

NAE Meeting

Some Personal Memories

This year has seem like one long sequence of silver anniversary events...

This symposium is designed to celebrate, in part, the 25th Birthday for the National Academic of Engineering

Two months ago in Ann Arbor we hosted the Symposium celebrating the 25th Birthday of Educom, the consortium of colleges and universities advancing the development and implication of information technology.

In a more personal sense, this was the year my wife and I celebrated our silver anniversary... and our 25th class reunions at our undergraduate colleges.

Hence it has been a time of nostalgia...and a time or remembrance...

When I think back, I remember 1964 as a time of great optimism in America... the glow of Camelot of the Kennedy administration... still lingered with us.

There were great causes to take up such as
...world peace...
...the conquest of space
...the Civil Rights movement

My Class of '64 graduated with feeling of boundless confidence in ourselves and our country.

But there were already clouds gathering on the horizon even during my senior year that suggested that things would be not quite so simple, that dramatic changes were coming...
John F. Kennedy was assassinated during the fall of my senior year...
The Cold War had begun to heat up with the Cuban Missile Crisis
A few people were talking about a distant war in a place called Viet Nam
The Free Speech Movement at Berkeley was revealing a new spirit of student anger and activism on the campuses.

But even with these warning signs, we were not prepared for the dramatic crises and confrontations, the great changes that Americans and their institutions would face in the years immediately following our graduation...

- the war in Vietnam that so profoundly affected all of our lives...
...both those who served and those who protested...
- the eruption of assassination and terrorism which robbed us of our heros
- the racial turmoil that tore apart our cities
- the emergence of the drug culture...
as more people turned on and tuned out...
- Watergate, and the crisis in confidence in our leaders

In a sense, during the decade following my graduation America lost its innocence...

In many ways, my class may have represented the last generation of Americans to be truly optimistic about the future... to welcome its challenges and to feel equal to them.

Yet the wheel continues to turn...
...and in many ways, today's generation of college students is remarkably similar to my own...
...with a growing sense of excitement and optimism about the future...and confidence in their own ability to response.

Possible Futures

This process of futuring is important for another reason.

The students on our campuses today were born and educated in the 20th Century... indeed, most of them are children of the 60s generation...
...**my** generation (and that's a frightening thought!)

Yet they will be spending the majority of their lives in the

next century...in the 21st Century.
Further most of us...and our faculties...are products
of the 20th Century...

While the structure of the American university
as we know it today is a product of the 19th Century!

It is therefore both appropriate and important to ask the question:
Is the University as we know it today really prepared to
educate the citizens and serve the society of the 21st Century?

To address this question, it is necessary to do a bit
of futuring...in an effort to understand the changing
nature of our society...and the challenges which
these changes will pose for higher education.

While it is always dangerous to speculate more than a few years
into the future, three themes seem very 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 truly extraordinary
in the history of our civilization...
- ii) It will be a future in which America will become "internationalized"...
in which every one of our activities must be viewed from
the broader context of participation in the global community...
as America becomes a "world nation", with not simply just
economic and political ties, but indeed, *ethnic* ties
to every part of the globe...
- iii) 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.

I believe it important to explore these themes in a bit more
depth for a moment, since they have very major implications
for our institutions.

1. Demographic Change: The New Majority

America is changing rapidly...

When we hear references to the demographic changes
occurring in our nation, our first thought probably
focuses on the aging of our population.

It is indeed true that the baby boomers are now entering middle age,
and their generation has been followed by a baby bust...
in which the number of young adults will be declining over the
remainder of this century by roughly 20%.

Indeed, today there are more people over 65
than teenagers in this country, and this situation will
continue for many decades.

Further, the growth rate in both our population and workforce is
is declining to the lowest level in our nation's history.

America will simply not be a nation of youth again in your
lifetimes.

Yet, there is a far more profound change occurring in the
population of our nation.

America is rapidly becoming the most pluralistic,
multicultural nation on earth.

Women, minorities, and immigrants now account
for about 90% of the growth in the labor force.

By the year 2000, they'll represent 60% of all of our
nation's workers!!!

Those groups we refer to today as
minorities will become the majority population of
our nation in the century ahead...just as they are
today throughout the world.

And women have already become not only the predominant
gender in our nation and our institutions, but they are
rapidly assuming their rightful role as leaders of our
society.

In this future, the full participation of currently underrepresented minorities and women will be of increasing concern as we strive to realize our commitment to equity and social justice.

