

Midland Adult Education Council

Introduction

Today I would like to discuss the State of Michigan's strategy to achieve prosperity in the face of intense international competition and rapid technological change.

However it seems appropriate first to broaden our perspective a bit and view the challenge facing Michigan within the broader context of the major changes occurring in the very structure, the very fabric, of the world economy...

In a sense, Michigan's challenge is the challenge of dramatic economic change itself, being driven in large measure by knowledge ...

Background

To discuss this challenge, I am going to toss aside my hat as president of the University of Michigan, and instead return to my roots as a scientist and engineer.

Throughout my scientific career, I have been heavily involved in stimulating technological change...

In areas such as nuclear energy, lasers, thermonuclear fusion...indeed, I even worked on the Rover Project to develop a nuclear rocket in the 1960s...

In the 1970s, I switched my attention to areas such as supercomputers and computer networks....

I am going to put on a hat as former dean of the College of Engineering at Michigan...as one who has been involved for the past several years in attracting to our state a number of the nation's thought leaders,

But there is one additional hat I would also like to put on... that of a member of the National Science Board...our nation's principal source of science policy...

My Message

My message today will be suffer from both of my character flaws as a scientist/engineer...
...it will be a vision of the future...
...and it will be unusually candid.

Few have realized the enormous changes that our society is undergoing as it approaches the 21st Century.

We are becoming more diverse, more pluralistic as a people. Indeed, almost 90% of the new entrants into our workforce during the 1990s will be people of color, women, or immigrants.

Our economy and commerce are becoming every more interdependent with other nations as the United States becomes a world nation, a member of the global community -- as this past year's events in China, Russia, and Eastern Europe make all too apparent.

And we are rapidly evolving into a new post-industrial society, in which the key strategic resource necessary for prosperity and social well-being has become knowledge itself, that is, educated people and their ideas.

Indeed, knowledge will play the same role that in the past were played by natural resources

or geographical location or unskilled labor...
In the pluralistic, knowledge-intensive, global
future that is our destiny, it is clear that the
quality of and access to
...education in general
...higher education in particular
...and great research universities
such as the University of Michigan
and its sister institutions
most specifically of all...
are rapidly becoming the key determinants
of the strength and prosperity of our state.

But here there is some good news...

America is particularly well positioned,
since our research universities are clearly
the envy of the world, as evidenced by the
extraordinary demand by graduates of
every country to see advanced education
and training in the United States.

Indeed, higher education is not only our nation's
highest quality, but also probably also its most
competitive industry as measured by the
test of the marketplace!

Further, Michigan is particularly well-positioned
from this perspective, since our state has
built over the years not only one of the
strongest systems of public higher education in
the nation, but possesses several of the world's
leading research universities.

But, now for the bad news...and the candor...

We--that is YOU AND ME--seem hell-bent, both as a nation
and as a society, on destroying the extraordinary
resources represented by system of
public education--from K through 12 through 16
through lifetime education--
just as we are entering an
age of knowledge in which they will become
our most valuable resources.

Indeed, a tragic combination of public
misunderstanding, short-sightedness,
and downright selfishness, is now threatening
to deprive our children and grandchildren
with the same opportunities for an quality
education that you and I enjoyed--
because of the sacrifices of our ancestors.

Leading to the frightening prospect that we will
manage to destroy our international competitiveness
of education just as we have many other
American industries.

In my home state Missouri we have an old saying
that the best way to get a mule to move
is to first hit it over the head with a 2x4 to get its attention.

Now that I have your attention,

let me explain more clearly what is at stake here...

Themes of Pluralism, Globalization, and Knowledge

And while it is always risky to try to speculate about the
future our students will find, three themes of 21st
Century America seem clear...

- i) It will be future in which our nation becomes a truly
multicultural society, with a cultural,
racial, and ethnic diversity that will be extraordinary

in our history

In which those groups we refer to today as minorities will become the majority population of our nation in the century ahead...

In which women take their rightful place as leaders of America...

ii) It will be a future in which America will become "internationalized"...

in which every one of our activities must be viewed within the broader context of participation in the global community...

In an age of intercontinental missiles, threats to the global environment, instantaneous worldwide communications, a world economy, and an international marketplace of ideas and arts and political trends,

it is clear that we are becoming increasingly interdependent with other nations and other peoples.

Further, as the destination of roughly half the world's immigrants, the United States is rapidly becoming a "world nation" with not simply economic and political but strong ethnic ties to all parts of the globe.

The 21st Century will be the first post-European century in American history.

An absolute majority of young people born in US in the 21st Century will be born of parents of other than European background...

Asian, African, Hispanic

And this will represent a major change in the character of our society.

iii) The Age of Knowledge

But there are even more profound changes underway...

Looking back over history, one can identify certain abrupt changes, discontinuities, in the nature, the very fabric of our civilization...

