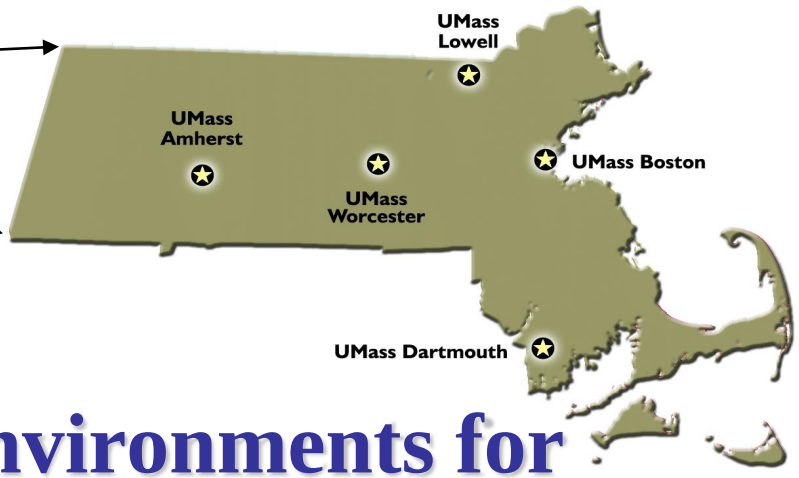


Creating New Learning Environments for Engineering Education: How Educational Research Drives Change

By:
Jack M. Wilson
President
University of Massachusetts

June 15, 2005

Engineering:
Global Opportunities,
Global Challenges,
Global Thinking

What shapes my views

- President, University of Massachusetts
- Vice President at both Univ. Of Mass. and Rensselaer (RPI).
- 35 years as a professor and administrator of all sorts
- Chairman, CEO, and Founder of software company built into industry leading public enterprise
- Formerly J. Erik Jonsson Distinguished Professor of Physics Engineering Science, Information Technology, and Management at RPI
- Co-Founder Severino Center for Technological Entrepreneurship
- Strong involvement in international programs including Asia, Eastern Europe, Mexico, etc.

The University of Massachusetts

- **$1.8 B enterprise** in FY05 ($326M state appropriation- $400M+- in FY05)
- Over **$350M in sponsored research** (90% outside of Rt 128)(# 3 in Mass)
- **$28 Million per year** (top 20) in commercialization of research
- **5 campuses** and 80 off-campus sites throughout the Commonwealth
- **14,000 employees**, making UMass a major employer across the state
- **About 58,000** undergraduate/graduate/continuing education students
- **UMassOnline: 17,000** enrollments in workplace in 40 degree programs
- Over **10,000 graduates** annually
- Over **450 BS/MS/PhD** programs
- Over **320,000 alumni** – 2/3 living and working in Massachusetts
- **$1.7 B capital program** with huge deferred maintenance needs

Issues in Engineering Education

- Globalism
- Nano-, Info-, Bio –, Cogno-, Enviro-
- Women
- Minorities
- Liberal Arts - Humanities
- Entrepreneurship
- Interactive Learning
- Continuing Education – Online learning

Messages to our universities

- While the ability to solve complicated models and equations will remain important, it will by no means be enough.
- Engaged rather than didactic education.
- Educating Engineers, and all students, more broadly to understand:
  - Communication,
  - Culture,
  - Economics,
  - People skills and team dynamics,
  - Entrepreneurship
  - Ethics,
- Tapping women and underrepresented minorities
- Take quality and standards to the next level!

National Academy Report

- broadly educated,
- who see themselves as global citizens,
- who can be leaders in business and public service, and
- who are ethically grounded.
- Chapter 4 takes the aspirations a step further by setting forth the attributes needed for the graduates of 2020. These include such traits as
  - strong analytical skills,
  - creativity,
  - ingenuity,
  - professionalism, and
  - leadership.

  (The Engineer of 2020: Visions of Engineering in the New Century, NAS/NRC 2004.)

National Academy of Science report

- This study suggests that if the engineering profession is to take the initiative in defining its own future, it must
  - (1) agree on an exciting vision for its future;
  - (2) transform engineering education to help achieve the vision;
  - (3) build a clear image of the new roles for engineers, including as broad-based technology leaders, in the mind of the public and prospective students who can replenish and improve the talent base of an aging engineering workforce;
  - (4) accommodate innovative developments from non-engineering fields; and
  - (5) find ways to focus the energies of the different disciplines of engineering toward common goals.

(The Engineer of 2020: Visions of Engineering in the New Century, NAS/NRC 2004.)

Universities must connect to communities.

- Work force development
  - Community needs in bio-, nano-, info-, medical-technologies.
- Educating underrepresented groups
- Collaborating with industry
- Research and Venture Capital are the fuel-air mixture for innovation.
- Technological entrepreneurship
- Understanding cultures

Educational Environment

- **Our present educational systems are the stable products of long evolution!**

The Three C's

- Our present educational systems were designed long before the research was done in at least three areas:

- Computing
- Cognition
- Communications

The University in the Convergence of

- **Computing, Communications, and Cognition**
  - **Transforming our educational programs**
    - **Studio classrooms and other innovations**
    - **Online programs,**
    - **Interactive learning in traditional classrooms**
    - **Linking communities in different geographies**
    - **Providing educational opportunities in underserved areas.**
    - **Developing global programs**
  - **Transforming our business practices**
    - **Enterprise systems – expensive and powerful**
    - **Development of Central Shared Services**
  - **Transforming our research**
  - **Transforming our community service.**

Computing

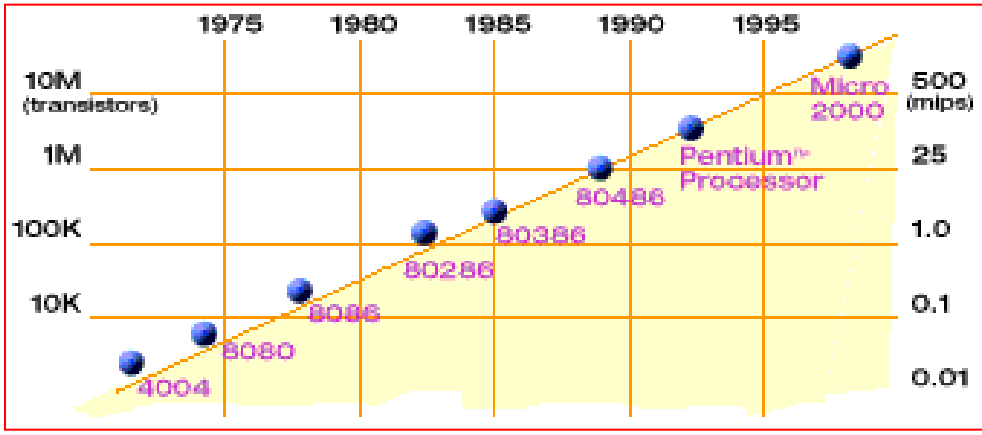
- Computing has changed both
  - What we teach, and
  - How we teach.
- Its only just begun!
- No one has repealed Moore's Law
- The Bandwidth Law (Gilder's law) is slower but still on track
- Metcalf's law remains the a key indicator for success.
  - Network value

