Full-time staff on the Wellspring payroll are supplemented by loaned executives, college interns, and adjunct researchers from state government.

The Wellspring Board has identified five areas for action:

1. <u>Technology and Job Creation</u>

   - Expand the number and variety of job created through the establishment and growth of technology-intensive companies.

   - Promote resource efficiency and productivity through technological innovation.

   - Make increased capital available for innovation and the introduction of new technologies in the marketplace.

   - Direct investments at bringing a return to the state by promoting research and development and the application of technologies in both new and mature businesses.

2. Technology Transfer

- Encourage necessary expenditures for innovation to help maintain our technological edge.

- Link the findings of academic research and development more closely to technological innovations that contribute to economic progress.

- Increase interactions between academic and company researchers.

- Encourage the transfer of promising but unutilized technologies developed in large corporations to entrepreneurs who may, in turn, introduce them into the marketplace.

3. Technology in the Workplace

- Devise methods to assist workers and their employers to anticipate changes in technologies by continuously acquiring new skills.

- Improve the match between the supply of and demand for workers.

- Develop policies to maximize workers' contribution to technological innovation, while minimizing threats to continued employment.

4. Technology and Education

- Increase the responsiveness of educational institutions to the skill and knowledge demands of modern jobs.

- Assist the educational system to develop fully the human resources entrusted to their care by taking advantage of new opportunities to improve learning.

- Stimulate the market for hardware and software components produced in Minnesota for education.

5. Technology and Public Understanding

- Enable citizens to better understand and take advantage of the increased capabilities offered by technological innovation.

- Stimulate increased collaboration among a broad range of Minnesotans by fostering innovation activities aimed at creating jobs.

Nine committees have been formed to address issues in the five general areas for action outlined above. Each committee is chaired by a Board member and consists of other Wellspring principals as well as persons with relevant expertise invited to serve. (It should be noted that over 300 people have formally indicated interest in participating in Wellspring committees and comprise an already powerful and far-reaching network.) A description of the committees is contained in the Appendix.

Criteria for determining Wellspring activities are consistent with organizational goals and working style. The decision guidelines are:

1. Wellspring projects should demonstrate collegiality and creative collaboration across activity and interest sectors. Activities should be undertaken in partnership with other organizations and build linkages among persons in business, labor, education, and government.

2. Projects selected by Wellspring should:

   a. Support viable or promising projects already in place; or

   b. Build on work occurring elsewhere; or

   c. Bridge gaps where no one else has been able to meet an identified need.

3. Wellspring should focus its efforts on those activities which are the most critical in stimulating the development and application of technology for Minnesota-based jobs.

4. "Technology" should be broadly defined as the process encompassing the inception of an idea to its application in the workplace.

5. Wellspring actions should emphasize the entrepreneurial and collaborative spirit, and should demonstrate innovation, flexibility, and creativity.

A number of concrete accomplishments have already been achieved by Minnesota Wellspring committees. They include:

1. Passage of a new provision by the 1982 Legislature to allow tax credit for investments in seed capital to provide early-stage financing for new high-technology companies.

2. A low-interest business loan program for companies pledging to create jobs on the Minnesota Iron Range, financed with taconite royalty funds.

3. A workshop on business-school partnership for educators detailing practical ways to collaborate and negotiate with business people.

4. Formation of formal groups to critique educators' grant proposals aimed at improving technological applications in school districts.

5. Participation in a special effort to study Minnesota's economy and public finance system.

Planning is also underway for a major education conference highlighting practical applications for new technologies in education, a comprehensive strategy to develop a "Wellspring Agenda" for use with legislators, public pension fund investments in seed/venture capital and other programs to benefit Minnesota entrepreneurs, and expansion of the current network for technology transfer.

In addition to committee work, Wellspring has initiated a number of other activities. A multi-media show which depicts the unique relationship of Minnesotans to science and technology has been shown to a variety of groups. Speeches are given on topics relating to Wellspring interests. First-round business planning help is provided to entrepreneurs who are then referred to other sources of assistance. A directory of technical and financial assistance available to business persons has been published and given to the public libraries in the state. A guidebook to assist inventors with promising ideas has been distributed. Briefing sessions with elected and appointed officials have been held; more are planned. A summary of systemic obstacles to change and promising strategies for improvement in math and science instruction in Minnesota schools has been prepared. Finally, (at least at the time of this writing), efforts are slated to assist local leaders in labor, business, education, and government throughout the state organize initiaties to improve the future of their towns and regions.

A busy and diverse group? Absolutely! Wellspring's goal is to mobilize support from all facets of the state's economy for more and better jobs. No single interest dominates, no one-item agenda prevails. This reflects the inherent interrelationships among the factors in economic development. It also, however, serves to maintain the inclusive political and philosophical base of Wellspring. Each Wellspring initiative will demonstrate that collaboration among labor, business, education, and government can and will work.

Wellspring calls Minnesotans to look with improved vision that new technologies make possible, through eyes with a wider lens and more focal length. It discourages the indulgent myopia of our predecessors. If Wellspring can give Minnesotans a believble view of a positive future, it will garner support for institutions charged with developing brainpower for the new age.

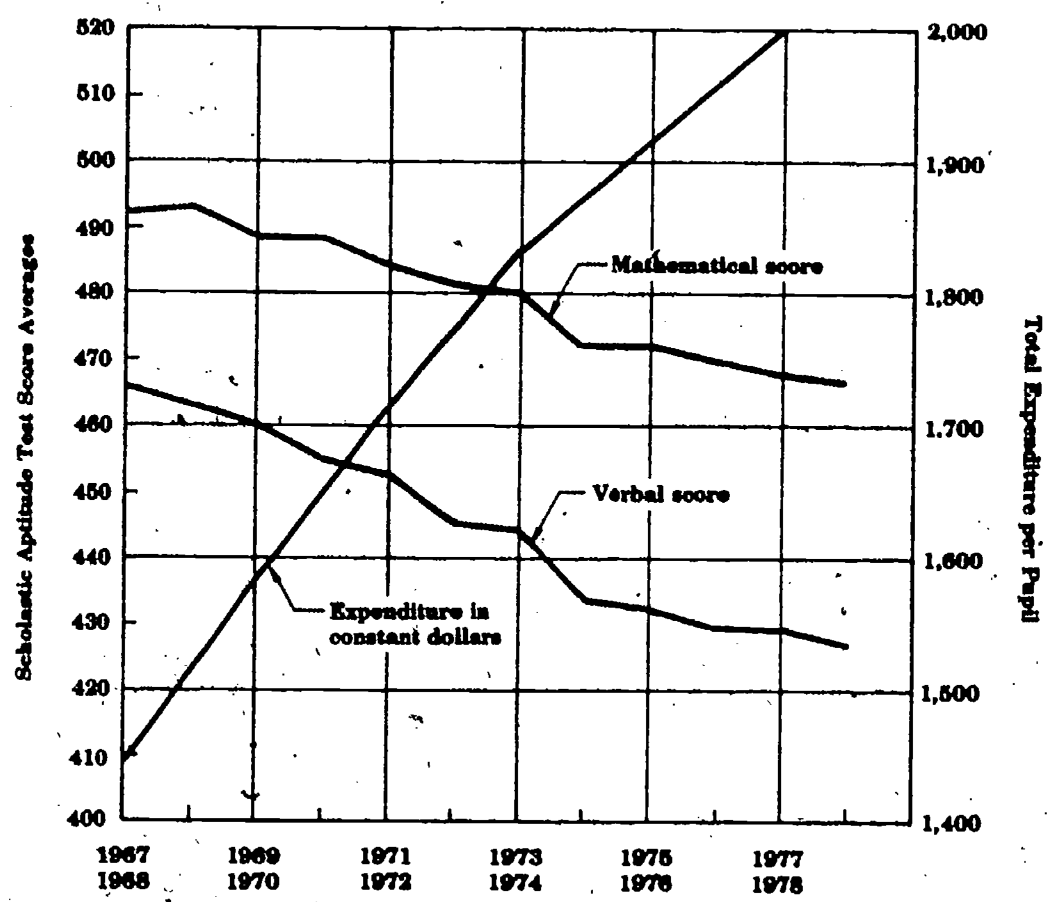
Nay-sayers would advise us to do nothing, cautiously. There is the story of the computer who ran, unsuccessfully, to catch his train. On arriving late, he commented, "If I had run faster, I would have made it." A bystander commented, "No, if you had started sooner, you would have made it." Wellspring participants are clearly on the side of starting sooner. They would agree with Edward Abbey's observation: "If enlightenment fails, we have always the traditional solution--disaster--to fall back upon."