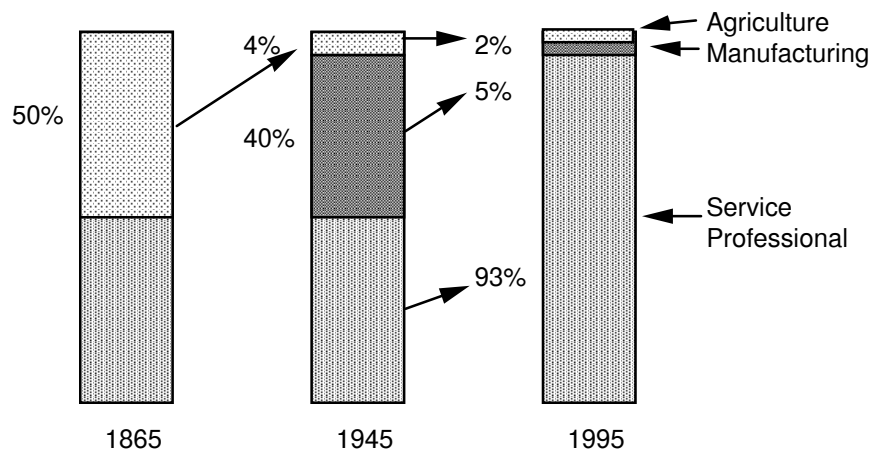
The Renaissance, the Age of Discovery, the Industrial Revolution

There are many who contend that our society is once again undergoing such a dramatic shift in fundamental perspective and structure.

Today we are evolving rapidly to a new post-industrial, knowledge-based society, just as a century ago our agrarian society evolved through the Industrial Revolution.

Some examples:

1. Industrial production is steadily switching away from material and labor intensive products and processes to knowledge intensive processes:
2. Our nation's future has probably never been less constrained by the cost of natural resources.
3. Increasing manufacturing production has come to mean decreasing blue collar employment!



4. We are in the midst of an information revolution that is changing the basis of economic competitiveness and world power. (Indeed, if you want to know the real reason for the recent events in Eastern Europe, China, and the Soviet Union--the collapse of communism--it was the silicon chip which created a truly international exchange of ideas and perspectives that could not be constrained by any government!)

In a sense, we are entering a new age, an age of knowledge, in which the key strategic resource necessary for our prosperity, security, and social well-being has become knowledge--educated people and their ideas.

This new critical commodity knows no boundaries.

It is generated and shared wherever educated, dedicated, and creative people come together... and, as we have learned, it spreads very quickly.

Key element in transformation, is the emergence of knowledge as the new critical commodity, as important as mineral ores, timber, and access to low skilled labor were at an earlier time.

The knowledge revolution is happening worldwide and at a very rapid rate.

Concerns...

Needless to say, these same challenges of pluralism, of globalization, and of this age of knowledge that is our future will pose great challenges and demand similar changes in our state and our nation.

The America of the 20th Century that we have known... was a nation characterized by a rather homogeneous, domestic, industrialized society...

But that is an America of the past.

Our students will inherit a far different nation...

a highly pluralistic, knowledge-intensive, world nation that will be the America of the 21st century

Of course, these themes of the future,

the changing nature of the American population...

our increasing interdependence with other nations and other peoples... and the shift to a knowledge-intensive, post-industrial society.

Are actually not themes of the future

...but rather themes of today...
...in a sense, I have simply been reading the handwriting on the wall...
Yet I also fear that few have realized the enormous changes that our society is going through as it approaches the 21st Century.
The impact of these changes are already painfully apparent to Michigan's workers and industries.
In fact, it is here in Michigan...in the heart of the "Rust Belt" that the impact of these extraordinary changes are most clearly seen...
We all know that past decade was a period of great difficulty for our state...
Industries of great economic importance to our nation such as steel and automobiles have fallen victim to intense competition from abroad...
Plants have closed...we still have many people chronically unemployed...or under employed
Indeed, Michigan's per capita income has now dropped below the national average...
Michigan has dropped to 20th in per capita income (and at \$15,393 is now slightly behind the national average of \$15,481)
We have slipped to the bottom in
...in our public support of higher education
...in the fraction of tax dollars we get back from Washington
...in the burdensome nature of our tax system
...in the climate we provide for small business development
We are still number one...or close to it...but in other areas
...but in unemployment
...in mortality
...in high school dropouts
...in the fraction of our citizens we lock up in jail
It is clear that our state is in the midst of a profound transition...
...from an industrial economy based upon the abundance of natural resources, unskilled labor, and, to some degree, constrained, slowly moving domestic markets...
To a knowledge-based economy, characterized by intensely competitive world markets, rapid change, and--most important of all--educated people and their ideas.
This has not been...and will not be...an easy transition to make.
The truth is that the outcome is still very much in doubt!
producing jobs and improving our quality of life.
Whether we will emerge from this transition as a world economic leader once again...with a strong, prosperous--albeit new--economy
Or whether we will fail to heed the warnings...
...to make the necessary investments and sacrifices today necessary for strength and prosperity tomorrow...
And become an economic backwater in the century ahead.
It is clear that we face a watershed--a fork in the road ahead.
My central theme is that education, broadly defined, will be the pivotal issue in determining which of these two alternative futures will be Michigan's...and America's.
Indeed, I am absolutely convinced that the dominant issue of the 1990s will be the development of our human resources.
Previous economic transformations were closely associated with major public investment in infrastructure such as railroads, canals, electric networks, and highways.
In the coming economic transition, an equivalent

infrastructure will be an educated population.
The actions we must take today...
...and the investments we must make...
...will clearly determine our capacity to
respond to this future...

The Good News and the Bad News

1. America's Strength...and Weakness

In December I attended a conference of the top scientists, government officials, and CEOs from a number of nations throughout the world. The CEO of Nissan pointed out that following an extended visit by a number of senior Japanese officials, they asked the group what they felt the greatest strength and weakness of the US were: They were unanimous in their conclusions:

America's greatest strength was our research universities.

Our greatest weakness was public education at the primary and secondary level.