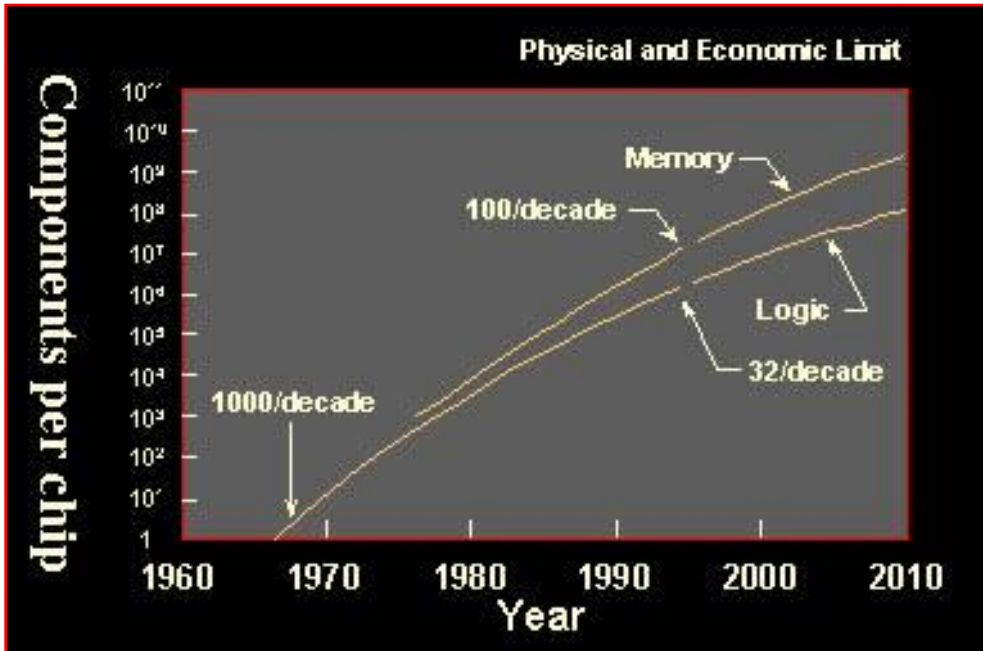
I. Wilson's Favorite Laws!

I. Moore's Law:

- CPU performance doubles every 18 months.
- Cost of equivalent computing power halves
- Basic physics drives this.
  - CMP, etc.

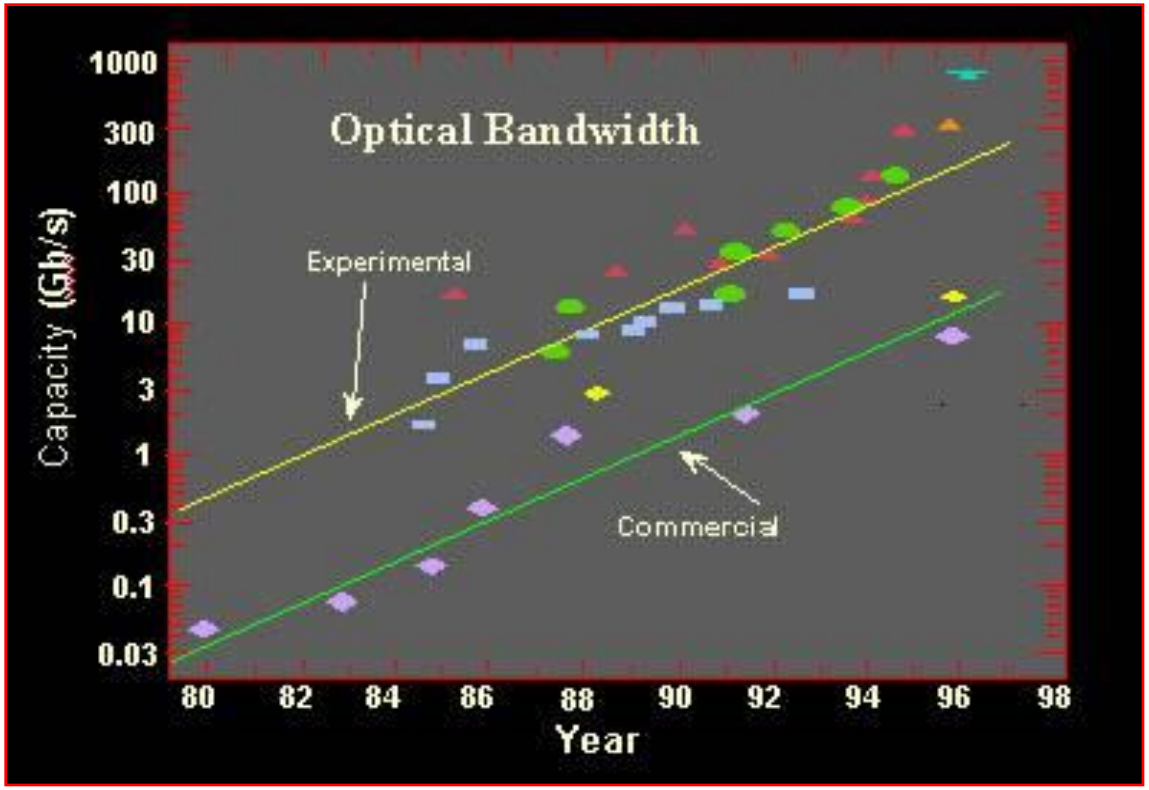
- Evolution of applications
  - ex PTC and Pro-Engineer