APPENDIX A

APPENDICES FOR: FORECASTING NEEDS: THE HIGH TECHNOLOGY INDUSTRY

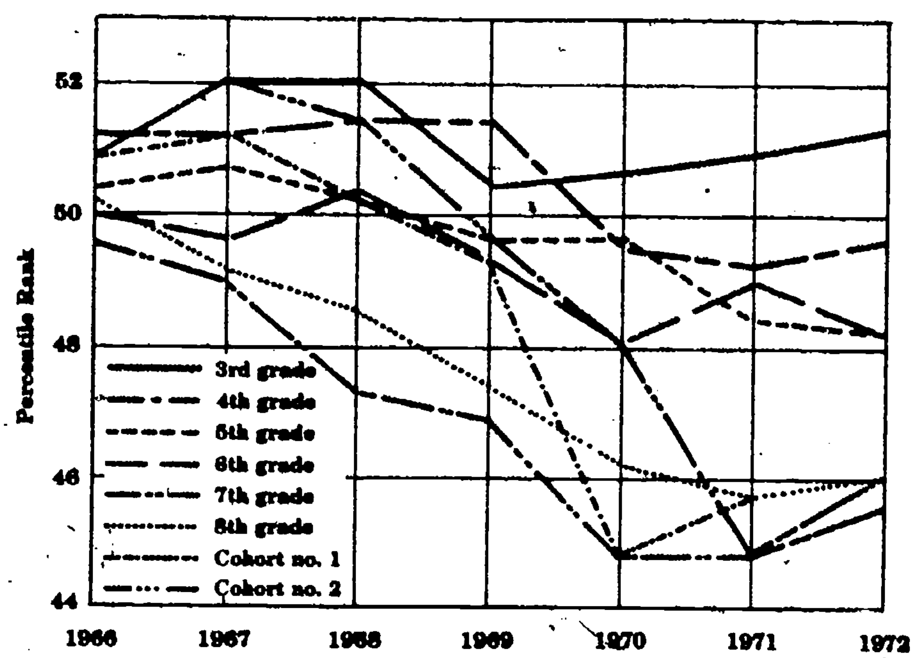
BY: ROBERT HENDERSON

Figure 1
SCHOLASTIC APTITUDE VERSUS EXPENDITURE
1967-1968 TO 1978-1979



Source: National Center for Education Statistics, "Digest of Education Statistics", 1980.

Figure 2
READING SKILL PROGRESS OF PUPIL COHORTS AND TRACES OF READING ACHIEVEMENT SCORES FOR 3RD THROUGH 8TH GRADES, IOWA, 1966-1972
1965 "Base-Year" Percentile Ranks*

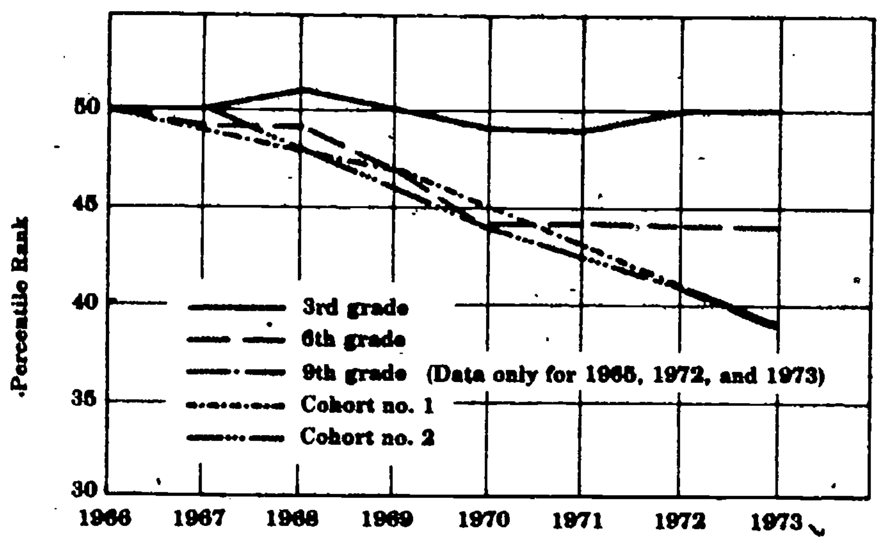


Source: Iowa Basic Skills Testing Program. As reported by Frank E. Armbruster in "Our Children's Crippled Future. How American Education Has Failed."