Quite a paradox, isn't it?

Quite a challenge!!!

2. BHEF

Two weeks ago I attended the annual meeting of the Business-Higher Education Forum in Tucson, an organization comprised of 40 of the nation's top CEOs and 40 university presidents.

During this meeting the CEOs stated their belief that the quality of public education in America was the most serious crisis this nation had faced since WWII!

And yet this is a crisis about which there is little public awareness, much less public consensus.

3. Growing Pessimism

In my frequent interactions with the leaders of the public and private sectors throughout this nation I detect an increasing sense of pessimism about America's will and capacity to take the actions necessary for our future.

Indeed, many now believe that that our nation is well down the road toward "outsourcing" its knowledge resources--just as we have been our labor, our manufacturing, our products--since American industry can not only depend on domestic knowledge resources--that is, a well-educated labor force or an adequate supply of scientists, engineers, and other professionals.

- i) There is increasing pessimism that the staggering problems facing K-12 education can be overcome on the time necessary to preserve our economic strength.
- ii) Further, despite the fact that most other nations regard higher education as our greatest strength, there is little sign that this view is shared either by our elected political leaders or the public at large. Indeed, it has become fashionable to attack our universities, even as we continue to seriously underfund them.
- iii) The rapid growth of "transnational" companies which seek resources, whether they be

labor, processes, or knowledge--wherever they can get them at highest quality and lowest price--suggests that outsourcing of knowledge from other parts of the world will become increasingly common as the quality of American education deteriorates.

This is truly a frightening prospect. Industry has already outsourced labor and manufacturing. Can we afford to lose its competitive capacity to produce knowledge as well?

Let's face the facts, people...

We're not going to be rich and prosperous if all we do is mow one another's lawns.

Or, more to the point, engaging in financial gymnastics such as leveraged buyouts financed by junk bonds...

We have to bring something to the table of the international marketplace.

We have to generate our wealth...through our people...their knowledge and their skills.

The Dangers of Underinvestment

But here there are dark clouds on the horizon... increasing evidence that we as a people have not yet recognized either the nature or the magnitude of the investments we must make to achieve prosperity in an age of knowledge.

1. Over the past several years, numerous studies have suggested that Michigan is seriously underinvesting in its "knowledge infrastructure"...by as much as 30% to 40% relative to other states.
2. The challenges faced by K-12 education are apparent. By any measure, K-12 is in serious trouble.

We are "A Nation At Risk"...

Earlier this fall, a group of visiting Japanese business leaders was asked to identify our nation's greatest asset...and our great liability.

They were unanimous in their opinion that America's great assets were its research universities... and its greatest liabilities were its schools...

Note: it is bad enough that...

10% of Americans are illiterate
25% now fail to complete high school

But in recent years we have learned that in international comparisons of achievement in science and mathematics, our grade school and high school students score at the very bottom of industrialized nations.

We are a sports-oriented society, and we like to frame issues in the language of the playing field like "being Number one".

But folks, this isn't a game we are talking about today, this is a deadly serious matter of raising a generation of American who will be able to hold their own in an increasingly competitive, increasingly complex, increasingly science-oriented world.

The coins of the realm in the age of knowledge will be science, mathematics, and technology...

But most American students are simply not developing these skills.

We hear along about the 21st century, but this sounds remote.

These kids that test at the bottom of the heap

in world terms will be the backbone of our labor force at the turn of the century...

...and will be running our country in 2025!

Unfortunately, what is also apparent is our inability to agree on actions aimed at improving the quality of our schools--or equity in their financing.

3. The situation is somewhat different yet no less acute for higher education in our state.

While the quality of Michigan higher education today is still high, the long term prognosis is poor if we continue as we have been in recent years.

Over the past two decades, the State of Michigan has dropped from the position of a national leader (ranked 6th in 1965) in its public support of higher education to among the lowest in the nation.

Let's look at the comparisons for a moment:

Among the states, Michigan currently ranks

- i) 38th in appropriations per student
- ii) 37th in appropriations as a percent of personal income
- iii) 26th in appropriations per capita

Further, we not only fall significantly below the national average in our support, but it is clear that we are slipping even farther behind with each passing year:

In fact, the increases we have provided in our support to higher education now rank

- iv) 42nd over the past two years
 - v) 45th over the past ten years
- nearly dead-last among the states.

Hence, no matter how you slice it, our state now ranks among the lowest in the nation in its support of higher education.

As a highly industrialized state undergoing a dramatic change to a knowledge-intensive economy, Michigan is critically dependent upon quality higher education for well educated citizens and creative ideas. Yet Michigan has now fallen into the bottom ranks of industrialized states in its support of these critical resources.

We are being outspent by 30 - 40% in state support per student...

Not simply by prosperous states like California...but by neighbors such as Indiana and Ohio!

They understand what we have yet to grasp.

The world is changing rapidly, and we have to prepare ourselves for tough competition.

Until now we have been able to sustain the quality of public higher education in this state in the face of a catastrophic loss of state support because of our traditional autonomy, so wisely granted almost 150 years ago by the authors of our state constitution.

This autonomy allowed Michigan's universities to take strong internal actions, reallocating resources, redefining priorities, and increasing tuition levels to partly compensate for reduced public support.

But in recent years, even this autonomy has been threatened...through efforts from Lansing

- i) to constrain tuition levels to artificially low levels even as state appropriations eroded

still further

ii) to dictate who we must admit

iii) even to dictate what we must teach...