But, in addition, this objective will be the key to the future strength and prosperity of America, since our nation cannot afford to waste the human talent represented by those currently underrepresented in our society, this human potential, cultural richness, and social leadership.

If we do not create a nation that mobilizes the talents of all our citizens, we are destined for a diminished role in the global community, increased social turbulence, and most tragically, we will have failed to fulfill the promise of democracy upon which this nation was founded.

But there are other important challenges associated with such demographic change.

In particular, it is important to realize here that 21st Century America will NOT be a melting pot in which all cultures are homogenized into a uniform blend -- at least not during our lifetimes.

Rather, it will be pluralistic...composed of peoples of vastly different backgrounds, cultures, and beliefs...peoples seeking to retain their cultural roots...to maintain their differences and identities.

Our challenge will be to find the common bonds and values that unit us, even as we learn to respect and value our differences.

The growing pluralism of our society is perhaps our greatest challenge as a nation...yet it is also among our most important opportunities, since it gives us an extraordinary vitality and energy as a people.

2. The Internationalization of America

The second theme is triggered by an event that happened from almost exactly two decades ago...when Apollo 11 set down on the Sea of Tranquility to put man on the moon.

The image I have in mind is that extraordinary photo of the earth taken by Lunar Orbiter as it circled the moon...
...an image that dramatically revealed how nations and peoples are passengers together on spaceship Earth.

It was a portent of today, a time in which all aspects of American life are becoming increasingly "internationalized", in which our nation has become a member of a truly global community.

Whether through travel and communication, the arts and culture, the internationalization of commerce, capital, and labor, we are becoming increasingly dependent on other nations and other peoples.

The world and our place in it have changed.

American will no longer take its know-how and apply it to low-cost natural resources from third-world countries, turn it into products, and then sell it back to them--as we do in a hierarchical economy.

Rather, we'll be only one member in a global dynamic economy with tremendous network interdependency between countries.

The fact is that a truly domestic US economy has ceased to exist.
...It is no longer relevant to speak of the California economy or the American economy...or the competitiveness of California industry or American industry.

Our economy...our companies...are truly international, spanning the globe...and intensely interdependent on other nations and other peoples.

In slightly more than 5 years, US trade deficit has taken

us from the world's largest creditor to its largest debtor nation.

We are no longer self-sufficient or self-sustaining. We are not immune to the shocks of the world society.

As the recent events in China and the Soviet Union make all too clear.

But beyond commerce and national security, there is an even more important reason to pay attention to the trends of internationalization...

The US has become the destination of about half the world's immigrants Probably 10 million this decade alone...

With falling fertility rates, immigration will soon become the main determinant of the variability in our population.

As we have been throughout our history, we continue to be nourished and revitalized by wave after wave of immigrants, coming to our shores with unbounded energy, hope, and faith in the American dream.

Yet today, in a very real sense, America is evolving into the first true "world nation", with not simply economic and political but also ethnic ties to all parts of the globe...

From this perspective, it becomes clear that understanding cultures other than our own has become necessary not only for personal enrichment and good citizenship, but indeed, necessary for our very survival as a nation.

3. The 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.

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.

As Erich Bloch, Director of the National Science Foundation suggests, we are entering a new age, an "Age of Knowledge in a Global Economy."

The signs are all about us.

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!!!

Our nation's future has probably never been less constrained by the cost of natural resources.

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

Recent Office of Technology Assessment report:

40% of all new investment in plant and equipment goes to purchase information technology

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

A transition in which..

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

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.

In these countries, indeed, in all developed nations, "knowledge workers"
are rapidly becoming the center of gravity of the labor force.

Themes of Change...

The America of the 20th Century that you and I 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 their 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...

(In fact, the brave new world I have been describing as
America of the 21st Century is California of the 1990s!!!)

But, whether these are themes of the present or of the future,
it is clear that they are also themes of change...
...themes that will both reflect and stimulate even more
fundamental structural changes in the nature of our
society and our civilization.

The Challenge of Change

Indeed, change itself might be regarded as the fourth theme
characterizing your future that I can predict with some certainty.

The French poet Paul Valery once said that
"The trouble with our times is that the future is not what it used to be."

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

Indeed, in many fields, the knowledge base is doubling every
few years... the knowledge you have mastered as
undergraduates is becoming obsolete even as you
are graduating!