**The fiftieth percentile point for each grade in 1965 is the starting point.*

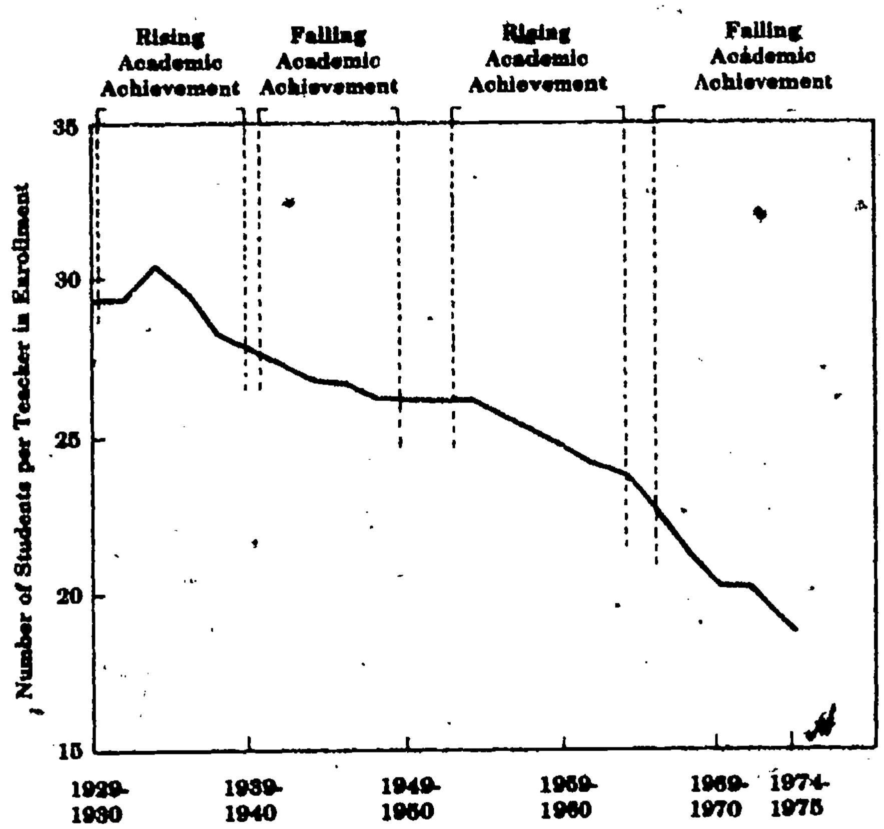
A-2

Figure 3
READING SKILL PROGRESS OF PUPIL COHORTS AND TRACES OF READING ACHIEVEMENT TEST SCORES FOR PUBLIC AND PRIVATE SCHOOLS, 3RD, 6TH, AND 9TH GRADES, NEW YORK STATE, 1966-1973
(Percentile Rank of Median Raw Scores, Pupil Evaluation Program, Base Year 1965)



Source: New York State Pupil Evaluation Program. As reported by Frank E. Armbruster in "Our Children's Crippled Future. How American Education Has Failed."

Figure 4
CLASSROOM SIZE VERSUS SAT SCORES



Source: Frank E. Armbruster with Paul Bracken, "Our Children's Crippled Future. How American Education Has Failed."

Table 1
COMBINED AEA AND MHTC DATA—UNITED STATES

Total, All Categories

Current	1981	1983	Projection Totals	Annual Compounded Growth Rate
286,663	**63,025**	**100,861**	**163,886**	**16.2%**

Number of Employees*

Technical Professional Categories †	Current	Projected		Projection Totals	Annual Compounded Growth Rate, percent
	1980	1981	1983		
Number of facilities reporting	**(671)**	**(615)**	**(637)**		
Engineers					
Electronics/electrical	**45,662**	**10,436**	**13,748**	**24,184**	**15.2**
Mechanical	**13,617**	**2,582**	**3,607**	**6,189**	**13.3**
Manufacturing/industrial	7,503	1,519	2,249	3,768	14.6
Electronic engineer technologist	3,709	1,074	1,449	2,523	18.9
Computer professionals					
Software engineer	**17,103**	**5,127**	**8,286**	**13,413**	**21.3**
Analyst/programmer	8,936	2,354	4,024	6,378	19.7
Other computer professionals	5,996	1,726	2,638	4,364	20.0
Other technical professionals	**43,408**	**5,378**	**7,900**	**13,278**	**9.3**
Total technical professionals	**145,934**	**30,196**	**43,901**	**74,097**	**14.7**

* Combined AEA-MHTC data is in bold print. All other figures report AEA data only.

† **Technical Professionals:** Those who hold jobs which require a bachelor's, master's, or doctorate degree or experience of such kinds and amounts as to provide a comparable background.

Source: American Electronics Association, "Technical Employment Projections of Professionals and Paraprofessionals", 1981-1983-1985

Table 2
PROJECTED ENGINEERING DEGREES—1976-1987

Year	B.S. in Engineering	B.S. in Technology	M.S. in Engineering	Doctorate in Engineering
1976-77	44,930	8,090	16,350	2,810
1977-78	53,990	8,580	16,230	2,800
1978-79	57,400	9,350	16,280	2,770
1979-80	61,190	9,870	16,290	2,750
1980-81	61,410	10,310	16,410	2,740
1981-82	61,290	10,700	16,400	2,690
1982-83	60,960	11,040	16,430	2,650
1983-84	60,490	11,390	16,440	2,620
1984-85	59,610	11,600	16,410	2,580
1985-86	58,310	11,750	16,350	2,550
1986-87	56,660	11,900	16,280	2,500

Source: NCES (Prepared by Task Force members of AAES, ASME, and ASEE.)

Note: NCES estimates exceed the actual count of awarded degrees made by EMC by 10 percent or more.

Table 3
GROWTH PROJECTIONS BY COMPANY SIZE
UNITED STATES

	Technical Professionals			Technical Paraprofessionals		
Number of Employees	1980	Projected Increase 1981-1985	Annual Compounded Growth Rate, percent	1980	Projected Increase 1981-1985	Annual Compounded Growth Rate, percent
1-50	972	5,709	47.0	1,033	9,095	57.9
51-100	1,779	5,610	32.9	2,305	10,088	39.9
101-200	3,123	6,409	25.0	3,333	8,705	29.3
201-300	1,743	-3,090	22.6	3,581	7,199	24.7
301-400	2,413	2,994	17.5	2,495	5,075	24.9
401-500	2,542	2,551	14.9	3,551	4,962	18.8
501-1,000	8,913	9,270	15.3	11,299	9,696	13.2
1,001-2,000	13,570	13,999	14.9	22,431	25,002	16.2
2,001-5,000	27,964	14,517	8.9	21,277	12,489	9.7
5,001-10,000	39,267	15,374	6.8	16,631	7,678	7.9
Over 10,000	24,194	16,664	11.0	22,906	13,184	9.6

Source: American Electronics Association, "Technical Employment Projections of Professionals and Paraprofessionals", 1981-1983-1985.

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Table 4
PERCENTAGE OF ENGINEERING GRADUATES TO TOTAL BACHELOR'S DEGREES
(Latest Year Available From UNESCO)

Country	Total Graduates*	Engineering Degrees*	Engineering Degrees, percent*	Population 1978†	Number of Engineering Degrees per 100,000 People
Bulgaria	14,661	5,880	40.4	8,840,000	66.51
Czechoslovakia	22,306	7,212	32.3	15,150,000	47.60
East Germany	43,206	17,356	40.1	16,570,000	104.74
Hungary	11,766	5,535	47.0	10,700,000	51.73
Poland	26,578	10,939	41.1	35,060,000	31.20
Romania	30,839	12,260	39.7	21,630,000	56.68
West Germany	60,436	22,400	37.1	61,250,000	36.60
Japan	315,122	65,422	20.7	114,850,000	56.96
United States	949,000	54,500	5.8	218,525,000	24.9

*Source: *Dallas Morning News*, Paul Kolsa.
†Source: *Information Please Almanac*, 1979.