Whether measured in terms of

state appropriation per student or fraction of our
tax dollars directed toward higher ed,

it is clear that in comparison with other states,
our present level of public support is simply inadequate
to maintain over the long run a system of higher
education that is competitive on a national basis.

Our autonomy has allowed us to continue to move forward

...even though the gas tank is running on empty...

...but now state government threatens to challenge
even about ability to manage our institutions during
a period of great financial difficulty...

And threatens to slam the brakes on quality education in
Michigan.

We recognize that the choices before Michigan are not easy.

We must address pressing social issues of employment,
health, social welfare, we must meet the important
needs of our citizens today.

But also we must balance these immediate needs with investment
in our future.

We cannot continue to address symptoms of our problems
without addressing their causes.

We cannot bring back the past even if we wanted to

For generations, the people of Michigan sacrificed
so that their children could have a better life.

They had faith in education.

We must rekindle that faith
and that commitment to the future today.

We must care for our children's future as much

as we attempt to our present needs and desires.

What has happened to our priorities?

What is wrong here???

Who is to blame???

Our schools and colleges???

Certainly they must take stronger actions to improve
quality...and strive harder to operate in a more cost-effective
manner...

But their present situation reflects as much as anything
else our own personal priorities...

...as parents

...as volunteers...

...as citizens and voters...

What about our elected public officials???

It is certainly not their fault!!

It is clear that our elected leaders, whether in Washington
or Lansing or our local communities...

Would like nothing better than to make education their
highest priority.

To become

...the Education Governor

...or the Education Party

...or the Education President

They understand clearly the importance of investing
in our human resources, and they are searching
valiantly for creative ways to improve the quality
of our schools and provide adequate and
equitable financial support.

But they also face formidable constraints, since in the

end they must be responsive to the wishes of the electorate...and face it, gang...the electorate today says:

i) no more taxes...

ii) no more crime...

iii) no more cuts in social services or national defense...

and our public officials have no choice but to respond.

No, the real finger of blame for the crisis we face in education should be pointed, as Michael Jackson would say, at "The Man in the Mirror"... ..at you and at me...

We are the ones who fail to demand the highest quality in our educational institutions in Michigan...

We are the ones who steadfastly resist a tax base adequate to support both our needs and desires...and provide an adequate level of support for quality education in this state.

We are the ones who block any effective efforts to achieve equitable financing of education in Michigan.

We are the ones who generally are too busy to help our own children in their studies or participate in their activities.

And we are the ones who insist on building more and more prisons, even when we know that this investment comes out of the hide of education and social services-- which are, of course, the only true long term solutions to crime!

We have become consumers of education, not investors in the future.

The Challenges

To Us...

In a very real sense, our state has entrusted to us its most valuable resources...its youth...and its future.

To be responsible stewards of the public trust, it is clear that we must strive to achieve greater cost-effectiveness in our use of public funds... and I can assure you that we intend to do just that.

But even beyond this, we must become staunch guardians for the quality of our institutions...

For in education, as in every other aspect of American life, quality will be the key to our future.

We need to give our children the best education and chance for the future that we can. We should be willing to pass on to them what we ourselves have received...opportunity for a better life.

Hence, to us falls the responsibility of taking the forceful and courageous actions necessary to sustain and enhance this quality...in the long run the people of this state both demand and deserve nothing less!

To You...

Education represents one of the most important investments a society can make in its future...since it is an investment in its people...

It is indeed the case that our state and our nation have developed the finest systems of public education in the world...

But we must also remember this resulted from the willingness of past generations to look beyond the needs and desires of the present and to invest in the future by building and sustaining educational institutions of exceptional quality--

Institutions that have provided those of us in this gathering today with unsurpassed educational opportunities.

We have inherited these marvelous institutions because of the commitments and the sacrifices of previous

generations...and it is our obligation as responsible stewards--not to mention as responsible parents--to sustain them to serve our own children and grandchildren.

It seems clear that if we are to honor this responsibility to future generations, we must re-establish the priority of both our **personal** and our **public** investments in education, in the future of our children ...and hence in the future of our state and our nation.

To our elected leaders...and those aspiring to public office

1. Our public leaders must develop and implement a strategy to restore an adequate level of public support for public education to raise Michigan --that raises us from among the very bottom among the states to a position of national leadership once again.
2. They must bring to an end the present freeze on capital outlay appropriations for higher education (now entering its fourth year) and begin to deal with the seriously deteriorating facilities on our campuses.
3. They must respect our constitutional autonomy and preserve it for generations to follow as the best safeguard for maintaining quality public higher education accessible to all.
4. And most of all, our public leaders must come to understand that they are stewards for the moment of an extraordinary resource for our state--one of the world's finest systems of public education--a system that has resulted from the commitment and sacrifices of eight generations of Michigan citizens. They will be judged by future historians by how wisely and effectively they protect and sustain this great resource, so critical to our future.

The Challenge to Us All...

Today the State of Michigan faces serious challenges that will clearly determine its future prosperity and well being...
the challenge of pluralism...
the challenge of participation in a global community...
the challenge of the Age of Knowledge
the challenge of change itself...

As we approach a new century, our state--just as our nation--is undergoing a profound and difficult transition to a new economic order...

Our fabulously prosperous industrial economy...
an economy that allowed us to build some of the world's great institutions---including some of its finest universities--

But that economy is rapidly disappearing...
...and our challenge for the next decade is to take the steps necessary to build a new knowledge-based economy which will be competitive in a world marketplace.

