Educating for the Age of Knowledge

- Introduction
  - Tremendous hype surrounding "high tech"
    - robotics, the chip, computers, genetic engineering
    - Visions of Silicon Valley dance in our head...
  - A major resurgence of interesting in science and technology
    - Almost akin to Sputnik era
    - But now focussed on industrial competitiveness rather than military security
  - Indeed, several weeks ago I overhead a prominent Michigan industrialist say that "It is far more likely that America will be bought up by the Japanese than be blown up by the Russians."
  - Since I have been immersed in this technology for many years, it seemed appropriate to make several comments about its implication for our state and our nation.
- Background
  - First, a couple of comments to introduce my background
  - Engineer -- rather, applied scientist
    - Participating and observing technological change
      - Nuclear rockets, lasers, fusion
      - Computers
      - Robotics, machine intelligence, expert systems
  - Dean
    - Demand for scientists and engineers
    - Demand on part of best H.S. students
  - Provost
    - Chief operating officer of a major research university
    - Attempting to set its strategy, to chart its course, into the 21st Century
  - National policy -- NSB
    - Concerns about both college and K-12 education
      - Science and Engineering Education Directorate
      - Education and Human Resources Committee
- The Glamor of High Tech = New 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
      - Economic competitiveness
      - National Security
      - The Information Age
  - But, if we look beneath the hype, we see danger signs!!
- Danger signs

- Familar ills:
  - The budget deficit
  - The trade deficit
  - Displaced workers
  - Marginal Industries
- More serious
  - Trade deficits show little improvement despite a sharp drop in the value of the dollar
  - Past areas of strength such as steel and automobiles contine to decline
  - Even industries like semiconductors and computers are vulnerable to competition from abroad
- What is happening?
  - We tend to blame all of our ills on international competitiveness...
  - But something else is happening...

The Challenge of Change

- Dramatic economic change...
  - Traditional industry economy is shifting to a new, knowledge-based economy
    just as our industrial focus 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. Michigan must
    develop an agenda to achieve and sustain prosperity in a new
    environment of intense international competition and rapid
    technological change.
- Some facts of life:
  - 7-fold increase in international trade since 1970
  - Market for nearly all significant manufacturing industries has become world-wide
  - 70% of goods we produce now must compete against merchandise from abroad
  - The world economy is now in control!
- The world economy is not "changing"...
  - it has already changed -- its foundations and its structure -- and the change is irreversible!
  - i) the primary products economy has become uncoupled

from the industrial economy

In 1986 prices were had their lowest level in history relative to manufacturing prices

In startling contrast to the Club of Rome study, there has been a collapse of prices and slowdown of demand.

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

1. Raw materials in a chip are only 1% - 3% of cost... in contrast to 40% for a car and 60% for pots.
2. 100 pounds of fiberglass cable transmits as many telephone messages as does one ton of copper

Note: To produce 100 pounds of fiberglass requires

only 5% of the energy to produce one ton of copper.

ii) production has become "uncoupled" from employment

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

It is not the American economy that is being deindustrialized...

it is the American labor force!

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

In the 1950s, 1 of 4; today 1 in 6 and dropping fast

ii) In 25 years, developed countries will employ no larger

a labor force in manufacturing than in farming: 10%.

iii) In particular, it is unrealistic to expect that the American automobile industry will employ more than

one-third of its present labor force, even through production may be 50% higher.

Hypothesis: A country will have less overall unemployment

the faster it shrinks its blue-collar employment in manufacturing. Why?

1. Acceleration of the substitution of knowledge and capital for manual labor -- replacement of manual workers by machines, the products of knowledge.
2. Shift to industries which are knowledge-intensive.

Example: 70% of chip costs is knowledge -- only 10% labor

Drugs: knowledge - 50%; labor - 15%

Cars: even fully robotized, still 25% labor

In all developed countries, "knowledge" workers have already
become the center of gravity of the labor force. Hence labor costs will continue to become less of an advantage
in international competition.

The Age of Knowledge in a Global Economy

What is happening?

Major force is technology itself!

At one 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.

Intellectual capital -- brainpower -- is increasingly regarded as the key element
needed to compete effectively in a highly technological and rapidly
changing global economy.

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.