Table 5
ENGINEERING DEGREES, 1950-1980—UNITED STATES

Year Ending	B.S. Degrees		M.S. Degrees		Doctoral Degrees	
	Foreign Nationals	Total	Foreign Nationals	Total	Foreign Nationals	Total
1950	NA	48,160	NA	4,965	NA	492
1951	NA	37,967	NA	5,134	NA	596
1952	NA	27,155	NA	4,132	NA	586
1953	NA	24,365	NA	3,636	NA	592
1954	NA	22,236	NA	4,078	NA	590
1955	NA	22,589	NA	4,379	NA	599
1956	NA	26,306	NA	4,580	NA	610
1957	NA	31,221	NA	5,083	NA	596
1958	NA	35,332	NA	5,669	NA	647
1959	NA	38,134	NA	6,615	NA	714
1960	NA	37,808	NA	6,969	NA	786
1961	NA	35,860	NA	7,977	NA	943
1962	NA	34,735	NA	8,909	NA	1,207
1963	NA	33,458	NA	9,460	NA	1,378
1964	NA	35,226	NA	10,827	NA	1,693
1965	NA	36,691	NA	12,246	NA	2,124
1966	NA	35,815	NA	13,677	NA	2,303
1967	NA	36,186	NA	13,887	NA	2,614
1968	NA	38,002	NA	15,152	NA	2,933
1969	NA	39,972	NA	14,980	NA	3,387
1970	NA	42,966	NA	15,548	NA	3,620
1971	1,565	43,167	2,930	16,383	741	3,640
1972	1,944	44,190	2,973	17,356	773	3,774
1973	2,136	43,429	2,551	17,152	708	3,587
1974	2,436	41,407	3,090	15,885	1,014	3,362
1975	2,468	38,210	3,260	15,773	891	3,138
1976	2,790	37,970	3,628	16,506	1,060	2,977
1977	2,906	40,095	3,835	16,551	965	2,813
1978	3,084	46,091	3,720	16,182	874	2,573
1979	3,786	52,598	4,096	16,036	929	2,815
1980	4,896	58,742	4,512	17,243	982	2,751

Data for 1950-52 taken from Facilities and Opportunities for Graduate Study in Engineering, Amer. Soc. for Engrg. Educ., Washington, D.C., March 1956. Data for 1953-70 supplied by Engineering Manpower Commission, New York, N.Y. Data for 1960-79 taken from Engineering Manpower Bulletin No. 50, Nov. 1979, Engineers Joint Council, New York, N.Y. 1980 data taken from Engineering Manpower Commission data. (Prepared by Task Force members of AAES, ASME, and ASEE.)

Table 6
COMBINED AEA AND MHTC DATA—UNITED STATES

Number of Employees*

Paraprofessional/Technician Categories†	Current	Projected		Projection Totals	Annual Compounded Growth Rate, percent
	1980	1981	1983		
Number of facilities reporting	(671)	(591)	(606)		
Technicians and aides					
Applications programmer	**2,227**	**759**	**1,203**	**1,962**	**23.4**
Engineering aide	3,339	747	1,261	2,008	17.0
Master/super technician	4,061	942	1,429	2,371	16.6
Electronic technician	**18,912**	**4,254**	**7,628**	**11,882**	**17.6**
Jr. technician/tester	4,874	1,367	2,455	3,822	21.3
Field service technician	**10,453**	**2,623**	**4,531**	**7,154**	**19.0**
Micro-electronic technician	510	139	245	384	20.8
Laser technician	176	100	127	227	31.8
Assembler/operator	**65,896**	15,744	**28,758**	**44,502**	**18.8**
Drafters					
Drafter	3,757	1,204	1,714	**2,918**	**21.0**
Design drafter	**2,723**	**806**	**1,125**	**1,930**	**19.6**
Machinists					
Machinist	5,833	855	1,296	2,151	11.0
Other paraprofessional/technicians	**19,948**	**3,290**	**5,188**	**8,478**	**12.5**
Total paraprofessional technicians	**142,729**	**32,839**	**56,960**	**89,790**	**17.7**

*Combined AEA-MHTC data is in bold print. All other figures report AEA data only.

†**Paraprofessional/technicians:** Those who hold jobs which require a combination of knowledge of basic theory and manual skills obtained through 2 years of community college, vocational school, or equivalent on-the-job training.

Source: American Electronics Association, "Technical Employment Projections of Professionals and Paraprofessionals, 1981-1983-1985."

Table 7
SUMMARY OF ENROLLMENT IN EDUCATIONAL INSTITUTIONS*, WITH PROJECTIONS, BY LEVEL OF INSTITUTION
(Fall 1970 to Fall 1988)

Enrollment (thousands)

Fall of Year	Total Enrollment	Elementary Schools (grades K-8)	High Schools (grades 9-12)	Institutions of Higher Education
1970	59,899	36,636	14,632	8,581
1971	60,152	36,068	15,116	8,948
1972	60,000	35,560	15,216	9,215
1973	59,962	34,999	15,380	9,603
1974	60,340	34,584	15,532	10,224
1975	61,063	34,174	15,704	11,185
1976	60,507	33,768	15,727	11,012
1977	59,955	32,951	15,720	11,284
1978	58,948	32,061	15,628	11,259

Enrollment Projection (thousands)

Fall of Year	Total Enrollment	Elementary Schools (grades K-8)	High Schools (grades 9-12)	Institutions of Higher Education
1979	58,129	31,376	15,245	11,508
1980	57,383	30,974	14,797	11,611
1981	56,603	30,614	14,296	11,696
1982	55,695	30,217	13,808	11,670
1983	55,381	30,273	13,495	11,613
1984	55,122	30,208	13,422	11,492
1985	55,111	30,257	13,496	11,358
1986	55,292	30,675	13,402	11,215
1987	55,576	31,369	13,103	11,104
1988	55,938	32,223	12,667	11,048

**Includes public and private institutions.*

Note: Details may not add to totals because of rounding.

Source: U.S. Department of Health, Education and Welfare, National Center for Education Statistics, "Projections of Education Statistics to 1988-89", 1980.

Table 8
MEAN AMOUNTS BY WHICH READING GRADES OF 1937 PUPILS AT A PARTICULAR GRADE LEVEL EXCEEDED READING GRADES OF 1957 PUPILS
(Expressed in Tenths of Reading Grade)

Grade	Mean	Grade	Mean
3.5	0.07	6.0	0.21
4.0	0.09	6.5	0.24
4.5	0.11	6.9	0.25
5.0	0.14	7.5	0.28
5.5	0.18	8.5	0.34

Source: Arthur I. Gates, "Reading Attainment in Elementary Schools: 1957 and 1937." Teachers College Press, 1961, p. 20. As reported by Frank E. Armbruster in "Our Children's Crippled Future. How American Education Has Failed."

Table 9
DISTRIBUTIONS OF IOWA HIGH SCHOOL PUPIL SCORES

Subject Matter Test	1934 Group Mean	1954 Group Mean	Differences
1934 9th Year Algebra	14.3	10.9	3.4
1934 General Science	43.9	42.9	1.0
1934 English Correctness (9th Grade)	61.9	45.6	16.3
1934 United States History	42.4	37.3	5.1
1933 United States History	47.0	39.3	7.7

Source: *Joseph R. Sligo, "Comparison of Achievement in Selected High School Subjects in 1934 and 1954," Ph.D. dissertation, State University of Iowa, p. 152. As reported by Frank E. Armbruster in "Our Children's Crippled Future: How American Education Has Failed."*

APPENDIX B

APPENDICES FOR: MINNESOTA WELLSPRING: EDUCATORS AS COLLABORATORS IN SPURRING TECHNOLOGICAL INNOVATION

BY: DONNA KNIGHT

MINNESOTA WELLSPRING

BOARD OF DIRECTORS

Albert H. Quie, Honorary Chairman
Governor
State of Minnesota

Raymond Plank, Co-Chairman
Chairman & Chief Executive Officer
Apache Corporation

David Roe, Co-Chairman
President
Minnesota AFL-CIO

Wendell Anderson
Attorney
Larkin, Hoffman, Daly & Lindgren, Ltd.

