

Educating for a World of Change

Introduction

Tremendous hype surrounding "high tech"
robotics, the chip, computers, genetic engineering
Visions of Silicon Valley dance in our head...
A major resurgence of interest in science and technology
Almost akin to Sputnik era
But now focussed on industrial competitiveness
and military security (Star Wars)
Since I have been immersed in this technology for many
years, it seemed appropriate to make several comments
about its implication for your business: education

Background

To discuss this challenge, I am going to toss aside
my hat as chief academic officer 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 intended to fly men to
the planet Mars!
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 attempting to strengthen and
diversify Michigan's industrial base.
Instead, I would also like to put on another hat as well...
that of a member of the National Science Board...our
nation's principal source of science policy...
In fact, I am co-chair of one of the NSB's two
principal standing committees...that on
"Education and Human Resources"...
and it is from this perspective that I would like
to make some observations.

Why the sudden interest in science and technology?

Society --> love-hate relationship with technology
Early 60s: Sputnik era -- space program
1970s: environmental movement, Vietnam
distrust of technology
Today: strong signs that technology is in vogue again
but for a much different reason...
the economic strength of our nation...
Throughout our state and nation one concern has
risen to the top to dominate all others....
"international competitiveness"
And this could be no more evident than in Michigan...
in the heart of the Rust Belt...

The view from Michigan..."the Rust Belt"...

While people generally look at the midwest as a relic
of America's industrial past, let me suggest that in
many ways, it can also be viewed as America's
future.
For it is in the industrial midwest...in Michigan...
that we have had to learn how to adapt to
a brave, new world of intense economic
competition...
We have learned through the school of hard knocks,
as we have fought and scratched and clawed our

way back from the economic brink to achieve prosperity.

The Bad News of the past several years...

Familiar Ills which dominate the headlines

The budget deficit

The trade deficit

Displaced workers

Marginal Industries

More serious

Trade deficits show little improvement despite a sharp drop in the dollar

Past areas of strength such as steel and durable goods manufacturing are declining

Even industries like semiconductors and computers are vulnerable to competition from abroad

The bad news for Michigan is obvious...

Industries of great economic importance to our nation such as steel and automobiles have fallen victim to intense competition from abroad...

Plants have closed...our cities are filled with chronically unemployed...

In Michigan we no longer worry about nuclear war and the bomb because we believe that

"The odds are greater that America will be bought up by the Japanese than blown up by the Russians..."

What is happening?

The world economy is now in control

However, it is misleading to blame all our ills on international competitiveness alone!

We tend to blame all of our ills on international competitiveness...

Something else is happening...

The Challenge of Change

The challenge of dramatic economic change...

Traditional industry economy is shifting to a new knowledge-based economy, just as our industrial economy evolved from an agrarian society at the turn of the century.

The days of low interest rates, limited foreign competition, slow-moving technology, stable markets, and mass production processes that once allowed our industries to thrive in a sheltered environment have long since passed.

This change has gripped the Rust Belt...

A transition is occurring in which..

Intellectual capital has replaced financial and physical capital as key to economic development

The challenge today is to develop an agenda to achieve and sustain prosperity in a new environment of intense international competition and rapid technological change.

Some examples:

Industrial production is steadily switching away from material and labor intensive products and processes to knowledge intensive processes:

In a car, 40% materials, 25% labor...

In a chip, 1% materials, 10% labor, 70% knowledge!!!

Increasing manufacturing production has come to mean decreasing blue collar employment!

In the 1920s, 1 of 3 was a blue-collar worker

today 1 in 6 and dropping fast

probably to about 1 in 10 within a couple of decades...

In all developed countries, "knowledge" workers have already become the center of gravity of the labor force.

As Erich Bloch, Director of the National Science Foundation

puts it, we have entered a new age, an "Age of Knowledge in a Global Economy"

The Age of Knowledge in a Global Economy

And in this age, the major force behind economic change is technology, itself.