Let there be no mistake about it...this will not be an easy transition...and the outcome is still very much in doubt.

In my frequent interactions with the leaders of

the public and private sectors throughout this nation I detect an increasing sense of fatalism about Michigan's--indeed, America's--will and capacity to take the actions necessary for our future.

Indeed, many now believe that that our nation is well down the road toward "outsourcing" its knowledge resources--just as we have been our labor, our manufacturing, our products--since American industry can not only depend on domestic knowledge resources--that is, a well-educated labor force or an adequate supply of scientists, engineers, and other professionals.

- i) There is increasing pessimism that the staggering problems facing K-12 education can be overcome on the time necessary to preserve our economic strength.
- ii) Further, despite the fact that most other nations regard higher education as our greatest strength, there is little sign that this view is shared either by our elected political leaders or the public at large. Indeed, it has become fashionable to attract our universities, even as we continue to seriously underfund them.
- iii) The rapid growth of "transnational" companies which seek resources, whether they be labor, processes, or knowledge--wherever they can get them at highest quality and lowest price--suggests that outsourcing of knowledge from other parts of the world will become increasingly common as the quality of American education deteriorates.

This is truly a frightening prospect. Industry has already outsourced labor and manufacturing. Can Michigan afford to lose its competitive capacity to produce knowledge as well?

Let's face the facts, people...

We're not going to be rich and prosperous if all we do is mow one another's lawns.

We have to bring something to the table of the international marketplace.

We have to generate our wealth...through our people...their knowledge and their skills.

I, for one, do not share the pessimism of many of my colleagues.

I believe that we can meet the challenge of the knowledge-based, global society that is our future.

But it is also clear that to do so will require sacrifices on all of our parts...

It will take renewed commitment to that most fundamental of all characteristics in the new economic order: quality

And it will take renewed investment in that most critical resource for our future--our system of public education.

Conclusion

As we approach a new century, our state--just as our nation--is undergoing a profound and difficult transition

to a new economic order...

I believe that we can meet the challenge of the
knowledge-based, global society that is
our future.

This will not be easy...

Our education system is complex and decentralized and the primary
responsibility is located at the state and local level.

There is no simple solution...we must push on all fronts.

We must weave a strategy of many strands--a strategy that places
existing programs in a larger context that established a clear
sense of direction, develops the leadership for the task, and
insures continuity of effort.

Above all, we must be consistent and persevere.

If we are to respond, we simply must reorder the priorities of this state...

We must shift away from the temptation to
address only the needs and desires of the moment

And, instead, we must begin to make some of the key
investments necessary for the long term...

The key investments in our people...
in our children...

It will take sacrifice on all of our parts...

It will take renewed commitment to that
most fundamental of all characteristics
in the new economic order: quality

And it will take renewed investment in that most
critical resource for our future--our system of
public education.

Michigan continues to be blessed with abundant
natural resources, a people of great strength,
and a system of higher education of a quality
envied by the rest of the nation...indeed the world!

But, the writing is on the wall...

If Michigan is to prosper in the age of knowledge
that is almost certainly our future, we must join together
now to restore both our public and
personal investments in education...

...in our people and their ideas...

...in our children...

...and in our future

Appendix: Clouds on the Horizon

Maintaining America's competitive edge requires attention

to our traditional strength -- people and research -- and a strong offensive strategy based on these resources.

Taxes, trade, and fiscal policies influence economic

competitiveness. But in the long run, a strong base of science and engineering research and education is more important.

WARNING SIGN 1: America's S&E lead is slipping

No question that US has lost lead in many areas

Industrial productivity and heavy manufacturing

Steel, durable goods, ...

Energy

Electronics

Also serious signs that lead is slipping rapidly in

Computers

Aerospace

Moreover, key activities such as product design, engineering, and software development increasingly are likely to be done overseas.

Whether automobiles or refrigerators, computers or microchips, nuclear power or energy transmission systems, the likelihood is increasing that the systems are assembled from components designed, engineered, manufactured, and shipped from all parts of the world.

Increasingly, excellence in research and engineering is to be found throughout the world, and the level of innovation is rising abroad. More than 43% of US patents went to foreign entities.

Creating marketable products is a long process. Solving the many problems along the way takes patience, commitment, and cooperation--qualities Japan has in abundance.

For historic, economic, and cultural reasons, America finds it hard to cooperate, be patient, and pursue long term goals.

We need to realize that if we don't cooperate and sustain the effort long enough--not just months, but years--others will reap the benefits of the insights produced in US labs.

WARNING SIGN 2: We are seriously underinvesting in R&D and

Education

As a percent of GNP, US R&D spending has been flat at 2.8% for a long time. Meanwhile, Japan's spending has increased two fold, while West Germany's has increased three-fold over the last 25 years.

For over two decades, US investment in civilian R&D has dropped while that of our competitor nations has risen rapidly. US investment in civilian R&D as a percent of GNP is now less than that of any other developed nation (and only 60% that of Japan and West Germany...)
(US: 1.8%, Japan, 2.7%, Germany, 2.5%)

Almost all growth has gone into military research (70% of federal R&D budget)

Support of basic research has dropped significantly (as has support of research in C&S)

We need a major commitment by the federal government and industry to research on understanding how people learn and to the development of new educational technologies.