Richard Caldecott
Dean, College of Biological Sciences
University of Minnesota

Harlan Cleveland
Director, Hubert H. Humphrey Institute of Public Affairs
University of Minnesota

Willis Drake
Chairman
Data Card Corporation

Phil Duff
Editor
Red Wing Republican Eagle

Kent Eklund
Commissioner
Minnesota Department of Energy, Planning and Development

Gleason Glover
Executive Director
Minneapolis Urban League

Dan Haggerty
President
Northwest Growth Fund, Incorporated

John Himle
State Representative
District 39B

William Hueg
Deputy Vice President and Dean
Institute of Agriculture, Forestry & Home Economics
University of Minnesota

Walter Johnson
Chairman & Chief Executive Officer
Conn-Co

Jack Jorgensen, Sr.
President
Teamsters Joint Council #32

Phyllis Kahn
State Representative
District 57A

Eugene Kotz
Dean, Graduate Programs in Management
Saint Thomas College

George Latimer
Mayor
City of St. Paul

Carlos Luis
Vice President of Public Affairs
3M

Richard McFarland
President
Inter-Regional Financial Group Inc.

Roger Moe
State Senate Majority Leader
District 2

Lloyd Nielsen
Superintendent
Roseville School District No. 623

Hazel Reinhardt
Vice President & Director of Human Resources
Minneapolis Star & Tribune

John Rollwagen
Chairman & Chief Executive Officer
Cray Research Incorporated

Richard Shepley
Vice President & Deputy Group Head
First Bank of St. Paul

Roger Staehle
Dean, Institute of Technology
University of Minnesota

Eugene Trumble
President
Trumble & Associates

Donna Knight, Executive Director
Minnesota Wellspring

PROGRAM STATEMENT

THE MOTIVATION

Minnesota is one of the world's important centers for technology. Out of scientific research and technological innovation have come new jobs—quality jobs that constitute one of the great strengths of our state's economy.

A variety of factors have brought Minnesota to its current position of leadership. While some have been fortuitous, most have been the product of vision and deliberate action. Minnesota's strengths include a superior pool of skilled labor, entrepreneurial vitality based on interaction between enterprising people and their businesses, an excellent educational system, a strong agricultural community, and enlightened leadership by state and local governments.

However, things have changed. Economic growth does not come as easily or as automatically as it once did. Interdependence is a reality of the times, linking our decisions and activities as never before. Our country is engaged in heightened economic competition with other countries, and our state with other states.

There are disturbing signs that Minnesota's economy is not as resilient as we assumed. Our state is no longer immune from national economic downturns. We are undergoing changing patterns of business growth. Companies have closed plants, causing displacement of workers and economic losses to communities. Established businesses have left our state, taking jobs with them. Entrepreneurs report escalating difficulty in starting and maintaining viable small companies. The skills of many workers seeking employment do not match the requirements of available well-paying jobs.

The fact is unavoidable. The steps we take now, or fail to take, to vitalize Minnesota's job climate and economic wellbeing will define our quality of life for the rest of the century. Minnesota's situation is not desperate, nor is the immediate future necessarily grim. However, we must act with disciplined urgency while time is on our side, rather than on the side of erosion, if Minnesota is to remain conducive to innovation.

THE GOAL

Minnesota Wellspring is a project intended to help us expand our technological leadership and increase the generation of new jobs. The name, "Minnesota Wellspring," derives from one of our state's great virtues: bountiful, life-giving water. In a broader sense, Wellspring represents the perpetual renewal of our physical, human and spiritual gifts.

Minnesota Wellspring is a forward-thinking, action organization. Its goal is to mobilize Minnesota-based support for new and better jobs through imagination, scientific discovery, technological innovation, business growth, and wise public policy.

Minnesota Wellspring is based on the belief that the processes and products of technology, and its civilized advance, hold great promise for Minnesota. This conception of technology is one that springs from a human source and results in human benefit.

In a sense, Minnesota Wellspring is a generator: its aim is to enhance, vitalize, and energize economic development. It is not a free-standing source or wielder of power. Nor is it another layer of government. Rather, Minnesota Wellspring, as the collaborative creation of labor, business, agriculture, education and government, will marshal the special talents of each of these institutions.

THE CALL TO ACTION

Twenty-seven leaders in labor, business, agriculture, education and government have created the Minnesota Wellspring. They comprise the first Executive Committee which is co-chaired by a labor and a business leader. Governor Quie, as incumbent governor, is Honorary Chairman.

Wellspring is an infant organization preparing for a lengthy life. Its success will be measured ultimately by the real jobs it helps create. Minnesotans should rightfully have great expectations for Wellspring, but should also recognize the need for the meticulous formation of a comprehensive and long-term project.

One of Minnesota Wellspring's first activities is the Technology Options Project (T.O.P.) housed in the Minnesota Department of Energy, Planning and Development. T.O.P. will provide research to explore how public policy can best be shaped to support technology-powered job development and economic growth.

Other Wellspring projects will be designed and conducted through special task forces and committees. Their specifics will be determined by the foresight of the men and women who will bring life to the idea of Minnesota Wellspring.

Qualitative growth can no longer be taken for granted, it must be worked for. Minnesota Wellspring extends an invitation to each person to become part of a new and creative impetus into the twenty-first century.

MINNESOTA WELLSPRING: COMMITTEES

TECHNOLOGY AND JOB CREATION

Capital Formation and Investment

Goal: To work with the investment community to help create jobs and improve technology transfer in Minnesota.

Strategy:
- Increase the pool of seed capital for early-stage business financing.
- Assist and strengthen organizations which provide assistance to entrepreneurs.
- Explore the feasibility of investing pension funds in ways that assist small businesses.

Chairman: Richard McFarland

Innovation and New Companies

Goal: To increase the number of jobs created by small, high-growth companies and improve the climate for entrepreneurial innovation.

Strategy:
- Identify the barriers faced by entrepreneurs and work to reduce them, especially through better use of existing resources.

Chairman: John Rollwagen

TECHNOLOGY TRANSFER

Technology Transfer

Goal: To facilitate the transfer of technology from the University of Minnesota to the marketplace.

Strategy:
- Establish procedures for the transfer of technology from the University of Minnesota.
- Improve the working relationships between University personnel and business people.
- Assist academic researchers who wish to market their ideas through sale, licensure, or by starting their own companies.

Chairman: Bill Drake

TECHNOLOGY TRANSFER (continued)

Biotechnology Center

Goal: To stimulate cooperative research and to facilitate the transfer of technology in medical, chemical, biological, agricultural, pharmaceutical, and energy fields.

Strategy: ·Establish a research center which brings together bioscientists from the academic and business sectors in cooperative projects.

Chairman: Richard Caldecott

Minnesota Energy Resource Center

Goal: To develop Minnesota's market potential as an energy resource and conservation state.

Strategy: ·Participate in the planning group aimed at establishing a center to:

- Identify and link appropriate actions
- Promote research and development of renewable energy and energy conservation technologies
- Develop a strong market infrastructure for energy conservation technologies and indigenous energy production.