Of course, we know that technology has played an increasingly important role for many years.

Technological innovation, achieved by applying new knowledge created through basic research, has been responsible for nearly half of all US productivity gains since WWII

At another level, technologies of transportation and communication make possible an integrated economy.

Tremendous new industries have been created by new technical knowledge: electronics is the obvious example of the last three decades; biotechnology may be the example for the coming three decades.

These industries depend on knowledge as the most critical resource.

But knowledge is highly mobile...it is not tied to geographic regions as coal or iron or oil.

Earlier historical periods that we remember with catch-phrases.. the "Age of Reason", the "Age of Revolution", the "Age of Discovery", were limited geographically to Europe. So was the Industrial Revolution since technology did not allow rapid dissemination of knowledge.

By contrast, the knowledge revolution is happening worldwide and at a very rapid rate.

That new technology means economic development and trade is widely understood in developed nations who have been sharply increasing their investments in science and technology.

But less developed nations are also learning the lesson and drawing knowledge from the developed world or generating it themselves.

Brazil, India, Korea are quickly advancing along the competitive path that Japan took 30 years before.

Note: As more countries understand that knowledge is now the critical resource, more are undertaking serious research programs. Our nation is already being challenged in the knowledge business itself.

The handwriting is on the wall...

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.

Clouds on the Horizon

WARNING SIGN 1: America 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.

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

For over two decades, US investment in civilian R&D has dropped while that of our competitor nations has risen rapidly. We are now far behind Japan and Germany in the fraction of GNP invested in R&D.

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)

WARNING SIGN 3: S&E Manpower Shortage

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 than 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%)

Japan: 85,000 (21%)

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!"

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 talent.

But things are going to get MUCH rougher: NSF Study

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

Supply will probably fall off dramatically

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),

there will be a cumulative shortfall of 700,000

by 2010!

Note: Composition of college age population is also changing...

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

students who have not traditionally chosen S&E careers.

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.

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

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!

WARNING SIGN 4: Technological Illiteracy

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

Incredible that students can graduate from high school without a solid education in science & math -- or can complete college without such coursework.

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

Math: Only 1 out of 100,000 high school students study calculus...and then for only part of a year
Five million Soviet high schools students receive a full two years!

Physics: Few US students will ever take a physics course. In fact, only one out of four American high schools even offer a course in physics!

In Europe, teaching of physics as a separate subject begins as early as 6th grade (also in USSR)

Student planning on majoring in physics will have had 6 years -- more than 500 class hours

Non-science major will have had 3 years

Face it, gang:

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

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

WARNING SIGN 5: Labor force of Michigan is becoming obsolete!

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...

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?

Some observations:

Claim: We are rapidly becoming a nation of illiterates ... in science and technology, no longer able to comprehend or cope with the technology that is governing our lives. Public's knowledge and understanding of science has not kept pace with technology

If, in the final analysis progress depends on having the generations who follow us be smarter and better educated than we are, it is evident that we are sliding backwards rapidly!

So what can we do about this?

A National Response

NOTE: Taxes, trade, and fiscal policies influence economic competitiveness in the short term. But in the long run, a strong base of science and engineering research and education is more important.

Maintaining America's competitive edge requires attention to our traditional strength -- people and research -- and a strong offensive strategy based on those resources.

People must be the major focus...

People -- not equipment or buildings -- are the source of creativity.

They generate the knowledge that makes the technological innovation possible. They are the workforce that makes society run.

They are our researchers and teachers, our leaders, managers, and decisions makers in modern technological society.

Two-fold challenge

1. Achieve basic scientific literacy among all our citizens
2. Provide enough scientists and engineers for industry and academe

For this reason, the administration has chosen as its highest priority in the year ahead major new initiatives aimed at strengthening the source of intellectual capital in this nation.

Hopefully, Congress will join in with strong support of this national imperative!

