

Science Awards

Themes of Future

My first observation involves a very interesting feature

of your class...

It is important to realize that while you and your classmates

were born in the 20th Century, you will in fact be spending the majority of your lives in the next century...

You will be citizens of the 21st Century!

(You probably should also be aware that those of us on

the faculty are very much products of the 20th Century, while much of this institution is, in reality, a product of the 19th Century!)

And our institution, the university of today, is in reality a product of the 19th Century!

The way we are organized into departments and colleges...our sequential approach to education... even the concept of courses and credit hours... all were introduced over a century ago.

While it is always dangerous to speculate about the future--

particularly another century--three themes seem crystal clear...

i) It will be a future in which our nation becomes a truly

multicultural society, with a cultural, racial, and ethnic diversity that will be truly extraordinary in the history of our civilization...

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

in which every aspect of American life must be viewed from the broader context of our place in the global community... as America becomes a "world nation", with ethnic ties to every part of the globe...

iii) Finally, it will be a future in which we rapidly evolve from a

resource- and labor-intensive society to a knowledge-intensive society...in which intellectual capital...educated people and their ideas...become the keys to our prosperity, security, and well-being.

Let's explore these themes for a moment to see how they

might impact on your college education...

Age of Knowledge

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.

As Erich Bloch, Director of the National Science Foundation

suggests, we are entering a new age, an "Age of Knowledge"

The signs are all about us.

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.

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.

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.

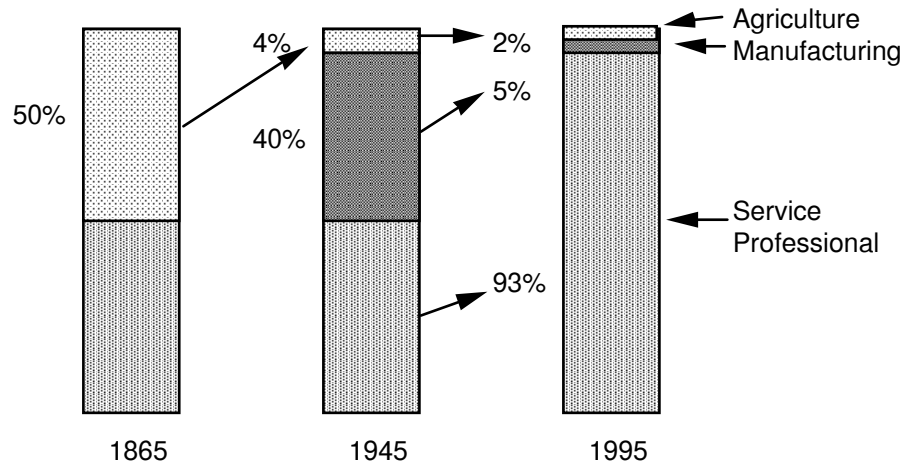
Knowledge and the people who can create and use it are the

new strategic resource.

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!!!
 (In fact, the material for computer chips is the world's most common substance...sand!!!)
- Our nation's future has probably never been less constrained by the cost of natural resources. Future areas of growth are likely to come from the application of technologies that require few natural resources.
- 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 20 within a couple of decades...
 Indeed, UM economic studies suggest that less than 5% of General Motors' work force will be unskilled labor by the year 2000.

Noland-Norton



- Recent Office of Technology Assessment report:
 40% of all new investment in plant and equipment goes to purchase information technology
 - What's more, these new technologies magnify the effects of change. "Today the velocity of change is so great... that the tectonic plates of national sovereignty and power have begun to shift" (Walter Wriston)
 - Today a microprocess can calculate the orbit of Mars in about 4 seconds, a task that took Johannes Kepler 4 years.
 A researcher can have on a desktop more computing power than existed in a standard mainframe only 10 years ago.
 Modern electronic technologies have increased vastly our capacity to know and do things. Moreover, they allow us to transmit information quickly and widely, linking distant places and diverse areas of endeavor in productive new ways.
 These technologies make many things possible.
 But they don't make things happen.
 Only people make things happen.
- US and Japan already have become postindustrial societies; with predominate sectors in service and high tech. By 1990, 75% of US labor force in services---not burger flipping, but financial services, professional and design services, and human services. Core of postindustrial society is professional and technical services.

A fundamental transformation is underway in our economy that is reshaping virtually every product, every service, and every job in the United States.

In our country, as in all developed nations, "knowledge workers" have already become the center of gravity of the labor force.

A transition in which..

Intellectual capital--brainpower-- is replacing financial and physical capital as key to our strength, prosperity, and well-being

This is having a profound impact on our social

structure, culture, and economy.

In this age of knowledge, one of our greatest strengths is

our system of higher education.

Our colleges perform over half of the basic research in America.