As the pace of the creation of new knowledge accelerates,
it seems apparent that we are entering a period in
which permanence and stability become less
valued than flexibility and creativity...
in which the only certainty will be the presence of
continual change...
and the capacity to relish, stimulate, and manage
change will be one of the most critical abilities of all.

Implications for Our Students

If indeed, your future will be one characterized by rapid,
unpredictable, and dramatic change, then it becomes
apparent that your capacity for continual renewal
and personal development will become increasingly important.

Indeed, most college graduates of today's generation will
find themselves changing careers several times during
their lives.

Hence a college education will be only one of many steps down
the road of lifelong education...

Our students will find themselves continuing to learn--and relearn--
and relearn yet again through self study and returning to
school on occasion, as they attempt to adapt to a world of change.

Just look at my example! Who could have predicted that
a Caltech graduate would end up a president of a
university that won both the Rose Bowl and the NCAA
national basketball championship in the same year!!!

For Our Institutions...

Further, as our society becomes ever more knowledge-intensive,

and hence ever more dependent upon educated people and their ideas...

It seems clear that education in general...

...higher education in particular...

...and the research university most specifically are rapidly becoming the key ingredients determining the strength, prosperity, and social-well being of our communities, states, and nations as primary sources of new knowledge and those capable of applying it.

Just think of the challenges

which cry out for our attention

- the plight of our cities,
the development of an underclass
the polarization of American society
- greenhouse effect and global change
- international competition
Pacific Rim or Europe 1992
- health care: cancer, heart disease, AIDS
- new frontiers: outer space
or spaceship Earth

Hence our institutions will face a period of unusual responsibility, challenge, and opportunity in the years ahead.

But I believe we will also face a period of major change.

The winds of change,

- i) the growing pluralism of our society
- ii) our evolution into a world nation, ever more tightly coupled to the global community
- iii) and our rapid transition to a knowledge-based economy

are changing not only our nation and the world society, but they will also compell changes in higher education.

The triad mission of the university as we know it today, teaching, research, and service...

was shaped by the needs of an America of almost a century ago...
as American expanded to the frontier...
as it evolved through the industrial revolution...
as it absorbed wave after wave of immigrants

Yet our nation today is changing once again, at just as rapid a pace...

I believe that the 1990s will be

a time in which we are called upon to re-invent the nature of the university once again...
...a university capable of educating the citizens and serving the society of not the 20th Century, but rather the 21st Century.

This is our challenge...

This is our responsibility...

This is our opportunity.

Some Examples:

Pluralism

It was my believe that for Michigan to achieve excellence in teaching and research in the years ahead, for it to serve our state, our nation, and the world...we simply must achieve and sustain a campus community recognized for its racial and ethnic diversity.

It seems apparent that we cannot sustain the quality-- indeed the relevance--of our universities in the pluralistic world society that is our future without a similar diversity among our students, faculty, and staff and in our primary businesses: teaching and learning, scholarship and research.

Here we have a two-fold responsibility...

i) First, to reflect the growing diversity in American society in the composition of our campus population...among our students, faculty and staff.

ii) But, beyond that, to build models of pluralistic multicultural communities for our nation.

Communities which value and respect and indeed, draw their intellectual strength from the rich diversity of peoples of different races, cultures, religions, nationalities, and beliefs.

Our challenge is not to make one group from many, to blend together all cultures into a homogeneous mixture...but to build from many varying cultural, racial, and ethnic groups a truly multicultural community in which we are bound together by a common core of values and beliefs.

To learn how to resist the great pressures of separatism, fear, and bigotry which push us apart...

...and instead commit themselves to a university...

...indeed, to a nation, committed to working together, to achieve common purposes.

After all, our institutions are first and foremost "UNI" versities, not "DI" versities.

Hence we view our challenge as learning how to weave together these dual objectives of diversity and unity in a way that strengthens our fundamental goal of academic excellence and serves our mission and our society.

In such an effort to build the multicultural university of the 21st Century, we are attempting to address the most urgent and difficult issue confronting our nation today.

It is clear that higher education alone cannot expect to correct the ills of our society...but it is also clear that neither can we simply sit on our hands, waiting for others to act.

America desperately needs leadership on this matter...

...and higher education must step up to provide it.

Internationalization

If our institutions are to serve America in its role as a member of the global community, we must think and act more imaginatively, more aggressively, and more strategically to strengthen our role as truly international centers of learning.

Certainly we have a long ways to go in this country to know what we need to know to participate fully as members of our human family. American knowledge of other languages and cultures is abysmally inadequate. By every measure we fall short educationally of the knowledge and skills it will take to do business, work cooperatively on common problems or advance our common ideals for humanity.