A Local Response

The real power to influence the education at the level

But here, we as parents and citizens have abdicated our political responsibilities.

We have not demand that our publically elected officials respond to the seriousness of our ever-weakening system of education.

While it is true that our school districts have suffered serious damage from an erosion in public support, the responsibility for education does not rest with the schools alone.

How many parents commit themselves to working with their children?
How many support the millages necessary to build strong schools?
How many are willing to make sacrifices to pay for college?
Perhaps it is the lack of commitment of the American public, in general, and American family in particular which so contrasts us with other nations such as Japan.
Few parents take an active interest in their children's education.
Few save toward a college education...
...whether due to an unrealistic expectation of public support...
...or a preference for expensive cars, vacations, snowmobiles...
Time after time, when given a choice, we vote against good schools.
We complain about taxes necessary to support education...
Even try to roll back taxes, even as education continues to starve

Why?

Is it simply an aging electorate?
Is it the "Me Generation" of the 1960s now growing up into mature Yuppies?

No...root causes lie much deeper.

We have ceased investing in our future!

We have chosen instead to mortgage this future to pay for mistakes made in our past.

Six-month planning horizon...desire for immediate results...inability to identify the investments which have to be made today to yield the objectives for tomorrow.

Education always falls at the bottom of the list of social needs.

Even though surveys indicate public supports education, our elected public officials do not seem to listen. They prefer to fund roads or prisons or football stadiums rather than the education of our youth!

Indeed, Michigan, a state with one of the highest per capita incomes in the nation, continues to slip further and further behind in its investment in education -- just as our nation continues to fall further and further behind those very nations now challenging our economic strength and prosperity.

The attitude we have taken toward our most precious resource, our youth, is both callous and alarming.

I simply cannot accept the excuse that "we can no longer afford this investment in the educational opportunities we offer our youth.

To be sure, the immense social needs for welfare assistance, medical care, prisons, and all of the other programs that drain our tax dollars are compelling.

However, by choosing to meet these needs with resources taken away from our system of public education rather than through reforms in our tax structure or political system, we have in reality mortgaged our future by withdrawing the educational opportunities from our youth.

We seem to have forgotten the commitments that past generations of citizens have made to build educational institutions of exceptional quality -- institutions that have provided many of us for years with unsurpassed educational opportunities.

We simply must re-establish the importance of both our personal and public investments in education, in the future of our children, in our own future, at the local level if Michigan -- indeed, if our nation -- is to face the challenge of the age of knowledge.

The University of Michigan Response

What can an institution such as my University do?

A Narrow Mission

Do we confine our attention to simply educating the scientists and engineers, the doctors and lawyers, the leaders of our increasingly technological society?
the leaders

Is this enough?...Of course not.

I believe our responsibility must go far beyond this... indeed, I believe that as the flagship of higher education in this state, the University of Michigan has a particular responsibility to provide leadership in education at all levels...from cradle to grave, if you will....

To work with you -- to strengthen your capacity to provide your students with opportunity to develop their abilities to the fullest...

But there is another important responsibility...

Recall the challenge of demographics -- the shortfall of 700,000 scientists and engineers that will occur due to the decline in the number of college age students...

But there is another important aspect of that challenge...

Note: Composition of college age population is also changing...

By 2020 30% will be composed of Blacks and hispanics... students who have not traditionally chosen S&E careers.

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.

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!

The Michigan Plan

In 1970s Michigan assumed a leadership role in higher education with its firm commitment to achieving appropriate representation of blacks and other minority groups among its students, faculty, and staff.

Over the next decade, UM developed and implemented an array of programs aimed at recruiting, retaining, supporting, and developing minority students and faculty unexcelled by any other university in this nation. The commitment of resources -- whether financial or human -- was extraordinary by any measure.

And during this period, it achieved success... minority enrollments to 10% and black enrollments to 7.2% in 1978.