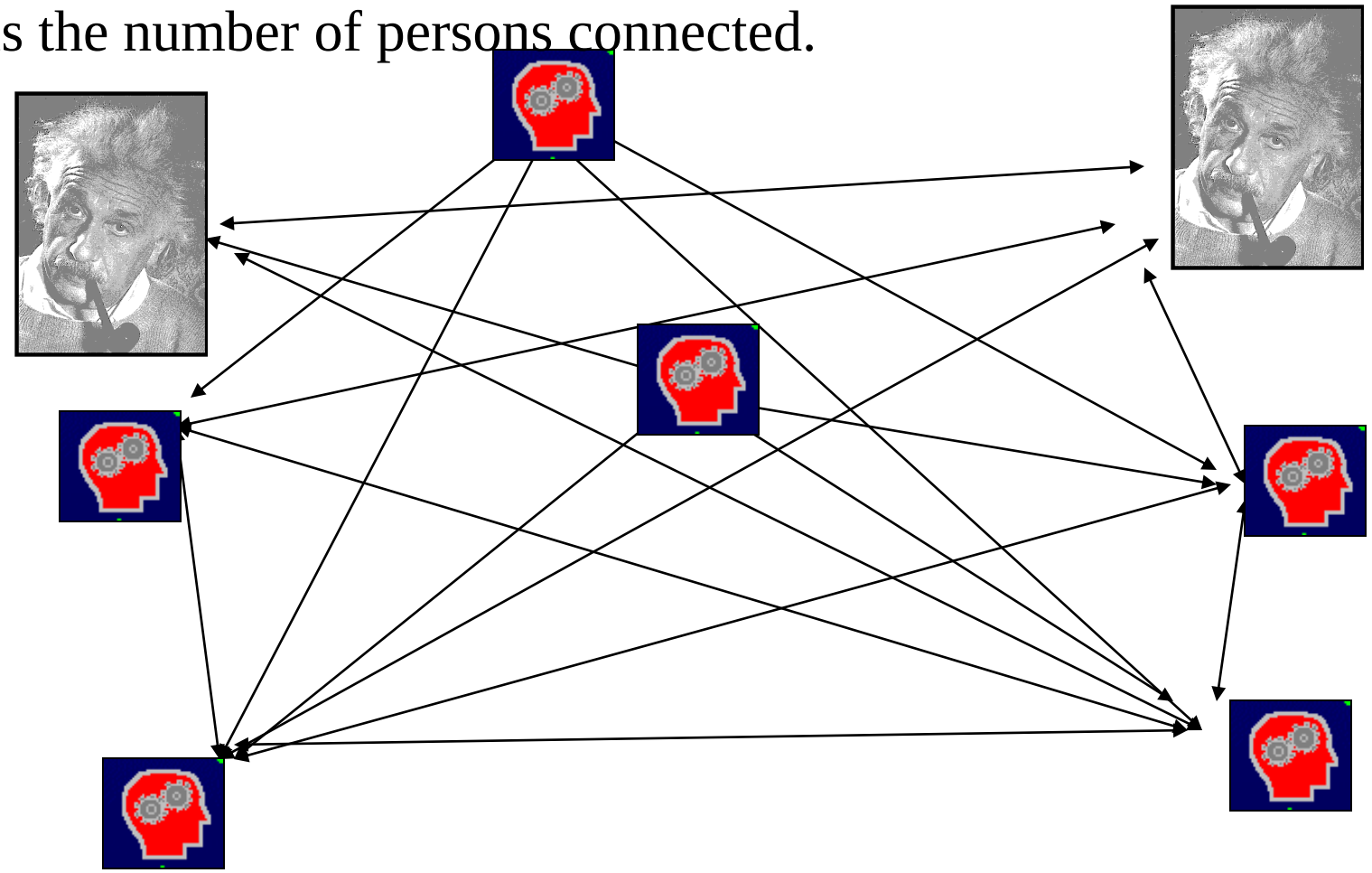
II. Wilson's Favorite Laws!

- II. Bandwidth law (sometimes called Gilder's Law): Bandwidth is doubling even faster!



III. Wilson's Favorite Laws!

- III. Metcalf's Law: the value of a network scales as n^2 where n is the number of persons connected.



Cognition

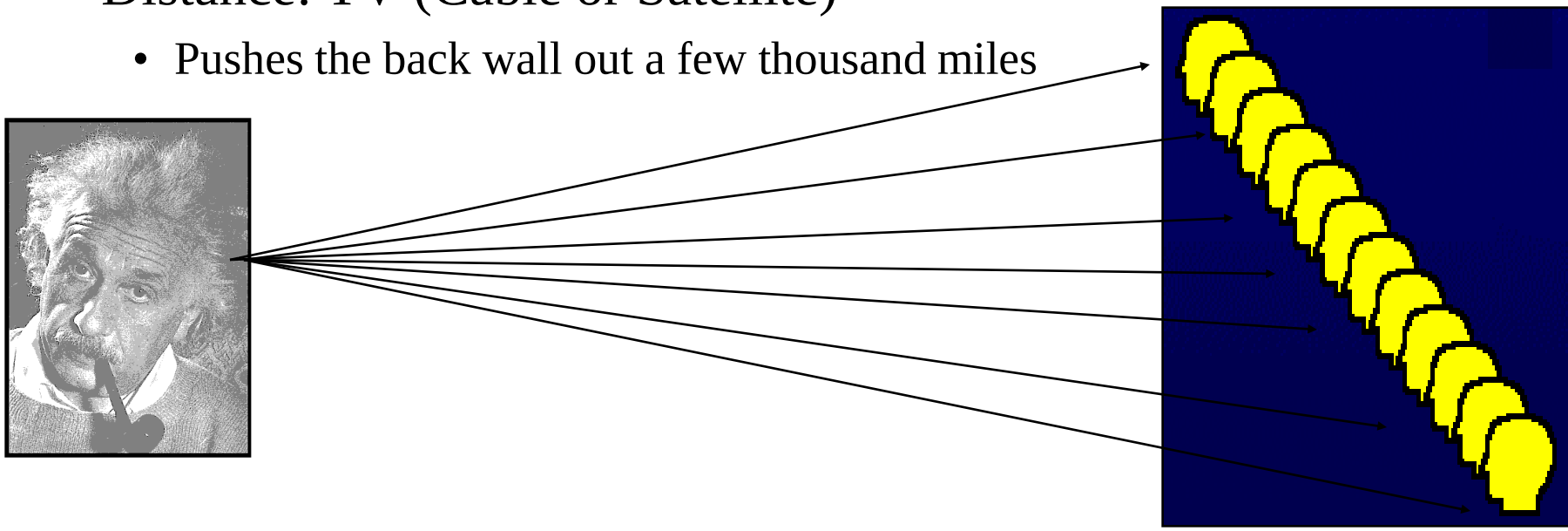
- Research on how we learn has taken off since early computer researchers began to study human learning in order to design “smarter” computer systems.
- Ironically, we have made far less progress in designing intelligent systems than we have in
- Learning how humans learn.
- Importance of engagement and real world activities.
- All of this research post-dates the development of the vast majority of learning environments in present use.