"If the fraction of gross expenditures invested in research were the same for education as for the average privately owned business in the United States, about \$9 billion a year would be spend on educational research--60 to 90 times more than the present allocation"

Note: While midwestern states such as Michigan and Ohio

have undertaken many important new initiatives, we still lag considerably behind areas such as California and New England in our investment in knowledge-based resources such as education. We've come a long ways in the past few years, but we still have one hell of a long ways to go.

WARNING SIGN 3: The S&E Pipeline Problem

Today, an unprecedented explosion of knowledge marks the onset of a new era. Since people are the source of new knowledge, we will rely increasingly on a well-educated and trained work forced to maintain our competitive position in the world and our standard of living at home.

While our competitors are sharply increasing their technical workforce, the share of US degrees--at all levels--awarded in S&E is dropping.

Yet the US faces a S&E manpower crisis of unprecedented proportions

0. Indeed, today the United States awards the smallest proportion of university degrees in science and engineering of any industrialized nation!
1. Proportion of graduating seniors who major in science and engineering is smaller today that it was in 1970s (5%). Particularly severe drops in physical sciences and mathematics. (Fallen by 40% over past decade)
2. Per capita production of US engineers lowest among industrialized nations:
US: 72,000 (3%) (7 in 1,000 graduates)
Japan: 85,000 (21%) (40 in 1,000 graduates)
USSR: 300,000 (35%)

Japan has doubled its technical workforce in past decade...

7 of 1,000 American students receive engineering degrees
40 of 1,000 Japanese -- indeed, Japan with less than half the population is producing far more scientists and engineers!

President of Sony:

"In US you produce 4 lawyers for every engineer.

In Japan, we graduate 4 engineers for every lawyer!"

As Americans take degrees in law and business, foreigners are replacing them in graduate science and engineering programs.

3. More than 60% of engineering PhDs are now foreign
Indeed, foreign students account for nearly 85% of growth.
It is bad policy to be dependent on an unpredictable resource and not to be able to meet more of our needs with American tealent.

But things are going to get MUCH rougher: NSF Study

Dominant factor controlling BS degree supply is the size of the college-age population, which will decline until the late 1990s

1. Demand for S&E likely to go up
Population is growing
S&E share of workforce is growing
Industry is becoming more scientific
Most experts predict growth in S&E jobs
2. Supply will probably fall off dramatically simply due to demographics...
Number of 22 year olds is a major driving force in determining BS S&E degrees
Traditional source of S&E college students is declining
25%-30% falloff in HS graduates by 1992
Assuming that same fraction (4.8%) choose to enter S&E, and assuming constant demand (very conservative), drop will be from 197,000 (83) to 152,000 in 1996; there will be a cumulative shortfall of 930,000 by 2010!

To put it another way, fraction of students choosing S&E majors will have to increase by 40% to maintain even present level of graduates.

3. Trends in Intended Majors:

Long term data suggest that percent of college age population receiving BS degrees is unlikely to be over 5%

This is compounded by the declining preference of college students for NS&E majors

Annual Freshman Survey: K. C. Green (UCLA)

Overall interest in science majors has dropped by half between 1966 and 1988, from 11.5% to 5.8%

Interest in biological sciences is sustained only by large number of pre-med students who major in biology

Largest decline has occurred in mathematics:

Dramatic decline in freshman interest in math majors.

From 1966 to 1988, dropped from 4.6% to 0.6%, almost a factor of 10!!!

Trends for men and women are similar

Note the implications, not only for technical careers, but also for pool of future graduate students and secondary school teachers!

Decline in physical sciences from 3.8% to 1.6%!!!

While women enrollment increased during 70s and 80s, it now appears to be dropping:

Interest in engineering is also declining

After recording big increases during late 70s and early 80s (increasing to 12%), now has dropped by almost one-third since 1982 (now down to 8.6%).

Again, decline is occurring among both men and women.

Puzzling, since no precipitating event in labor market demand helps to explain this drop.

The shift in student interests must be driven by other factors.

Clearly these declines point to potential problems in future supply of newly trained engineers.

Freshman plans to pursue computing careers is down more than two-thirds since 1982, from 8.8% down to 2.2%.

Where are they going?

Business is not the most popular major and career among college freshman, having doubled since the late 1960s.

One-fourth (24.8%) of the 1988 class plan to major in business, up from 16.4% in 1966.

The proportion of freshman women has increased by a factor of 6, from 3.3% to 21.2%.

More women plan to pursue accounting careers (6.4%) than men (5.6%). NOTE: Total interested in math is only 0.6%, almost ten times less!!!

(My daughter says she can believe this, since accountants can make money and mathematicians cannot.)

After a 14 year decline, freshman interest in teaching has almost double over past 6 years, from 4.7% in 1982 to 8.8% in 1988.

Even with these recent increases, far fewer freshmen plan to pursue teaching careers than 20 years ago (23.3% in 1968).

Furthermore, recent gains have not off-set the dramatic decline in freshman interest in secondary school teaching.

Far fewer freshman entering teaching plan to study liberal arts fields than two decades ago.

Virtually all aspiring teachers are education majors!!!
All S/E fields have experienced a decline in the proportion
of aspiring freshman major four-year institutions:

Biology: -21%
Engineering: -9%
Physical Sciences: -39%
Pre-Med: -20%

In contrast, business is up 22% since 1978.
Humanities majors have increased 10% over past decade...
...social science is up 20%

Survey data provide some evidence that minority
participation has increased in past several years.
Corporate, governmental, and institutional investment
in fostering minority interest in science is beginning
to show a return.