Conclusion: Success in the long run requires a healthy science and engineering base -- which is what we call the collection of people, institutions, equipment and faculties -- that make basic research and innovation possible -- which provide the "knowledge resources" -- the intellectual capital -- so essential to competing effectively in the new global economy.

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, autos, ...

Energy (particularly nuclear)

Electronics

Also serious signs that lead is slipping rapidly in

Computers

Aerospace

WARNING SIGN 2: S&E Manpower Shortage

US faces a S&E manpower crisis of unprecedented proportions

Some examples:

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

President of Sony:

"In US you produce 4 lawyers for every engineer.

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

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!

Yet, in the United States:

1. Proportion of graduating seniors who major in science and engineering is smaller today that it was in 1970s. Particularly severe drops in physical sciences and mathematics. (Fallen by 40% over past decade)
2. Major decline in graduate enrollment
3. More than half of engineering PhDs are now foreign

WARNING SIGN 3: THE IMPACT OF TECHNOLOGY

We really haven't appreciated impact of technology.

Example:

Technology doubles every 5 years in some fields!
Graduates are obsolete by the time they graduate!

Engineers must factor change into their career objectives.
Change is a permanent feature of our environment
Traditionally, engineer stayed in same general area.

However now engineers will have to change areas frequently.

Continuing education will be an absolute necessity.

WARNING SIGN 4: Technological Illiteracy

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

Some examples:

How many of you recognize the follow terms
expert systems, polymeric composites,
lattice guage theory, recursive procedures,
knowledge engineering

Examine education system:

Incredible that students can graduate from high school without a solid education in science & math -- or can complete college without such coursework.
80% of hs graduates --> 1 course in physical science
Another example: K-12 education in physics
In US, one year for a few...
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:

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

Already see danger signs: misunderstanding of science

Pop or psuedo-science:

astrology, health fads, parapsychology

Nonsense surrounding nuclear power, genetic engineering, hazardous waste disposal, smoking

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.

NOTE: Projection is that less than 10% of American work force will be in manufacturing (about the same as farming).

Automotive industry will drop to only one-third present
employment in next two decades -- even with a 50% increase in productivity.

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 prospet of a signficant 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?

Possible Responses

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

Investments

For some reason, education is always at the bottom of the list of social services (usually dominated by health concerns) -- perhaps an aging electorate!

There seems little doubt that we are underinvesting in our children…we are simply not willing to provide them with the same opportunities that we ourselves have benefited from.

Some signs:

Michigan is a state with one of the highest per capita incomes in thenation. Yet it has slipped to the bottom (45th) in its level of state support per student in higher education

How many parents are willing to make the sacrifices these days to pay for a first class education for their children? Few families save toward a college education anymore -- whether because of an unrealistic

expectation of public support or simply a preference for expensive vacations, cars, or snowmobiles.

I am sure that each of you has seen the erosion in public support of millages -- of your schools

Some Structural Problems with our Education System

Structure of science & math instruction

The problems with tracking and stereotypes

We set up an obstacle course with AC and AP

Very few survive

We don't seem to recognize different rates of intellectual maturation

Should broaden out the paths into S&E education

And we should require ALL students to continue with some form of science and mathematics in ALL of their years of education.

Should intensify our efforts to attract minorities and women
into careers in science and engineering.
Must attract more into teaching careers by broadening the paths...eliminating undergraduate B.Ed.
Allow graduates with B.S. in math, science, engineering... even practicing engineers and scientists...to obtain easily the credentials necessary for instruction.
The importance of a liberal education
Should address the serious problems of
Need for a reawakening of interest of interest:
For most of this century our nation has enjoyed world leadership in science and technology.
In a sense it has been this fact, more than any other, which has led to the standard of living we now enjoy -- which has provided
both the means and opportunity to free us from physical and mental drugery -- which has built the American we know today.
And yet, at just that point in history in which the world has made a transition to a new knowledge-based economy, in which strength
in science and technology have become the key to our quality of life. this nation stands on the verge of losing this leadership.
The challenge is before us: We must encourage more of our talented students to choose careers in science and engineering.
And we must make the investments to provide them with both the quality of education and career opportunities essential to the strength of America's science and technology base.
We simply have no other choice!