Communication

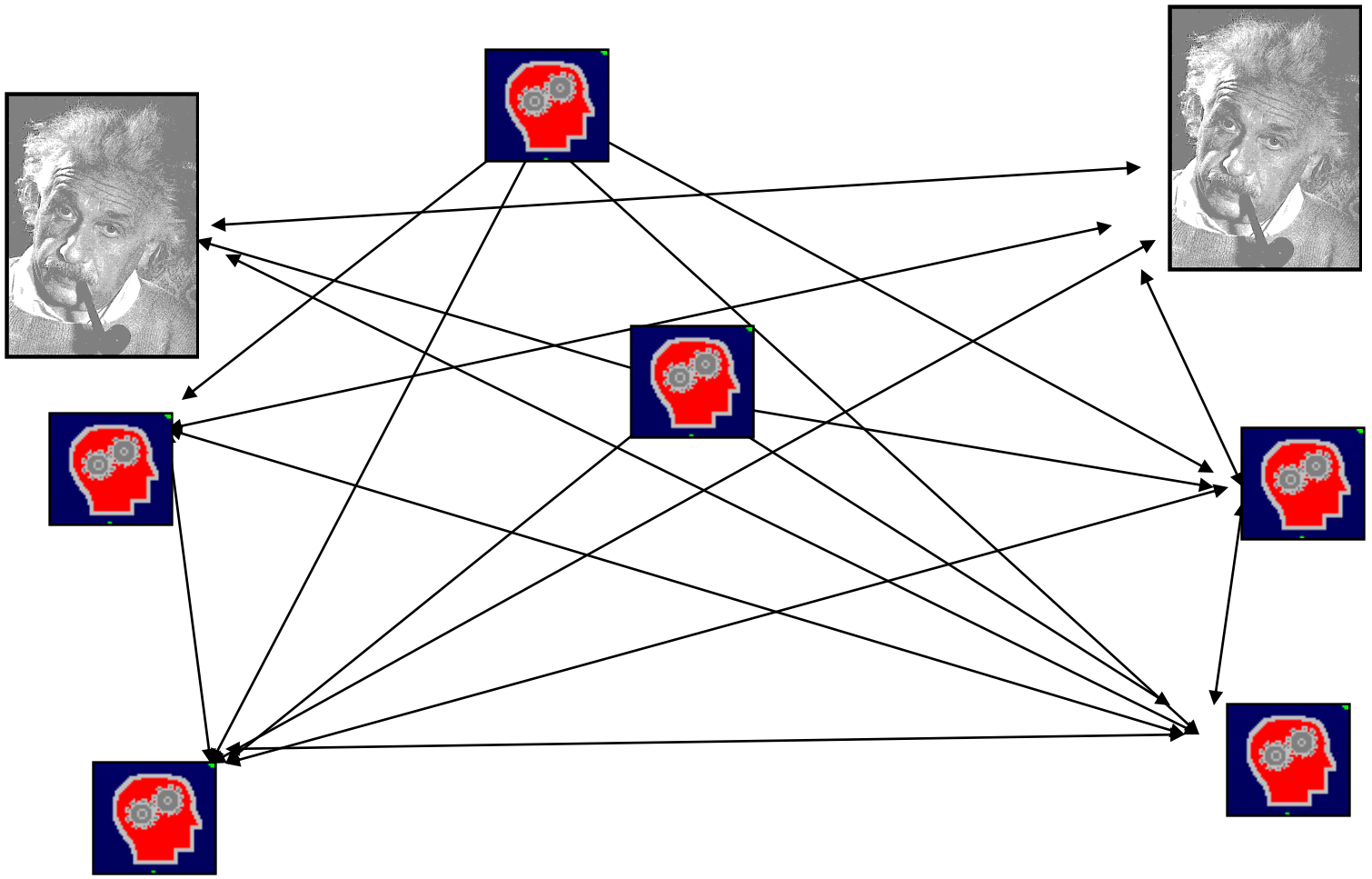
- As we saw in Gilder's law, it is an ever increasing world of communication
- This intense communication has created new kinds of world communities.
- These tools are now well developed in all sorts of e-learning platforms.
  - In use in both on-line and traditional courses.
- Can connect students in different countries into the same class.
- Can provide opportunities to students who have few.

The transmission model

- The mainframe approach
  - Face to Face: The Lecture
  - Distance: TV (Cable or Satellite)
    - Pushes the back wall out a few thousand miles



Distributed Collaborative Model



The horrible mismatch

- People change very slowly
  - Both a comfort and irritant!