Chairman: Kent Eklund

TECHNOLOGY IN THE WORKPLACE

Labor Force Supply and Demand

Goal: To improve the effectiveness of the "fit" between the supply of workers and the demand for skills by technologically-oriented employers.

Strategy: ·Assess and compare the workforce skills needed by technology-intensive companies and the response of education and training institutions to those needs.

Chairman: Phyllis Kahn

TECHNOLOGY AND EDUCATION

Partners in Learning: Practical Applications of New Technologies in Elementary-Secondary Education

Goal: To accelerate the practical application and demonstration of technology in elementary and secondary school instruction, seeking to both increase the achievement of students and to stimulate the market for components produced by Minnesota.

Strategy:

- Accelerate the application of technology in education by developing and demonstrating creative use of hardware and software.
- Improve the technology of education by developing more effective course design and delivery adapted to the learning needs and styles of individual students.
- Develop school improvement projects which demonstrate the relationship between technology and education.
- Encourage collaboration among business, labor, education, and government in developing projects to improve the economy.

Chairman: Lloyd Nielsen

Entrepreneurial Management

Goal: To develop the kind of entrepreneurial manager necessary to promote the ongoing creative growth, especially in large organizations.

Strategy:

- Design new kinds of educational and training programs for managers.

Chairman: Eugene Kotz

TECHNOLOGY AND PUBLIC UNDERSTANDING

Public Information and Involvement

Goal: To stimulate increased collaboration among a broad range of persons in labor, business, education, and government in job-creating activities to benefit Minnesota.

Strategy:

- Increase interaction of Minnesota Wellspring with other organizations.
- Develop ways for broad public involvement in Wellspring activities.
- Produce and disseminate informational materials, print and non-print.
- Design ways in which Wellspring activities can identify and build on Minnesota strengths.
- Expand and strengthen the "Minnesota Strategy".

Chairman: Harlan Cleveland

APPENDIX C

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APPENDIX D

Obstacles to Change in Minnesota's K-12 Schools

By: Donna Knight

IMPROVING MATH/SCIENCE EDUCATION:

PART ONE:
Obstacles to Change in Minnesota's K-12 Schools

1. Inadequate Teacher Supply

1972-1980 in Minnesota:
- Number of new math teachers down: 84%
- Number of new physical science teachers down: 82%
- Number of new physics teachers down: 100%
- Number of new chemistry teachers down: 83%

In Minneapolis, beginning of 1980-81 year:
- 5 unfilled math positions
- 3 unfilled science positions

2. Concern for Qualifications of Teachers

- In Minnesota, teachers can teach any subject one hour per day without certification.
  In minor field, teachers can teach up to 1/2 time.

- Some elementary teachers have not even had high school math. (Interview with Sally Sloan, Minneapolis Public Schools, Math Computer Specialist)

- No science requirement is mandatory for certification in elementary education.

- Lower vacancy rate in Minnesota than in other states may be attributable to less stringent licensing requirements.

- No special teachers for science in elementary schools, while, for example, music has special staff.

3. Inadequate Number and Uneven Quality of Teacher Inservice Programs

- Locally-controlled, but usually 1-5 days/year.

- Estimate (SDE) 1-2 days every 5 years are devoted specifically to math/science inservice training, and then for teachers in those subject areas only.

- Studies show that average teacher gets most information from textbook sales people--not journals, workshops, or newsletters.

- Teacher burnout: science not an exception. It takes a lot of planning, work and organization to do something different in a classroom. But after 15 years of teaching, it is difficult to do.

4. Low Salaries

- Math/science teachers paid the same as other teachers and can earn more elsewhere (i.e. business).

5. Lack of Universal Computer Literacy of Teachers

- Even with Minnesota Educational Computing Consortium, it is estimated that only 1/4 of the teachers (10,000) in Minnesota have some kind of training in computers.

- Average of two teachers per district have had contact with MECC.

- Generation of teachers: few of whom who know how to use a computer, many of whom are wary; and most of whom see computers as in the domain of mathematics or the source of billing errors. (Christian Science Monitor, 3/30/81)

6. Lack of Student Interest and Motivation

- Don't see how subjects are used in "real life."

- Lack of role models, especially females: in Minnesota 1976-77; only 18% of secondary math teachers were women.

- Science is often textbook-bound.

- Science/math are not seen as useful tools for adulthood. (In Richfield High School, science ranked at the bottom in terms of usefulness.)

- Alfred B. Sloan Foundation study on underrepresenation of minorities and women in engineering found that few junior and senior high students:
  - understand what an engineer does;
  - are aware of job opportunities in engineering;
  - know math and science requirements.

- At University of Minnesota Institute of Technology, only 24 of 3,500 undergraduates are black, Indian or Chicano.

- 1% of engineers in the United States are black. Little change has occured in the past 15 years.

- Science Magazine (October, 1980) reports results of study by Professor Paul Hurd:
  - 50% of all high school grads in the United States have had biology and algebra;
  - 30% chemistry;
  - 16% physics;
  - Every Japanese high school graduate receives twice as many hours of math and science as U.S. high school grads.

- 1973 Survey of Science Ed in Europe, Third World and United States: U.S. scored above the mean only in the number of hours of television viewed. (Washington Post: 10/23/81)

7. Declining Enrollment Makes Offerings Difficult

- Minnesota schools are still providing. (Study by Minneapolis Tribune: 1981)
  - 95% of districts make science/math available somehow.
  - Math is holding its own.
  - Courses in computer science have increased.

- However, virtually no science is taught in elementary schools. (SDE study indicated 10 minutes per day.)

8. Declining Student Achievement Scores

- Achievement in math in Minnesota has declined slightly more than the national average.

- Particular decline in problem-solving in science.

- Science scores of Minnesota students are lower than those in reading, social studies, math, and even music.

9. Lack of Concentrated Instruction Time or Requirements

- Science in elementary: average time per week is 30 minutes (8% of curriculum).

- Grades 10-12: 60% of high schools require one year of science.

- Elementary: suggest math as 13% of time.

- Grades 10-12: 50% of high schools require at least one year of math.
  - Grade 10: 50% take geometry.
  - Grade 11: 33 1/3% take higher algebra.
  - Grade 12: 1/8 take advanced topics.

- Too many students take math courses out of sequence: 10% of graduating seniors.

10. Lack of Public Investment in Science/Math Education

- Determined locally by districts.

- Minnesota is 41st among the 50 states in the per capita production of engineers. (American Society for Engineering Education)

- SDE study: relationship exists between money spent per student in science (textbooks and consumables) and student performance.

- Fiscal pressures on locals, yet Minnesota schools purchased 800 computers last year.

- Some districts have cancelled specific programs--e.g. "Math Bridge" in MPS.

- Sources of federal, state money for science education have dried up. Requests to business and industry have increased over 25% in one year.

11. Lack of Coordinated Efforts

·"Turfism".

·Multiple constituencies with competing demands.

·Need vehicle for communication.

·"Small explosions" theory.

12. Public Attitudes

·Math, but not science regarded as basic skill.

·13th Annual Gallup Poll: parents fairly satisfied with quality of instruction:
-Math: A or B = 47% (C=29%)
-Science: A or B = 44% (C=33%)
Therefore, no great parental pressure for improvement.