They produce essentially all of our knowledge workers.

By coupling research and education, our academic institutions provide an unmatched opportunity for advanced training and learning-by-doing.

The fact that our schools draw students and faculty from all over the globe and attract investment from foreign companies indicates that in a competitive educational market, our institutions are delivering the best product. They are probably more competitive today in the world marketplace than any other US "industry".

The Role of Technology

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.

Example:

Over past two decades, India has increased its population of scientists and engineers by tenfold!!!

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...

Our economy is at a crossroads...and its future course rests on a disparate set of conscious choices.

Whether the economy moves on a path leading to stagnation, rising imports, and growing unemployment or on a path of rapid growth and technological change, will require "an unflinching reexamination of the way businesses are managed"

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.

Central theme is that education, broadly defined, will play a pivotal role in the coming economic transition and its impact on individuals.

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.

Synergisms

While some warn against expecting more from science in the coming years, HTS disagrees. The critical new dimension of the next decades will be the new synergetic and productive relationship among science, technological innovation, and the implementation of new technology. This will coincide with the increasing internationalization of world markets.

Most new technologies have international rather than national origins and will depend on the international transfer of technology for their full development.

A particular challenge:

Even as our society becomes more knowledge dependent, we are confronted with a shrinking college-age population and declining degree attainment at all levels of higher education.

What has come to be called the "pipeline" problem pervades the entire educational system. It is reflected in the absence of science and math courses and prepared faculty in K-12, in the low standing of our students in international comparisons, and in the pervasive disinterest and lack of preparation of our students in college-level careers in science and engineering.

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 force 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 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%) (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 talent.

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 rank 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 freshmen 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 freshmen 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 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.

**Engineering Commencement
 Congratulations**

It is my honor to convey to you congratulations

on behalf of the Officers of the University
Congratulations to the Class of 1988E...
And to your families and friends who have
gathered with us this evening to
celebrate your achievements
Actually, this is also a great personal pleasure,
since your class is very special.

The Class of 1988

1. In a sense, I view you as half mine!
Some of you who are able to remember far
back into the dim past of your freshman and
sophomore years may also remember that
I was once your Dean way back in those
prehistoric times...
2. It was your class that led the charge to
the North Campus...and while the move
during your years at Michigan may have
sometimes been inconvenient and
frustrating, I suspect that you will also
look back on this as a time of great
excitement for Michigan Engineering
3. Your Class is special for yet another reason...
because of the time at which you are graduating
--at the dawn of what is sometimes called the
Information Age

Actually, something even more profound is

happening at just the time when you are graduating
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 Reason, the Age
of Discovery, the Industrial Revolution

You are graduating at a time when our
civilization is going through yet another
such change...

A change in which we are evolving from a
resource-intensive to a knowledge-
intensive society...

A transition in which..

Intellectual capital--brainpower-- is replacing
financial and physical capital as key to
our strength, prosperity, and well-being

It is not just the impact of science technology...
although, to be sure, this is playing a critical --
indeed, perhaps a driving, role.

New ideas and concepts are exploding forth
at ever increasing rates...

New forms of thought such as
Feminism and Pluralism
Liberation Theology

Obscure, yet profound, new ways to
approach knowledge such as
Deconstructionism
Knowledge Engineering

Even new fundamental philosophies
of life, such as the new philosophy
of "literalism", first stated in last
week's Bloom County by Opus...

"You're born...

You live...

You go on a few diets...

You die."

Think about it...

Some real words of wisdom, there...

In a very real sense, the Class of 1988
is graduating during the birth of an
entirely new age...

"An Age of Knowledge"...

In which people and their ideas will be
the most precious commodity of all.

In one sense you are probably the best

prepared of Michigan's graduates today to
respond to this new age, since your
combination of a rigorous education in
science and engineering, pursued within the
more general context of a liberal education,
has prepared you to create and apply new
knowledge across the full span of disciplines
In contrast to the majority of our society, you are
literate both in our traditions of culture...and in
the new forms of knowledge that will determine
our future...

Yet, with this knowledge comes not only opportunity
but responsibility as well.

Remember the haunting passage from T. S. Eliot:

"Where is the life we have lost in living?"

"Where is the wisdom we have lost in knowledge?"

"Where is the knowledge we have lost in information?"

While you might view your education at Michigan

as one aimed at extracting knowledge from the vast
information characterizing our society, let me suggest
that our real goal was something far beyond that.

Our goal, indeed, the goal of any liberal education,

was to help you learn how to extract wisdom from
knowledge -- and through that wisdom, prepare you
to learn the art of life itself...

We hope that while at Michigan you have

learned how to find the wisdom in knowledge...
and hence to find the life that is in living"

Congratulations!

Godspeed!!!

And may the force be with you...

The force of the maize and blue!!!