- Technology changes very rapidly

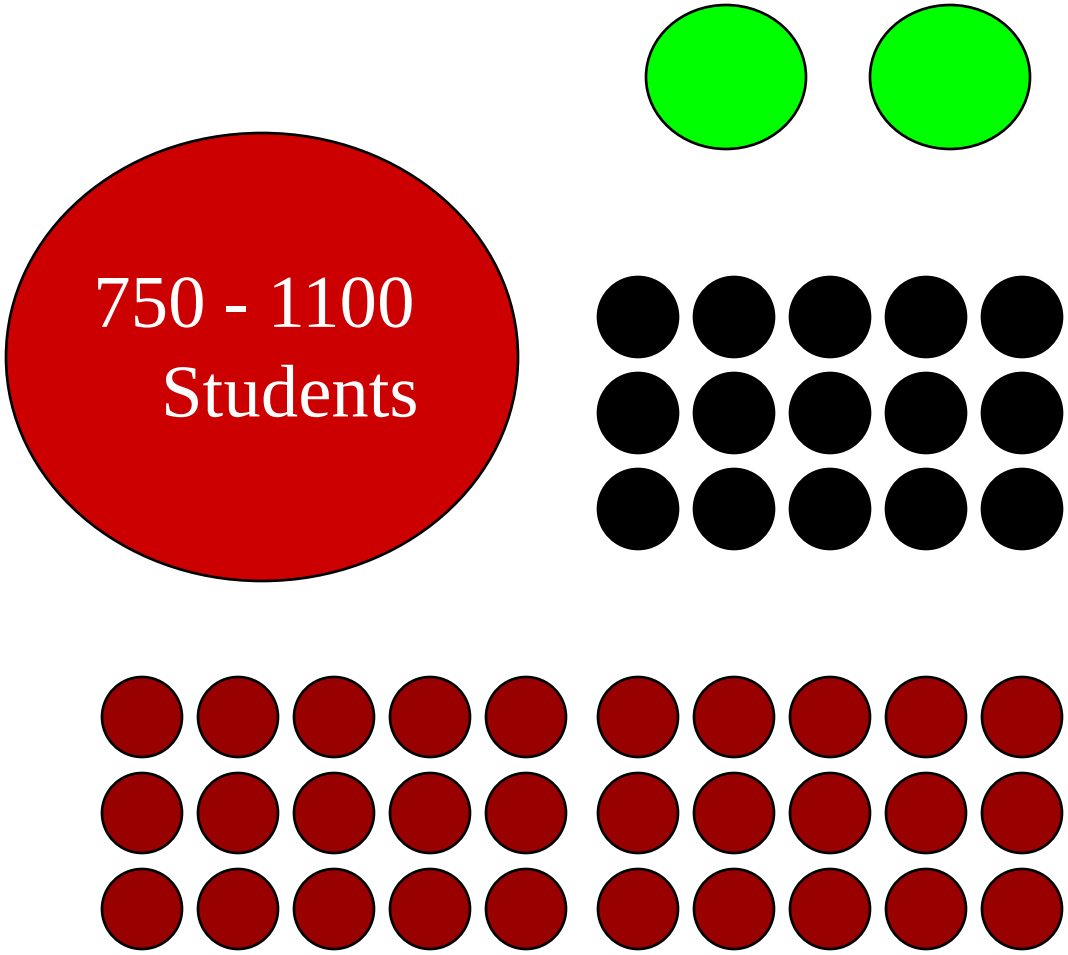
RPI Restructuring strategy: 1990-2001

- Replace Large Lectures with Studios
- Create 4 X 4 Curriculum
- Restructure majors
- Extend Studio into Distributed Learning
- Student Mobile Computing
  - laptops
- Wireless deployment
- Planning for a moving target
  - 11 year effort
- Changed the student experience of EVERY student on campus.

Features of the Studio Courses

- De-emphasize lecture
- Combine Lecture/Recitation/Lab
  - Extensive MBL use
- Constructivist approach
- Multimedia courseware
- Theater in the Round Classroom
- Multipoint video/audio/collaborative