Gains in front of pipeline do not automatically translate
into more minority graduates, however.

Some good news, however:

Over past decade, fraction of freshman planning to earn
graduate degrees rose by 20%, from 49% to 58.7%.
Proportion of women planning to earn PhDs increased from
6.5% to 11.7%.

NOTE: These data suggest that students no longer view
the BS as adequate preparation for the demands of the
labor market in the 21st Century.

More bad news:

Increased in college teaching has dropped by more than
3/4 over past two decades, from 1.8% to 0.4%.
Preference for research careers has fallen from 3.5% to 1.6%.

Why get a college education:

Get a better job: 70% to 85%
Get a general education: 70% to 60%
Earn more money: 50% to 75%

Note shift in life goals:

"Developing a meaningful philosophy of life": 85% to 35%
"Being very well off financially": 35% to 80%

Other tidbits:

Larger proportion of S/E majors spent significant time on
homework and studying than peers in other majors.
S/E freshmen rake higher on academic skills.

Some observations:

The 1960s were a period of social upheaval;
the 1980s are an era marked by economic upheaval
Today's students:
Have less confidence in their academic skills...
Came of age during a period of continuing economic upheaval...
inflation, recession, restructuring
See the middle-class "goodies" as being difficult to attain,
now requiring real wealth.

But this situation may become even worse:

Over period from 1966 to 1987, proportion of students
who intended to major in physical sciences has
dropped from 3% to 1.3%; in mathematics, the
decline was from 4% to less than 1%.

Recent trends in engineering also show softening.

Applications to most engineering schools are
down by 10-20% this year. (USC 30%)

Interest in computer science is always waning. Drop
from 4% in 1983 to below 2% in 1987.

Note: dramatic increase in proportion of freshmen
interested in business majors--now up to 25% and

rising rapidly

Furthermore, the dropout rate is extraordinary...

From 8th grade through PhD, the half-life of students in the mathematics curriculum is one year!

That is, if we begin with 32 million students in junior high school, we lose 50% each year until only a few hundred attain the PhD.

Number of freshman planning to major in computer science has dropped by two-thirds since 1982. Interest in engineering, which increased during late 1970s, has dropped by a quarter in 1980s.

4. Later effects

Further, there is an alarming loss of students in the early college years due to difficult courses, bad teaching, and declining interest. Only 40% of NS&E freshman survive to BS.

And of those getting BS, fewer than half are in NS&E jobs within 5 years because of reward structure biased toward management

5. Composition of college age population is also changing...

In 1966 44% of college freshmen were women; today 52%.

By 2020 30% will be composed of Blacks and hispanics...

students who have not traditionally chosen S&E careers.

Indeed, by the turn of the century, over 50% of K-12 students will be Black or Hispanic.

Less than 15% of new people entering the labor force of the 1990s will be white males.

The fastest growing pool of youths has the lowest participation rate in college and the highest dropout rate in high schools -- not to mention the least likelihood to study science and math.

Furthermore, virtually none of the Black college freshmen who score highest on the SAT intend to major in mathematics or the physical sciences

Among engineering students, 70% complete school... but completion rate among Blacks is 30%; Hispanics 40%.

Indeed, while Blacks and Hispanics account for 20% of total population, they account for less than 2% of scientists and engineers!

At all the key decision points during a student's career, blacks, hispanics, and women fall away from the sciences, math, and engineering at a steeper rate than the rest of the population.

At sophomore level, 20% of all students are interested in science, but only 10% of minorities.

1988 Engineering enrollments:

Women: 15% BS, 12% MS, 7% PhD, 2% faculty

Blacks: 3% BS, 0.3% PhD (14 total, nationwide)

Last year only 10 Blacks received PhDs in math and only 12 received PhDs in Engineering. Hispanics were not much better: 9 and 24, respectively. Of 4,614 doctoral degrees awarded in physical sciences, 41 were awarded to Blacks. This number is declining, down from 60 a decade ago.

Among women, despite significant increase in the number enrolled in graduate programs, they earn fewer than 15% of all technical degrees.

We must reverse this now, because women and minorities are the key human resource of the future and they need extra encouragement to pursue technical careers.

NOTE: We must make special efforts to expand participation by these groups...not just because that is good social policy, but because we cannot afford to waste their talents!

Conclusions:

- i) If we couple demographics with student preferences, we have got a timebomb on our hands...
- ii) Indirect effects, since smaller enrollments in S&E will mean less justification for investments in faculty and facilities...
- iii) We must act rapidly...
First to plug up the leaks in the pipeline...
Then, over the longer term, to adapt the education system in American to a changing population

WARNING SIGN 4: Undergraduate S&E Education

NSB Report:

"Serious problems, especially problems of quality, have developed during the past decade in the infrastructure of college-level education in the United States in mathematics, engineering, and the sciences."

"The NSB concludes that the NSF must become a strong leader of a nation-wide effort to enhance the quality of UGS&E education, an effort that will require participation by public and private bodies at all levels."

WARNING SIGN 5: PhD Education: our Future Faculty

25% of engineering faculty will retire in next 6 years

On the basis of BS production alone, PhD production will decline by 20% in the decade after the mid-1990s.

Yet, over the next two decades, PhD replacement needs will double in all sectors (academic, industry, government)

The PhD production rate simply cannot respond quickly to market signals.

Salary increases, now projected at doubling during the 1990s, will increase production, but response will be quite delayed.