Too many of our graduates have never been exposed to a foreign language or visited a foreign country. Many have not had a chance to feel the texture of life in another era or another culture through literature and poetry or film. Some cannot locate Mexico or Egypt on a map.

Despite the intellectual richness of our campus, we suffer still from the insularity and ethnocentrism that is the heritage of a

country that for much of its history has been insulated from the rest of the world and self sufficient in its economyperhaps even self absorbed

Consequently, we must reexamine the way in which we foster, manage and promote the international dimension of our educational mission.

- We must strengthen the international component of our teaching and scholarship so that it pervades the liberal arts curriculum and that of the professional schools.
- We must be mindful that knowledge is not tied to geographic regions; rather the knowledge revolution is a world wide phenomenon and science speaks a universal language
- We must be open to the challenge and excitement for our intellectual work in the disciplines that results from the infusion of other experiences and perspectives of other regions, cultures and traditions.

We must ensure that our students are prepared with an understanding of how the rapidity of modern communications and ease of travel will change the texture of their lives.

Above all, we must enable our students to appreciate the unique contributions to human culture which come to us from other traditions.....to communicate.. to work.. to live.. to thrive..in multicultural settings whether in this country or anywhere on the face of globe.

The Age of Knowledge

If our future is indeed one in which the capacity to stimulate and manage intellectual change becomes important...

And in which change is also viewed as a highly nonlinear, occasionally dramatic, and usually unpredictable process triggered by extraordinary people and their ideas...

Then, this suggests that academic institutions may well wish to think carefully about how they go about their business of teaching and research...

In this future, renewal and change will become essential for both the achievement and sustaining of excellence.

It seems critical that academic institutions not just respond grudgingly to change; A university must relish and stimulate and manage a process of continual change and renewal if it is to achieve excellence and leadership.

We should seed our campuses with "change agents" people capable of stimulating intellectual change...to encourage paradigm shifts...bifurcations of the knowledge curve... knowledge revolutions...

We should provide the kind of fault-tolerant environment in which people are encouraged to take chances, to pursue bold and daring scholarship...without fear of failure.

A Focus on Engineering Education...

Let me dwell for a moment on an example of

particular interest to this group: engineering education
All of the themes of change characterizing our profession...
Pluralism, Globalization, Knowledge
Examples of Change...

1. Intellectual Change

Time-scale of research, development, implementation
Cross-disciplinary nature of important problems
Moving from "natural science" to an age in which
science may be less concerned with nature,
and more concerned with man-made objects
Biological molecules
Synthesized organic molecules
Integrated circuits
Artificial retinas
Computers
Other manifestations of our knowledge and ingenuity
Federal Trends: emphasis on macro, systems
NSF-NSB: ERCs, STCs, "big engineering" like "big physics"
Pushing engineering toward private sector?
Pushing engineering away from single-investigator activities
toward cross-disciplinary team research
Bankruptcy of traditional ABET curriculum
Importance of liberal education

Intellectual Questions:

Engineering \Leftrightarrow Applied Science \Leftrightarrow Basic Science
Science \rightarrow Engineering \rightarrow Systems \rightarrow Society
Scientific foundation \rightarrow Subsystems \rightarrow Systems
Macro vs. Micro

2. Changing Tools of the Engineer

Computer is a "lever" for the mind
Now improves both the productivity and the
intellectual span of S&E
CAD, CAM, CIM, CEP, CAE

Implications

Obvious

- i) Must integrate ("saturate) curriculum with use of computer
- ii) Take advantage of enhanced productivity
- iii) Unleash student's creativity

Not so obvious, but more profound

- i) Computer has changed engineering practice
No longer design-analysis-production-...
Now one engineer spans...
Hence we demand a generalist--not a specialist
- ii) Computer has provided powerful analytic tools
No longer does engineer pick a design and spend
days analyzing it
Instead, can explore many designs...let computer
do the dog work
Reemphasizes creativity over analysis--
science back to art
Right to left side of the brain...

NOTE: See Appendix A for a "Case Study" of how
we have responded to this challenge at Michigan

Rapid Pace of Technological Change

Engineers must factor change into their
career objectives

Change is a permanent feature of our environment
Continuing education will be an absolute necessity

Societal Uses of Engineer:

Why do students choose engineering?