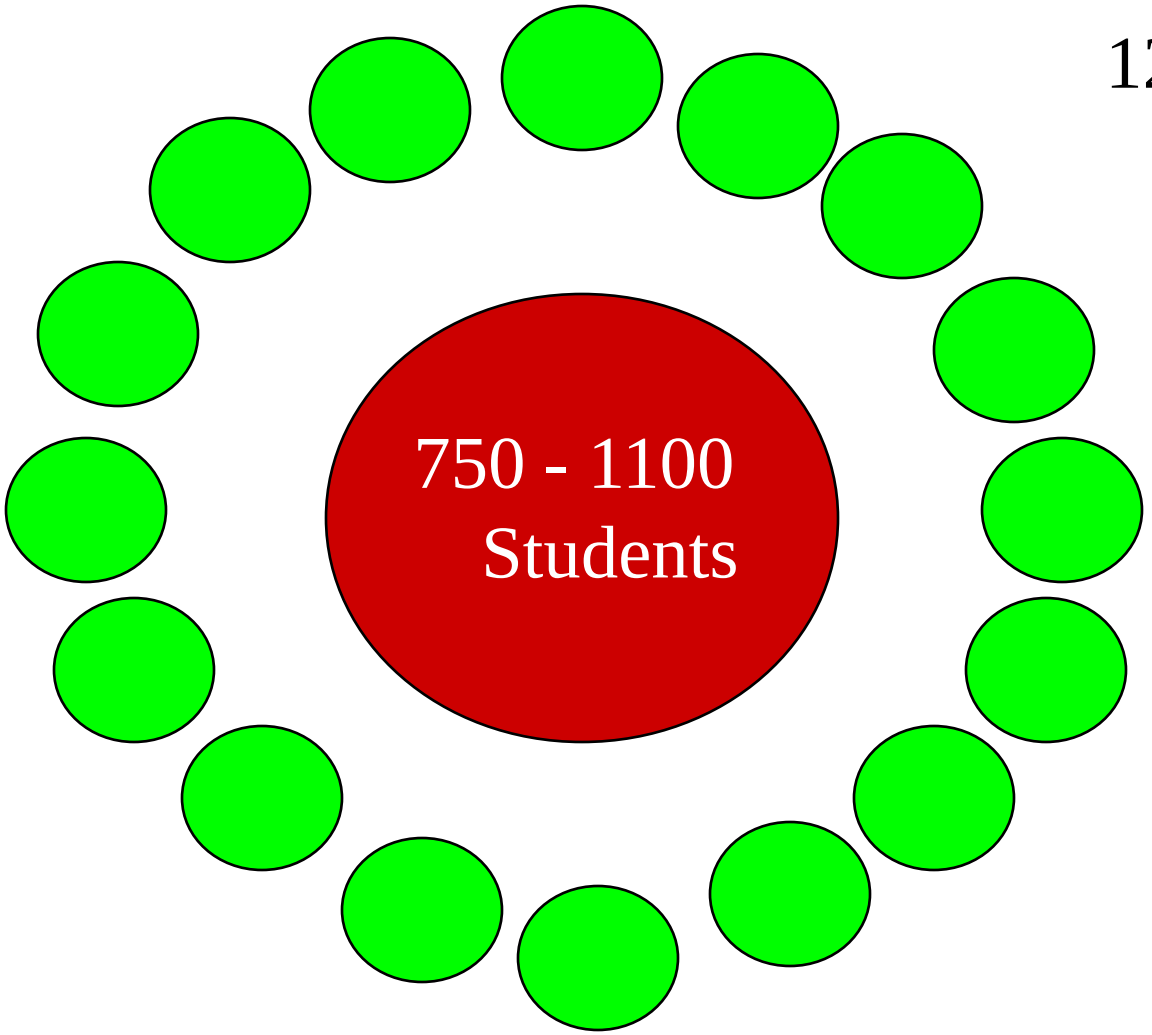
The Introductory Course



2 Lectures

25-30 Recitations

30-40 Labs



12-15 Studios

48-64 each

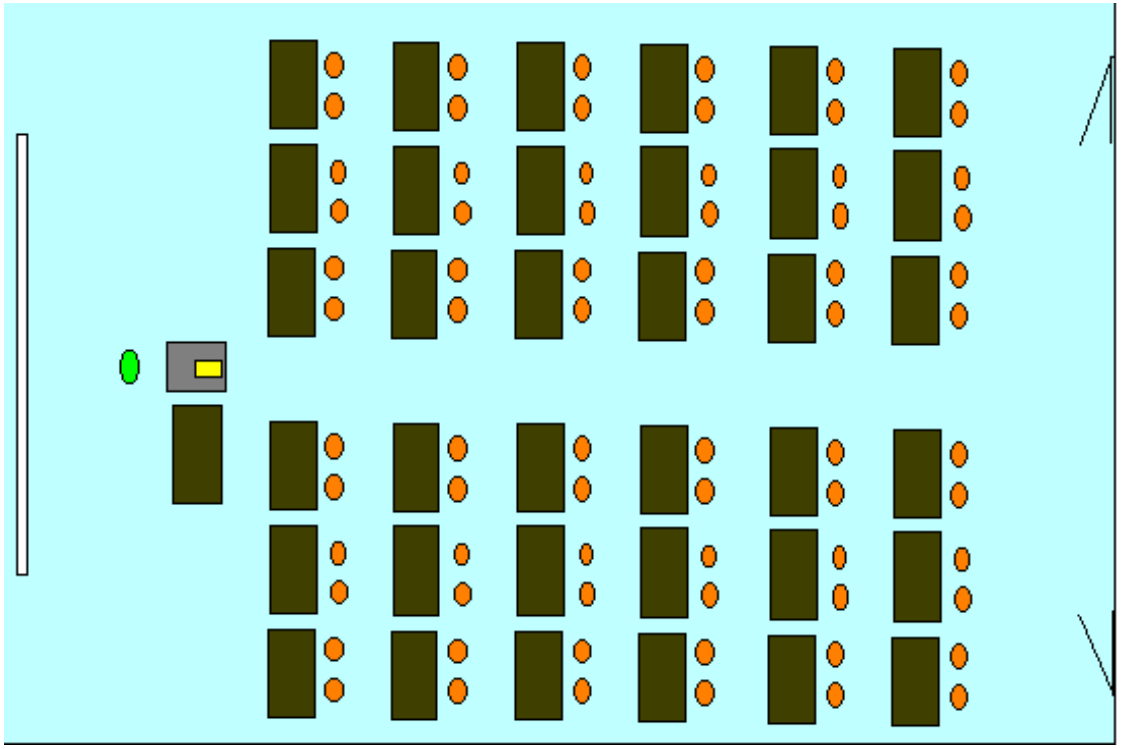
1 faculty

1 TA

1 UG TA

The Introductory Course

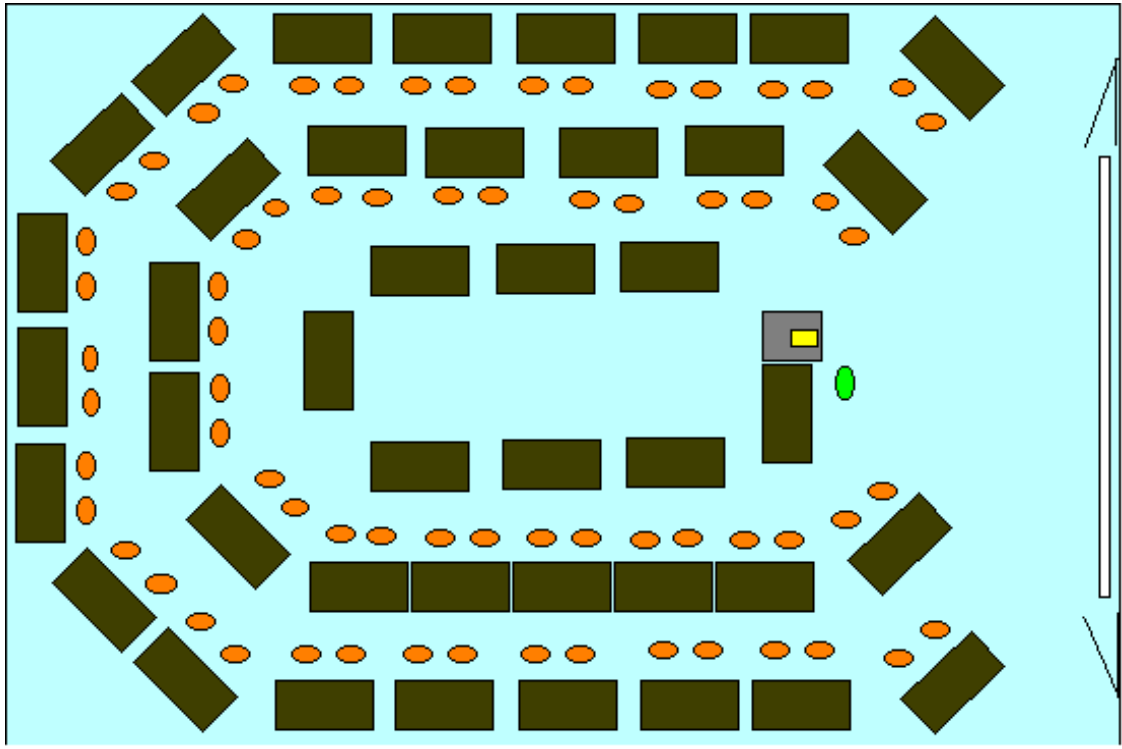
The Traditional Classroom



The Studio Classroom

We shape our buildings and afterwards, our buildings shape us.
-Winston Churchill

Reform the environment, stop trying to reform the people.
They will reform themselves if the environment is right.
-Buckminster Fuller



