MLC--Schence Manpoper Nee
s

My own concerns...

As you Ànow, I am a sa entist and!Öngineer
by training and background...

¡ must also confess I tend to be one of those
people who lives more in the future than in
the present or the past...

Over the years, I have become incr}asingly convinced
that education -- or more generally, the development
of human capital -- will become the dominant issue
for our state, just as it will be for our nation, in the
1990s and beyond.

Yet I also fear that few have realized the enormous
changes that our society is going through as it
approaches the 21st Century.

And, now, entering the 1990s, I find myself
looking once again to the future, facing
the challenge of helping to build a University
able to serve our state and our nation in
the 21st Century.

My personal agenda as president is to challenge the
University of Michigan to once again play the
leadership role is did during the 19th century, by,
in effect, re-inventing the very nature of what a
university must become to serve 21st Century America.

Themes of the Future

Think about it for a moment...

A few themes of the future...

The students we are educating today will spend most of
their lives in the 21st century...

Yet most of us...and our faculties...are products
of the 20th Century...

Furthermore, the structure of the American university
as we know it today is a product of the 19th Century!
The way we are organized into departments and
colleges...our serial approach to education...
even the concept of courses and credit hours...
all were introduced over a century ago.

And yet the American society we serve has changed dramatically

during the past century and continues to change at an
ever accelerating pace.

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?

While it is always dangerous to speculate about 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...
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.
In this future, full participation of underrepresented minorities
will not be just a matter of equity and social justice.
It will the key to the future strength and prosperity
of American, since our country cannot afford to
waste the human talent represented by its minority
populations.

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 ethnic ties
to every part of the globe...
The fact is, a truly domestic US economy has ceased to exist.
In slightly more than 5 years, US trade deficit has taken
us from the world's largest creditor to its largest
debtor nation.
US is the destination of about half the world's immigrants
Probably 10 million this decade alone...
One-third of annual population growth is immigration

iii) It will be a future i production is steadily switching away from
material and labor intensive products and processes
to knowledge intensive processes:

A transition in which..
Intellectual capital--brainpower-- is replacing
financial and physical capital as key to
our strength, prosperity, and well-being

It is my belief that these themes of pluralism, internationalization
of America, and our evolution to a knowledge-intensive society
will not only dominate the future, but will creat≈ a time of
unusual challenge and responsibility, opportunity and
excitement for this University.

Clouds on the Horizon

.heyd 2 + Maintaining our nations's competitive edge requires attention
to our traditional strength -- people and research -- and
a strong offensive strategy based on these resources.

Central theme is that education, broadly dexined, 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.

WARNING SIGN 1: America's S&E lead is slipping
No question that US has lost lead in many areas
Industrial productivity and heavy manufacturing
Steel, durable goods, ...
Energy
Electronics
Also serious signs that lead is slipping rapidly in
Computers
Aerospace
Moreover, key activities such as product design,
engineering, and software development increasingly
are likely to be done overseas.
Whether automobiles or refrigerators, computes or
microchips, nuclear power or energy transmission
systems, the likehood is increasing that the systems are
assembled from components designed, engineered,
manufactured, and shipped from all parts of the world.
Increasingly, excellence in research and engineering is to
be found throughout the world, and the level of innovation
is rising abroad. More than 43% of US patents went to
foreign entities.

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. US investment in civilian R&D as a percent of GNP is now less than that of any other developed nation (and only 60% that of Japan and West Germany...)

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

Support of basic research has dropped signipicantly (as has`support of research in C`S)

We need a major commitment by the

federal government and
industry to research on u e□rstanding how people learn
and to the development of new educational technologies.
.he`d 4 - "If the fractioŒ of gross expenditures(invested in research
were the same-Üor education as for t`e average priwÅu□ly owned business in the United States, about $9 billion a year would be spend on educational□research--60 to 90 times more than the present allocation"

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

WARNING SIGN 3: The S&E Pipeline Problem

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

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

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

Japan has doubled its technical workforce in past decade...
7 of 1,000 American students receive engineering degrees
40 of 1,000 Japanese -- indeed, Japan witj less than half the population is producing far yore scientists and
.heyd 7 - 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 tealent.

But things are going to get MUCH rougher: NSF Study

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 graduat≈s.
3. Trends in IntendeeÄMajors:
   But this situation may become even worse:
   Over period from 1966 to 1987, proportion of students who intended to major in physicsal sciences yas 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.

4. Compositionof 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 the 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 BlacÀs is 30%; Hispanics 40%.

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

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

Cm

clusions:

i) If we couple demographics with student pr}ferences, we have .h}ad 5 - got a timebomb on our hands...

ii) Indirect effects, since smaller! nrollyents in S&E will mean less justification for investmenuÉ in faculty and facilities...

iii) We must act rapidly...

First to plug up the leaks in the pipeline...

Then, over the longer term, uè adypt the education system in American to a changing population

WARNING SIGN 4: Undergraduate S&E Education

NSB Report:

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

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

Engineering Education

At the UG level, concern is primarily one of quality rather than quantity.

Extraordinary quality of students attracted to engineerng has masked the decline in the quality of instructional programs.