- i) Excitement about science and engineering?
...or money \$\$\$
- ii) As a "preprofessional" education (problem

solving--analytical)
We now find students spring off engineering
into other professions
Business (30% of MBAs), law, medicine, academe
At Michigan, 50% of graduates will be in management
with 5 years

Question:

Is our present, narrowly focussed education appropriate
for the future leaders of America?
Importance of a broad and liberal education
Not just technical subjects, but art, literature, history...
Note: With this broadening, an engineering education
will be far more "liberal" than other fields which do
not include science and technology
Importance of generalist approach
Maybe a general undergraduate education followed
by graduate studies
How do we reintroduce creativity into education?
Can we "teach" creativity?

Educational Change

The problem is that we really aren't prepare people
for a world in which they'll change careers four or
five times in a lifetime. In this type of world,
the most successful people will be those who
can deal with ideas, who can look at things from
many perspectives.
Yet, in education, we continue to move to more and
more specialization. Further, we are approaching
the point of information overload, and it will take
discerning individuals to figure out what is important,
what they should use, and how they can understand
it. Yet the majority of people coming out of
universities today have weak communication skills
and a limited view of the world.
Young people are too quickly encouraged into job-
related specialization when they really should be
challenging the ideas of the past, discovering the
wisdom of others, exploring knowledge, and stretching
the intellectual breadth of their minds.
In the 21st century, people will finally think in terms of
lifelong education; college will be only one intermediate
step in one's education.

Suspicion

We have just begun to realize major changes required in
engineering education.
These changes will be just as profound as the earlier
transitions from a craft to a profession or from an
"experience-based" to a "science-based" discipline.
Major frustration:
Few seem to realize the changes which must occur
Industry, government, present-day engineers seem
satisfied
Indeed, they even resist such changes
Perhaps it will be the extraordinarily talented students
now seeking engineering education who will demand
the changes.

3. Societal uses of engineers

4. The quality of students

The Engineering Curriculum

Engineering graduates must prepare themselves
for a future in which permanence and stability
are less valued than flexibility and creativity...
in which the only certainty will be the presence of
continual change...

So how does one go about preparing for this future?

Evolution of Engineering Education

Stage 1: Artisans and craftsmen -- apprenticeship

Stage 2: Engineering schools (like medicine) -- teach profession (self-contained)

Stage 3: Shift to science base -- fundamental science education

Complexity demanded increasing specialization

- Civil, mechanical, electrical, chemical
have subdivided...
- Furthermore, engineering functions have
subdivided: research, development, design
production, project,...

Yet, despite the increasing emphasis on science and specialization, the engineering profession remains the only profession requiring only a 4-year UG degree!

The Real Key: A Liberal Education...

These challenges suggest that the principal focus of an undergraduate education appropriate for the 21st Century will be the goal of liberal learning... that is, a liberal education as the preparation for a lifetime of learning.

Perhaps Emerson put it best in his famous address at Harvard almost exactly 150 years ago:
"Colleges have their indispensable office, to teach elements. But they can only serve us when they aim not to drill but to create; when they gather from far every ray of various genius to their hospitable halls, and by the concentrated fires, set the hearts of their youth aflame..."

And, that is our real purpose...

To ignite the intellectual fires within each of our students...

We want to stimulate in each of you a spirit of liberal learning...a spirit that will be with them for the rest of their lives...

A Future of Hope

Rather, my crystal ball suggests a future characterized by rapid, unpredictable, and frequently dramatic change...
...in the nature of our people...
...in our bonds to other societies...
...in what we do...

As the United States becomes a pluralistic world nation, intensely dependent upon knowledge--upon educated people and ideas--and hence intensely dependent upon these marvelous, mysterious, and complex institutions we know as research universities.

It will be a future of great challenge and responsibility...

Indeed, as we stand today on the threshold of a new century, it seems clear that this generation of students will face problems and challenges of a magnitude that would have been incomprehensible in earlier times...

Further, the years following their graduation will be a time of less security, less stability, and more unpredictability than yours and mine.

But they will also face a future of extraordinary opportunity and excitement.

For, as the philosopher Alfred North Whitehead has noted,
"The great ages have been unstable ages!"

How of much of this particular vision of the future will actually come to pass?

Will the themes of pluralism, internationalization, and knowledge really dominate our future...

To be sure, change is not a predictable process..

There is always a hazard to predicting the future...

But then I always remember that old saying

"The best way to predict the future is to invent it!"..
And isn't that, after all, just the role of the University...
the job of inventing the future?...