Student Mobile Computing

- Laptop requirement
- 4 years of pilot
- cost crossover
- 4 year phase in
- student reaction
- faculty readiness
- key to affordability and pervasiveness

Challenge: Partnerships

- CASA: An Engineering Research Center
  - Collaborative Adaptive Sensing of the Atmosphere
  - ~ $40 million from NSF, State, Industry, UMass
  - Partners: UMass Amherst, University of Oklahoma, Colorado State University, and the University of Puerto Rico, Mayaguez
  - Industrial partners: Raytheon, IBM, MA/COM, Vaisala, Vieux and Associates, Telephonics, and The Weather Channel
  - Government partners: NSF, NOAA's National Severe Storms Laboratory and Oak Ridge National Labs
  - Student involvement in undergraduate research
  - Educational outreach with partners

Challenge: Partnerships

- Center for Nanotechnology Manufacturing
  - The University of Massachusetts Lowell
  - Northeastern
  - University of New Hampshire
  - NSF - $ 12 Million

- Industry Outreach
- Undergraduate and Graduate Research
- Educational Outreach

Challenge: Bio- Engineering

- Susan Hockfield appointed as president of MIT
  - Illustration of the importance of Bio-Tech.
  - "Many were pleased that Hockfield is a neuroscientist rather than an engineer, a sign of a change already underway at MIT. The past two presidents, who served a total of 24 years, were both engineers, and MIT built its global reputation on engineering. But **life sciences and their intersection with engineering are the hottest topics at MIT** today. This is the first year in MIT history that research funding from the National Institutes of Health equals or exceeds funding from the Department of Defense, Mead said at a press conference yesterday. 'So the shift is already taking place.' "
    - Boston Globe 27 August 2004

Challenge: Entrepreneurship

- RNAi Discovery
  - University of Massachusetts Medical School
  - Promises opportunities for both research and treatment of genetic or DNA and RNA based diseases.
  - Science magazine designates this as the number one discovery of 2002.
  - Initial license for $10 million to existing company.
  - New companies created in Massachusetts.
- Operation of incubators on several campuses.
- Getting students connected to entrepreneurship

Challenge: Enabling Underrepresented Groups

- Teaching Mathematics and Science into Schools via online multipoint video, audio, sharing, collaborative systems – both real time and any time.
  - Project funded by AT&T, Lucent and Verizon
- Boston Public Schools and UMass Partnership
  - Math Science Partnerships
  - $12.5 million from NSF
  - Focus in urban minority in majority schools.

And there is more

- Konarka Technologies
  - Lowell
- Avant Immunotherapeutics
  - Fall River
- Green Chemistry
  - Boston – Lowell
- Fisheries/Marine Sciences
  - Dartmouth
- UMass Amherst
  - BayState Partnership

Challenge: The Global Economy

- *"We are moving toward a global economy. One way of approaching that is to pull the covers over your head. Another is to say: It may be more complicated -- but that's the world I am going to live in, I might as well be good at it."*

Phil Condit,
former Chairman and CEO,
The Boeing Company

Why?

- Gail Dundas, Intel Corporation
  - "You have to look at all the factors. There are times when cost effectiveness is a part of it, but it is not the stand alone reason. We have growing markets, good talented people in those markets, and people who are more educated than ever before."

Great universities all over the world

- Tsinghua, Beida, and other Chinese Universities
  - China has about 3.7 million student enrolled in engineering
  - China graduates over four times as many engineers per year as does the U.S.
- Indian Institute of Technology
- Max Planck Institutes and others in Europe
- Many Japanese Universities.
  - Aside: William Smith Clark, fourth President of UMass, helped with the founding of what is now Hokkaido university. "*Boys, be ambitious*"
- Universities are the nucleus of economic and social development.

Global Corporations are moving jobs

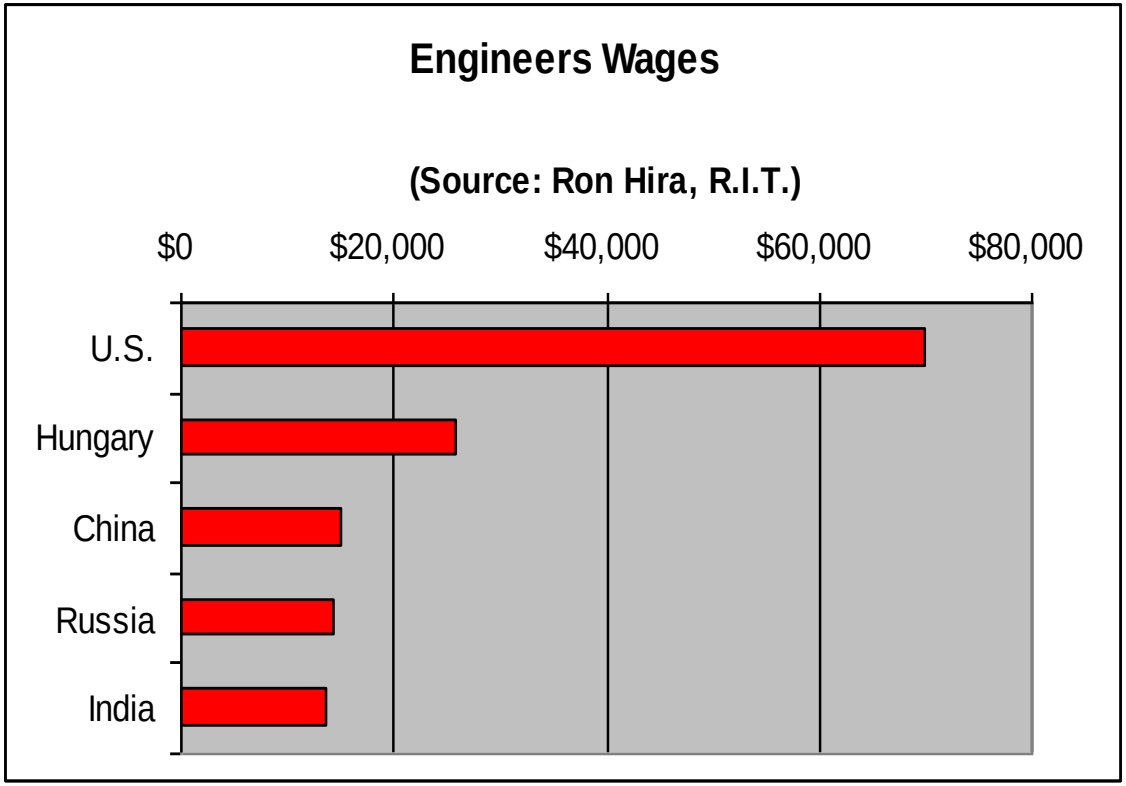
- According to Business Week
  - Intel: 3,000 chip design jobs to India by 2006.
  - Microsoft 500 software design jobs to India and China in 2003.
  - Oracle: 4000 software design jobs to India in next five years.
  - Phillips: 700 consumer electronic design jobs to China in next few years.