Further, the increasing number of foreign PhD graduates will reduce salary inflation, thereby reducing the number of Americans pursuing PhD degrees.

Must focus on currently enrolled college students to affect PhD shortfall in late 1990s.

Of 10,000 HS sophomores, fewer than 20 receive PhD's

If one looks at the ratio of BS to doctorate degrees over next decade, one sees a precipitous decline. The stabilization is only because of the rapid growth in foreign citizens receiving US degrees.

While we can be proud our universities attract so many foreign students, we should not be blind to the fact that, increasingly, American students are not pursuing careers in S&E. Depending on foreign students is a dubious substitute for growing our own.

Hence US PhDs will decline due to reduced BS graduates

Foreign PhDs are beginning to return...

Strong evidence that foreign students are beginning to return home.

US universities are becoming less attractive...

we've become complacent

Like balance of trade problem--we are building our infrastructure (including faculty) on foreign nationals

All multinational companies are going after US-trained foreign nationals to be based in their home countries

We have created a situation in which we are highly dependent on a resource over which we have little control.

PhD shortage in faculty...

Compensation (in constant dollars) was constant from 1964 to 1984

It has gone up by 21% in past 5 years and will accelerate even more rapidly as the real PhD shortages appear late in the 1990s

Time to Degree

Average length of time from BS to PhD (past 20 years)

All Fields: 7.9 to 10.4 y

NS&E: 6.7 to 7.9 y

Market forces will probably lower NS&E

However, a successful effort to accelerate PhD achievement could increase degree production up to 25% for several years

Key factors to shorten:

Minimize field and institution switching

Long-term financial support commitments

Note that the PhD recipients of 2000 are already in college.

WARNING SIGN 6: Technological Illiteracy

By any measure, K-12 is in serious trouble.

Our students bring up the rear in most international comparisons

Problem solving abilities have worsened

What students know and can do has declined

Knowledge is cumulative, especially in math, science, and engineering. Without basic skills, a student cannot advance his studies.

But most American high school students are not developing these skills. Only 7% of the 17 year-olds tested are prepared for college-level science courses.

Compared to students in 15 other nations, US high school seniors scored among the bottom fourth on calculus and algebra achievement tests. In some areas of science such as biology, we placed last.

Nearly 30% of nation's high schools offer no courses in physics, 17% offer none in chemistry, and 70% offer none in earth or space science.

We really haven't appreciated impact of technology.

Today we are witnessing an unprecedented explosion of knowledge.

Technology doubles every 5 years in some fields!

Graduates are obsolete by the time they graduate!

Technological change is a permanent feature of our environment

Examples of just the past few months:

i) hole in the ozone layer over Antarctica

ii) new supernova in the heavens

iii) new high temperature superconductor

iv) a new theory suggesting that all matter is composed of infinitesimal "superstrings" rather than point particles

Yet, at the same time public ignorance is extraordinary!

A recent NSF survey indicated that only 18% of those asked said they knew how a telephone works -- and only half of these gave the right answer.

Yet more than half of those surveyed indicated they believed we were being visited by aliens from outer space!

And yet, our education system has not responded...

Note: it is bad enough that...

10% of Americans are illiterate

25% now fail to complete high school

Scientific Literacy of K-12 Teaching Force

Only 30% have had college chemistry

Only 20% have had college physics

Less than 50% have had calculus or computers

International Association for Evaluation of Educational Achievement (IEA)

Grades 4, 8, and 12

US was 8th of 17 for 4th graders

US was 14th of 17 for 8th graders

US was 11-13 of 17 for 12th graders

Bottom 25% of US students were scoring at chance level, indicating that they were scientifically illiterate

(Top scores were Japan, Korea, Hungary
"For a technologically advanced country, it would appear that a reexamination of how science is presented and studied is required...in the United States."

More than half of all our high school graduates have not had even one year of science.

Face it, gang:

The tragedy is not simply our poor showing relative to other nations.

Science, mathematics, and computer literacy will increasingly become a requirement for almost all employment.

We are condemning an entire generation to a lifelong estrangement from the very technology that will inevitably govern their lives.

WARNING SIGN 7: Labor force of Michigan is becoming obsolete!

The education of the Michigan workforce is inadequate to the demands of the next century.

Michigan is undergoing dramatic change in industry...

Away from low-skill, blue-collar workers

The factory of the future will have NO low skill workers
Unskilled labor will lose relevance in a world dominated by microelectronics, computers, and automation.

An example: Expert systems

The "expert system" craftsman...

Key input, however, is quality of the workforce.

Our principal competitors are simply producing workers better capable of absorbing modern production skills. The lack of these skills is preventing us from achieving the productivity gains that we should be getting.

Serious concern:

1. The present generation of blue-collar workers does not have the formal education to be retrained!!!
2. Little sign that education system is adapting to this future. High school graduates "illiterate" in science and mathematics will be condemned for the remainder of their lives to low-level service employment ... IF they can find jobs at all!

It is bad enough to face the prospect of a significant fraction of our labor force becoming permanently unemployable because of an inadequate education. Do we want to condemn their children...OUR children...to a similar fate? Can we afford it?

What might we do?

Lengthen school year from 180 days to 240 days
(note this would also achieve higher teacher salaries)
(It also eases child care needs)

All world-class industrial nations have some post-secondary skill training system for noncollege bound.
Only US has nothing.

State governments now subsidize every student that gets a college degree. How about a federal subsidy for noncollege bound?