·Parents may not be aware of implications.

13. Sense of Impotence, Being Overwhelmed, Resignation

APPENDIX E

Promising Strategies for Reform in Minnesota's K-12 Schools

By: Donna Knight

IMPROVING MATH/SCIENCE EDUCATION:

PART TWO:
Promising Strategies for Reform in Minnesota's K-12 Schools

1. Business Support and Involvement: Actual and Potential
   - Much already occurring--e.g.:
     - -Honeywell, MPS: money, expertise in program development, manpower.
     - -3M: recognition of excellence.
   - Other forms include:
     - -Money in targeted education fund: direct cash assistance.
     - -Computer services.
     - -Student tours, internships.
     - -Teacher participation in company-sponsored courses.
     - -Business people on loan to help school boards in planning and budgeting.
     - -Find ways to solve problems to mutual advantage.
     - -Communicate business need for employees.
     - -Involve high tech companies more in public affairs: but need to prove value of cooperation and need to help shape educational policies.
     - -Donate equipment.
     - -Allow students to use labs in off-hours.
     - -Internships.
     - -Work with Junior Achievement.

2. Make Facilities and Technology Available to Community

3. Convene Math/Science Teachers to Discuss Common Problems and Solutions.

4. Provide Special Support for Math/Science Teachers.

   - Salary supplements.

   - Don't lay off.

   - Subsidize educators in return for commitment to classroom teaching.

   - Professional development and increase resources.
     E.g. Science Museum of Minnesota: Opportunities in Science Project targeted at Northern Minnesota with Blandin Foundation Support:
     - -Enrichment workshops
     - -Visiting scientists programs
     - -Travelling exhibits
     - -Special summer computing program
     - -Phone hotline on science fairs
     - -Newsletter: The Bog Hopper
     - -Resource Centers.

4. Provide Special Support for Math/Science Teachers. (continued)

•MPS: to address learning needs of all staff in technology: computers, AV media.

•Minnesota Educational Computing Consortium Workshops--opportunities to "play" with computers, use in creative, innovative ways.

5. Increase Number of Inservice Training Days Dealing with Technology for All Staff.

6. Restore Interest in Science/Math and Related Careers.

•Provide supportive yet challenging environment to help students develop a positive attitude.

•Make students aware of course requirements of jobs.

•Improve guidance of students in career and course selection.

•Convince students, school board, public, teachers of importance of science/ math.
St. Cloud Apollo High School: video-tape "Math In" at registration time to change student attitudes.

•Focus attention on girls, minorities.

•Demonstrate importance of science/math across subject areas.

•Generate interest in and understanding of technology.
-Computer camps (Compu-Camp, Minnesota).
-Holiday classes, clubs.
-Twin Cities Institute for Talented Youth: 6 weeks, MPS, St. Paul, 7-11 grades (100 students), math/science, Macalster College.
-Minnesota Talented Youth Mathematics Project, University of Minnesota, Math Department: 62 students selected by competition, 7th & 8th grades: University one day per week for special courses.
Also, special pilot project in calculus for 9th & 10th grade students.
-Experience-Based Career Education: Anoka.
-Shadowing.
-Integrate technology into all--even CETA.

7. Increase Number of Minorities in Technical Fields.

•Inroads: Minneapolis, St. Paul: Home grow minority talent. Identification, scholarships, incentives; instruction, 80 students (20, each grade 9-12): University of Minnesota and corporations.

•Peer Teaching Program (CQE): 55 students in 34 classrooms.

•Role models (3M).

•Screen materials for bias.

8. Expand Use of Computers.

- Great acceptance of micros.
  Minnesota Educational Computing Consortium: 92% of districts use computers. 3,000 micros now. Purchasing contract for Ataris micros: cost of disc-drive system is $500 (from 2,000).

- MPS: Plan for integrating computers.

- Incompatibility of software.

- Integrate with all areas.

- Issue is becoming the quality of use, not whether schools have computers or not.

9. Increase Math/Science Requirements.

- Somehow increase emphasis.

10. Strengthen Existing Courses-Including Vocational.

- MPS: Magnet for Science/Math Technical Education (within existing school).
  - To upgrade program: lighthouse.
  - Improve technology abilities of students.
  - Readdress range of social problems.
  - Strengthen alliance with business.

- Redesign--gear toward modern.

- Increase computers and other hardware.

11. Expand Array of Cooperative Programs.

12. Provide Incentives for Teachers.

- Fellowships for teachers.

- Inservice.

- Summer employment opportunities.

- Lengthen contract.

- Different salary schedule.

- Increase equipment.

- Design scholarship for post graduate work to strengthen teaching in classroom.

- Vary length of contract (1-10 months).

- One-time dollar bonus for completion of 5 years of teaching.

12. <u>Provide Incentives for Teachers</u>. (continued)

.Lab aides.

·Reduction in non-teaching responsibilities.

·Free summer development programs (paid).

·Money for fairs, trips, etc.

·Differential-staffing.

13. <u>Develop Strategy for Attacking Problem on a Large Scale</u>.

Need:
-Data base for awareness mechanism.
-Core of committed individuals.
-Identified target groups.
-Broad-based campaign.

APPENDIX F

Example Recommendations from NSF Conference on Cooperative Relationships Between College/University Scientists and Pre-College Educators

CONFERENCES ON COOPERATIVE RELATIONSHIPS BETWEEN COLLEGE/UNIVERSITY SCIENTISTS AND PRE-COLLEGE EDUCATORS - AN INTEGRATED SUMMARY*

Science educators from around the country met in three conferences sponsored by the National Science Foundation's Pre-College Teacher Development in Science (PTDS) Program in the Spring of 1981. The Conferences were held in conjunction with the 1981 Directors' Meetings to develop and define an "action agenda" to address the severe crisis in mathematics and science education in the United States.

The emerging theme of the conferences, Expanding the Science Education Partnership, first appeared in the keynote address given by Dr. Lawrence Senesh, University of Colorado at the Phoenix conference and was enlarged upon by conferees, becoming a central element in the two following conferences in Washington, D.C. and Los Angeles. Keynote speakers also having long-standing involvement in science education opened each of these conferences: Dr. William Wells, American Association for the Advancement of Science, (Washington, D.C. conference), and Dr. James Rutherford, American Association for the Advancement of Science, (Los Angeles conference). Most of the recommendations which were developed at the conferences detailed suggestions for meeting specific problem situations by new associations of support sources, both for funding and for public policy and planning.

Some of the concerns which prompted these conferences and on which the participants frequently focused appeared also in an October 1980 report to the President entitled "Science and Engineering Education for the 1980's and Beyond". The report was prepared and released by the Department of Education and the National Science Foundation. It summarized findings which all pointed toward a national crisis in mathematics and science education and suggested that a series of conferences be convened to further define the problem and to suggest appropriate action.

Since the report was intended to be national in scope, it lacked some of the detail and individual variations in problems and possible solutions which are apparent from the local level. Accordingly, it was decided that the Pre-College Teacher Development in Science (PTDS) Program would hold three conferences in conjunction with the Spring 1981 Project Directors' Meetings to define local aspects of the mathematics/science education problem and to discuss suggested courses of action. Since the focus of the projects and the discussion was middle-high school (grades 5-12), each project director was asked to bring an educator from the pre-college system. Participants included teachers, science supervisors and administrators from local and state levels. The interaction of college and pre-college educators added a positive dimension to each conference which was widely praised.