Outsourcing of engineering/technical

- Forrester Research: 3.3 million jobs by 2015
  - $ 136 billion in wages lost
- Gartner Inc.: estimates 10% of Computer services and software jobs to be outsourced by 2004 end.
- Deloitte Research surveyed 100 of the worlds largest financial services companies
  - Expect to outsource 2 million jobs in next five years.
  - Outsource $356 billion in operations in next five years
- A political challenge and an economic conundrum
- But particularly: **An Educational Challenge**

Cost of Engineers

- U.S. $70,000
- Hungary $25,690
- China $15,120
- Russia $14,420
- India $13,580



- In spite of the wage differential, overseas wages make engineers well paid by local standards.

Steve Ballmer, CEO of Microsoft

- Steve Ballmer, the CEO of Microsoft and I were the two keynote speakers to a group of 750 high technology business executives last fall.
- “Free flow of scientific and engineering talent is critical for the economic development of the U.S., China, and the world.”

Steve Ballmer
CEO, Microsoft

Jack Wilson
President, UMass

THE CHRONICLE OF HIGHER EDUCATION
Wednesday, June 15, 2005

- The United States and China have agreed to offer each others' students and scholars **one-year, multiple-entry** visas, the U.S. Embassy in Beijing announced on Tuesday. Academic visitors traveling between the two countries currently receive visas good for only six months and two entries.
- The policy shift, which takes effect on June 20, means that students and scholars will not have to return home as frequently as before to renew their visas, saving them time and money. In a written statement, the embassy said the reciprocity agreement "is a sign of the United States' continuing interest in attracting talented students from China and elsewhere to American campuses."
- The embassy noted that Chinese applications for study in the United States are already on the rise, due in part to the recent extension of security clearances for foreign students and scholars who work in sensitive technical fields. Visas Mantis clearances are now good for up to four years, instead of only one. The U.S. Embassy in China and its four consulates issued **2,314 student visas and 617 exchange-visitor visas this past May, up from 1,518 and 309 in May 2004**.

Challenge: Continuous Education

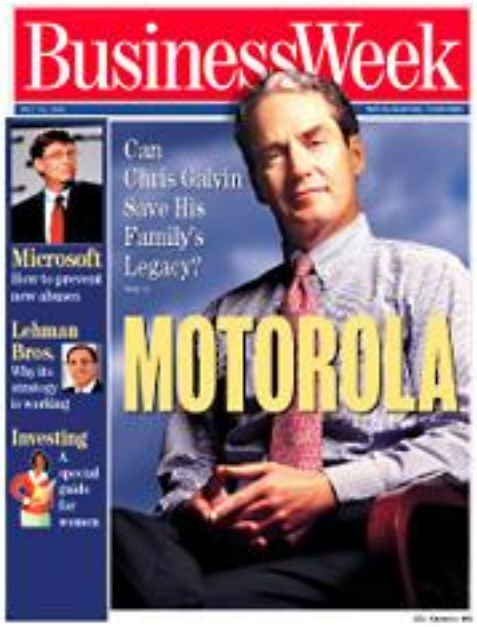
- Rapidly changing economy
- Unpredictable career paths
- Busy lives
- Learning corporations
- Changing environment
- Research breakthroughs

The Forty Year Degree

- Many years ago I keynoted an ASEE International Conference with:

- Christopher Galvin,

  then President Motorola:
  - We are not hiring any more graduates with four year degrees.
  - We want employees with **forty year** degrees



Challenge: Continuous Education

- The paradox of the Internet
- Engineers in the workplace face a difficult challenge.
  - How can they keep up with the pace of technical change and the new economy business environment when they find themselves overwhelmed with work and with little time for traditional educational programs?
  - They are ideal candidates for high quality and high flexibility learning environments.
- Can the internet bring learning to the learner rather than forcing the learner to come to the learning.
- So much to learn and so little time.

Maintenance contract on every degree

- No longer good enough to give a student a four year degree and send him or her out into the world with a quick goodbye and an occasional request for a donation.
- Need to be there for every student throughout his or her career.
  - Updating a degree
  - Career direction changes
  - Lifestyle education requirements

UMassOnline – www.umassonline.net

Fiscal Year 2005:

- Total Enrollments: 17,000+
- Tuition Revenue: $15 million
- Revenue growth rate: 39% per yr
- Enrollment growth rate: 32%

Models based upon cognitive research

Recognized Market Leadership - Awards

- Winner, United States Distance Learning Association Excellence In Distance Teaching Award, 2003
- Winner, Sloan Consortium Award for Effective Practices in Student Satisfaction, 2003
- Winner, University Continuing Education Association's (UCEA) Outstanding Continuing Education Faculty Award, 2002
- MBA, MPH, and MEA degrees designated "Top U.S. Online Programs" by U.S. News and World Report in 2000.

UMassOnline Programs

- Graduate Degrees: 11
- Graduate Certificates: 4
- Undergraduate Degrees: 7
- Undergraduate Certificates: 13
- Non-Credit Certificates: 2

Challenge: filling the pipeline

- EiMC The Engineering in Mass Collaborative
- Now called the STEM initiative
  - http://www.eimc.org/
  - “We have a technology pipeline problem: Not nearly enough of this country’s students, especially young women and minorities, are pursuing studies and careers in math, science, and engineering.”

Recap: Issues in Engineering Education

- Globalism
- Nano-, Info-, Bio –, Cogno-, Enviro-
- Women
- Minorities
- Liberal Arts - Humanities
- Entrepreneurship
- Interactive Learning
- Continuing Education – Online learning

And each of these strategies must be based upon the best research available and not upon random reinventions of the wheel!

Creating New Learning Environments for Engineering Education

THANK YOU!

Jack M. Wilson, President

www.jackmwilson.com