Few academic institutions have taken steps to re-establish a balance between engineering enrollments and resources through major internal reallocation or limits and reductions of enrollments.

While American industry has been a driving force in the intense demand for engineering graduates, it has been slow to accept a corresponding responsibility for supporting engineering at a level adequate to meet this demand.

Finally, federal programs have tended to focus on K-12 and graduate

level education and research, largely ignoring the fact that the critical limiting factors in the supply of engineering graduates

are at the UG level.

Industry did the same by focusing support on graduate education and research that was more closely related to corporate interests.

Nature of the crisis:

1. Faculty shortages
   - 2,000 vacant faculty positions...
   - 50% foreign national
   - Things are only going to get worse...
     - greying of engineering faculty...
     - return of foreign nationals...
     - demographics coupled with declining student preferences...
2. Facilities
   - Few schools have managed to maintain either the quantity or quality of facilities necessary to respond to surging enrollments and sophisticated technology
   - Absence of federal programs to assist in construction
3. Instructional Laboratory Equipment
   - Deterioration in lab equipment is a national scandal
   - NSF surveys indicate that only 16% is state-of-the-art
   - Backlog exceeds $4 billion...
   - Similar investment in computing environment...
4. Curriculum
   - Growing vocational focus of engineering curriculum as more and more specialization occurs
   - Inadequate exposure to engineering practice--particularly in areas such as design, synthesis, and systems integration
   - Inadequate exposure to practicing engineers due to research focus and limited industrial experience of faculty
   - Traditional approach to instruction along discipline line is unable to keep pace with intellectual evolution of engineering
     practice which tends to be cross-disciplinary in nature
   - General concern that entry degree should be M.S. degree

Haddad Report:

"Today's four-year baccalaurate engineering curriculum is largely obsolete. It does not provide adequate depth in engineering subjects, adequate breadth in engineering science and mathematics, or adequate exposre to engineering practice. Furthermore, the largely vocational focus of most undergraduate programs deprives today's student, characterized by broader interests and career objectives than in the past, of the liberal education so necessary to adapt to technological change and assume

leadership roles in our society."

NSF Study Groups:

"The NSF program should be designed to deliver a good 2x4 shot across the buttocks of engineering education..."

"NSF's role should be to encourage and support the intellectual efforet necessary to restructure the curriculum and teaching
methods in the light of present day and near future technical realities. This should be a process of "bottom-up" rather than "top-down" direction of a program from the federal level."

NSF Response to Date:

NSB Report recommend +$42 M in FY88 and +$92 M in FY89 targeted across a variety of programs in curriculum development,
laboratory instrumentation, faculty development, and so on.

Yet, in the aftermath of the December deficit reduction actions:
+$8 M in FY88
+$18 M in FY89 (although this is still at risk)

Hence, despite the rhetoric from the NSF, we still have a very long ways to go...

WARNING SIGN 5: PhD Education: our Future Faculty

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

Hence US PhDs will decline due to reduced BS graduates

Foreign PhDs are beginning to return...

US universities are becoming less attractive...
we've become complacent

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

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

PhD shortage in faculty...

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

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

WARNING SIGN 6: 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 mater 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 survyed indicated they believed we were being visited by aliens from outer space!

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

Note: it is bad enough that...

10% of Americans are illiterate

25% now fail to complete high school

Scientific Literacy of K-12 Teaching Force

Only 30% have had college chemistry

Only 20% have had college physics

Less than 50% have had calculus or computers

International Association for Evaluation of Educational Achievement (IEA)

Grades 4, 8, and 12

US was 8th of 17 for 4th graders

US was 14th of 17 for 8th graders

US was 11-13 of 17 for 12th graders

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

(Top scores were Japan, Korea, Hungary

"For a technologically advanced country, it would appear that a reexamination of how science is presented and studied is required...in the United States."

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

Face it, gang:

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

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

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

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

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

Michigan is undergoing dramatic change in industry...

Away from low-skill, blue-collar workers

The factory of the future will have NO low skill workers

Unskilled labor will lose relevance in a world dominated by microelectronics, computers, and automation.

An example: Expert systems

The "expert system" craftsman...

Key input, however, is quality of the workforce.

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

Serious concern:

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

It is bad enough to face the prospect of a 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?

The Need for a New Coalition

Somehow we must reprioritize the agenda of this state...

To shift away from our present myopic policies of addressing only the needs and desires of the moment

And, instead, to begin to make some of the key investments

necessary for the long term...

The key investments in people in general...and in our children in particular...

This is not just the worry of local communities or state government or public institutions

It is everybody's concern!

Leaders in the private and public sector are going to have to step forward and unit behind this initiative.

We must learn to build new coalitions involving the public and private sectors...state government, education, business, industry, and labor...to develop an agenda appropriate to secure the future of our children, our state, and our country.

Michigan still has the opportunity to regain economic leadership.

We still are blessed with abundant natural resources, a people of great strength, and a system of higher education of a quality envied by the rest of the nation...albeit sustained by "overachievement" in the face of inadequate state support.

But, the writing is on the wall...

The future of our state is being lost rapidly through serious underinvestment in our most valuable resource, our youth...