* The full text of the recommendations and detailed suggestions for implementation are contained in the individual conference reports, available from Pre-College Teacher Development in Science Program, National Science Foundation, Washington, D.C. 20550. The purpose of this summary report is to integrate the substance of the three conference discussions, insofar as possible, into an action plan which sets forth specific problems and suggested approaches to their solutions. The results of the conferences address a number of common factors in the problems of pre-college science and mathematics education.

"Expanding the Partnership" involves adding a selection of other constituencies to the usual combination of pre-college schools, colleges/universities and the Federal Government. These constituencies include industry, state and local governments, educational/research organizations (science centers, museums, zoos), parents and students. Each of these has a vital stake in strengthening the pre-college mathematics/science preparation received by students as they progress through school and prepare for their chosen roles as members of society. Those who will form the manpower pool for the technological areas of our society need a strong background in basic mathematics/science; industries and colleges express increased distress over the lack of this training. Those who are employed in other areas will still live within an increasingly technological world and, as informed citizens, need an understanding of its basic principles.

Problem: Scientific literacy is the foundation of public understanding of the importance of science. Standards need to be set for the definition of scientific literacy and measures taken to achieve them.

Suggestions:

o Scientists need to work with the media (perhaps through professional scientific and teachers associations) to reach a wide audience through radio and TV. Building and maintaining the public understanding of science is a continuing long-term process and to be effective must be carried out consistently.

o The public should be involved with science through Science Fairs, Junior Academy of Science and Science Days at schools. Colleges, students, parents and industries as well as representatives of local and state government should be drawn into cooperation through these events.

Problem: A rapidly growing problem is the shortage of qualified teachers whose knowledge of their subject is up to date. This situation is the result of several conditions: inadequate certification requirements, difficulty in recruiting students to teach in certain fields (mathematics and the physical sciences), diminished opportunities for teachers to keep up with current information in their fields, and the reassignment of teachers out of their fields. These conditions are widespread in districts across the country, though the reasons for them may differ.

Suggestions:

o Teacher shortages occur around the country, differing by state and school district as well as discipline. A study should be made on a regional basis to identify shortages of teachers in specific disciplines and to recommend measures to alleviate them. These studies might most efficiently be done through State Departments of Education. Once the demographic character of the teacher supply is defined, shortages can be addressed through recruitment of students into preservice science and education degree programs, or, more commonly, by redirecting the use of existing personnel within the system through a planned program of updating and retraining on an in-service basis.

o <u>Certification requirements</u> should be studied on a state-by-state basis, being upgraded where necessary, with plans made to meet the requirements with a continuing flow of new teachers. This effort must involve the major scientific and teacher organizations, as well as parents and school administrators. Selected organizations (professional scientific and teacher organizations) should be asked to make presentations about science education to all major statewide and national meetings of associations of school boards, superintendents and PTA's, discussing guidelines for teacher training.

o <u>Recruitment of students to teach in fields of teacher shortages</u> must take into account the difference in salary scales between teaching and industry. It was suggested that a loan program could be established by the Federal Government which would incorporate a provision of partial payback based on years of teaching after graduation. The former NDEA loan program was cited as an example. Recruiting efforts can also be mounted with the cooperation of professional teacher organizations who can promote mathematics/science teaching as a meaningful and rewarding career. Specific outstanding teachers at all levels need to be identified and recognized.

o <u>Retraining and upgrading of the background of current teachers</u> appears to be a particularly useful method of assuring a high level of competence in mathematics/science instruction in a school system, whether teacher shortages result from the low supply of new teachers coming into the system or from reductions in force. Updating of the knowledge of teachers already trained in science areas can be done through continuing education courses in universities, those offered with outside funding such as the NSF Pre-College projects, or through research internship opportunities made available by industries. These can all serve the double purpose of keeping the teacher abreast of new developments in science and providing the career insights necessary for effective advising of students. A modification of the NSF Chautauqua program was also suggested as a means of bringing teachers and students into touch with recent scientific findings.

Retraining to enable a teacher to move into a field other than his/her original one should be planned and encouraged by the state and local education authorities. When a teacher must be assigned to teach outside the field of certification it was suggested that the teacher be required to undertake professional retraining (with appropriate financial support) and to complete it within three years on an in-service basis. The conference recommendations made the point emphatically that this retraining was not the sole responsibility of the teacher, but was rather to be done with the help of the local school district, the State Department of Education, industry and universities.

Problem: Women, minorities and the physically disabled are still underrepresented in the ranks of professional scientists.

Suggestions:

- Projects which increase the involvement of women, minorities and the physically disabled in science should be supported with specially earmarked NSF funds. These would raise the level of minority participation and serve as model projects.

- A national conference should be held to disseminate programs and methods of instruction designed to improve mathematics and science instruction for women and minorities. Federal, state and private funds could be combined to develop a comprehensive report on the state of minorities, women and the physically disabled in science.

Problem: Industry has not been fully involved as a partner in the science education endeavor.

Suggestions:

- Relationships between industry, local school districts and universities should be developed and strengthened, based on common concerns for a strong science education background in the population. NSF should play a catalytic role in organization of these relationships.

- Research internships in industry should be arranged as opportunities for both pre-college teachers and students. Local professional societies can be involved in initiating these opportunities as well as in arranging plant visits, identifying resource persons who will visit classrooms, and in providing career information to students, teachers and guidance counselors.

- Creation of public support for a strong science/mathematics curriculum in grades K-12 should also be an area of involvement for industry on the local and national levels.

Problem: There is always a need for revision of mathematics/science curricula to incorporate new material and new information about patterns of learning.

Suggestions:

- Curriculum concerns were expressed from several perspectives. They included the need for continual updating and revision of existing materials, means of disseminating materials developed by teachers, interdisciplinary materials; and the need for materials which include an ethical approach to the study of science. The conferees assigned the responsibility for curriculum development and dissemination to a wide spectrum of groups. They suggested that local school districts,

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universities and business communities paticipate in the development of appropriate curricular materials, and they encouraged professional mathematics and scientific organizations to publish directories listing sources of full information on curricular and staff development projects.

The proceedings of the conferences can be summed up as a plea for recognizing the growing crisis in science and mathematics education as a national concern and for involving many sectors of the community in addressing this concern. The specific means of accomplishing this goal are detailed in the individual conference reports, available from Pre-College Teacher Development in Science, NSF. The conferences identified the production of future scientists and the establishment of a scientifically literate community as the two vital goals of science education in the years ahead.

PRE-COLLEGE TEACHER DEVELOPMENT IN SCIENCE PROGRAM
NATIONAL SCIENCE FOUNDATION
Washington, DC 20550

August 1981

NATIONAL ASSOCIATION OF STATE BOARDS OF EDUCATION

State boards influence the educational directions in the state. State boards do not act alone: they interact with the chief state school officer, the legislature, the governor, local constituents, and state level associations of administrators, teachers and school boards. Through their state level policy development and adoption process, and by virtue of their relationship with the state legislatures, state boards determine the tone, direction and quality of education in their states.

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