However, during the late 1970s and early 1980s, Michigan, like every other major university in this nation experienced setbacks in achieving these goals...enrollments began a gradual decline (down to 5% black). Why?

- i) Universities recognized that existing support services were simply inadequate to handle the large numbers of at risk students being admitted, and hence attrition rates were unacceptable high. Therefore, more selectivity in admissions qualifications was necessary.
- ii) Major programs which had traditionally enrolled far higher percentages such as Education suffered major declines due to the sharp decline in opportunities for graduates in these fields. At the same time, enormous demand built in areas such as Engineering which required far

stronger pre-admission preparation.
Hence, in the early 1980s Michigan once again decided to assume a role of national leadership by implementing a broad array of new programs -- and once again it was successful in turning around the national trend and rebuilding, albeit slowing, the decline in minority student and faculty representation:

- i) Minority enrollments have risen to 12.7% ; Black enrollment to 5.3%.
- ii) Black freshmen enrollment has increased by 50% in three years
- iii) Black enrollment in Medicine (9.8%), Dentistry (8.5%), and Law (7.5%), Bus (7.6%)
- iii) UM now has higher black faculty percentage of any Big Ten or Ivy League university

But, any attempt at leadership is accompanied by certain risks...and at Michigan, despite our efforts.

- i) We have not been as successful as we should have been...
- ii) Expectations both within and outside the University were very high...
- iii) The growing national concern -- indeed tension -- over minority representation specifically and racial issues more generally was reflected on our campus

We are now convinced that leadership requires a major increase in our efforts...
A renewed commitment to our aspiration of eventual representation of all minority groups in proportion to their numbers in our society.
Commitment of additional human and financial resources...
And the involvement of our faculty, students, staff, alumni, and friends -- at all levels of the University, inside and out, in the effort to move toward this goal.
Hence we are setting out upon a new and exciting agenda to move toward these objectives.

The University's Commitment:

On March 23, the University announced a 6-point plan to increase representation of Blacks and other minorities throughout the University. More precisely, we stated:
"The aspiration of the University is to achieve representations of Blacks and other minorities proportionate to their numbers in the population. In order to achieve this target, we believe it will be necessary to establish appropriate goals and timetables within each area of the University."
Key in achieving this objective must be the recognition that the University must reach out to involve itself in all levels of education -- to work with you and your colleagues to build the capacity of your schools to better provide students with the opportunities to continue their education as far as their abilities and their interests allow.
To facilitate this, we have moved to create new position at the highest levels of the University -- the Vice-Provost level -- to provide strong leadership for these efforts.
And, I suspect that the individual we have asked to assume this challenging role is very familiar to many of you...
Dr. Charles Moody, Professor of Education at the University -- a distinguished scholar and leader in education.

Conclusion:

As Provost at the University of Michigan, I have become convinced that key to our mission in serving this State and its people is a renewed commitment to our aspiration of eventual representation of all minority groups in proportion

to their numbers in our society.

This will require major new commitments of human and financial resources. It will also require the active involvement and cooperation of our faculty, students, staff, alumni, friends, and supporters in the effort to move toward this important goal.

The new agenda we have embarked upon aligns naturally both with the mission of the University and with our determination to be a leader in efforts to achieve new levels of understanding tolerance, and mutual fulfillment for peoples of diverse backgrounds.

As a Presidential appointed member of the National Science Board, let me convey my personal belief as well that the most important natural resource of our nation are our youth...

As we enter the Age of Knowledge, our ability to sustain the strength of our nation...to achieve the quality of life for our citizens...will be determined by, more than any other factor, how we develop, nurture, and educate that most precious of resources, our children.

We simply must provide them with the most outstanding education possible to prepare them for the age in which knowledge will hold the key to prosperity and quality of life...

And we must make a special effort to ensure that all students... regardless of race, creed, or national origin...have the opportunity to develop their talents to the fullest...

For, after all, that is what America is all about, isn't it!