

eLearning in Engineering: The Interplay of Technology and Pedagogy

Jack M. Wilson,
CEO, UMassOnline
And
Vice President, Professor
The University of Massachusetts

Wilson's Favorite Laws!

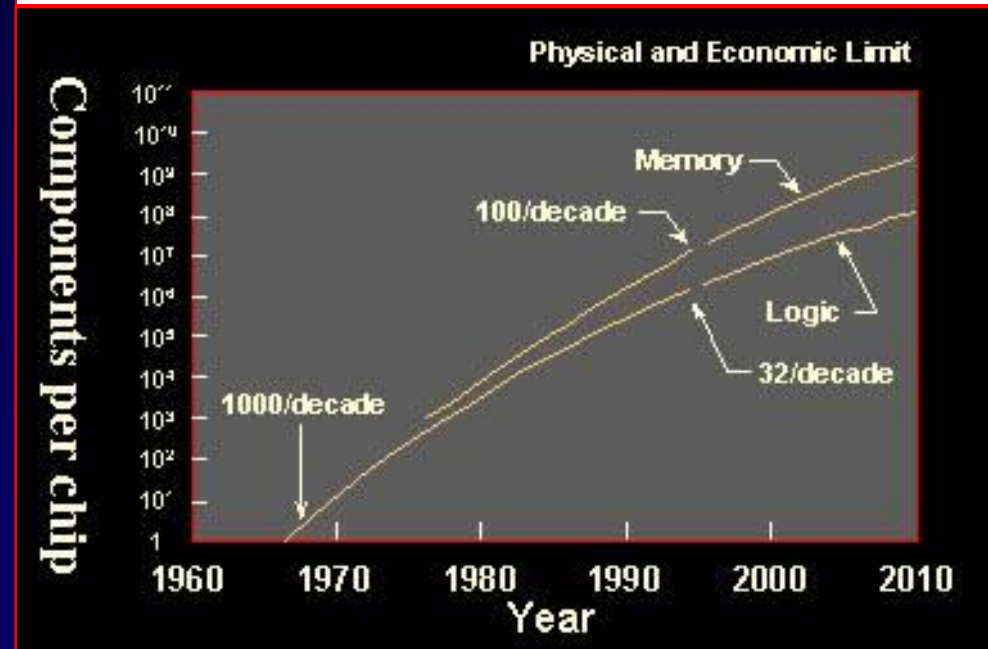
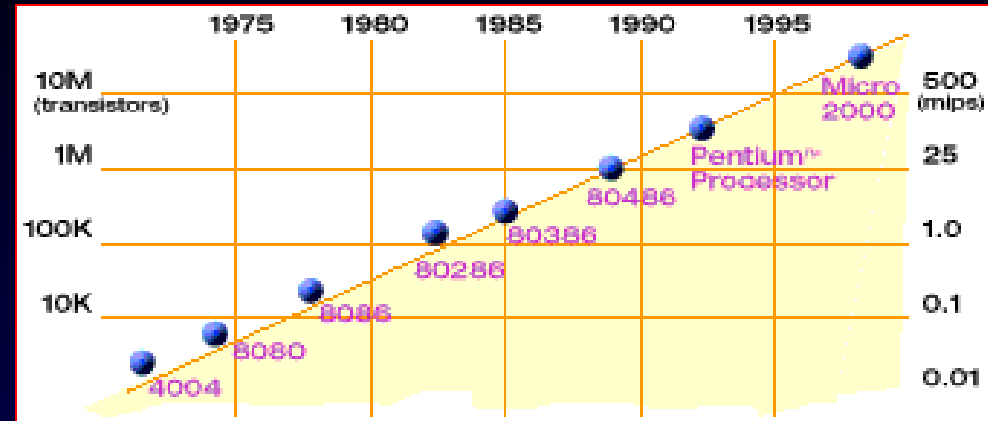


- I. Moore's Law:
- II. Bandwidth Doubling Law:
- III. Metcalf's Law:

I. Wilson's Favorite Laws!

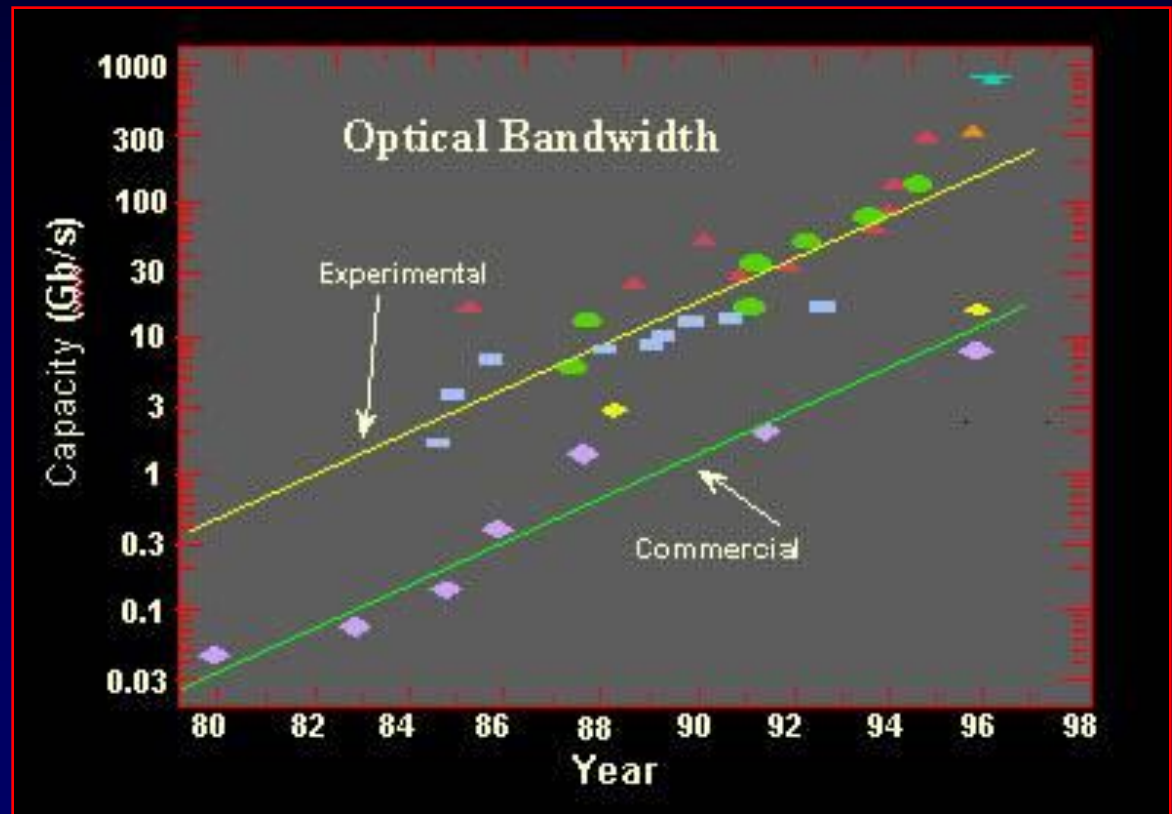
I. Moore's Law:

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



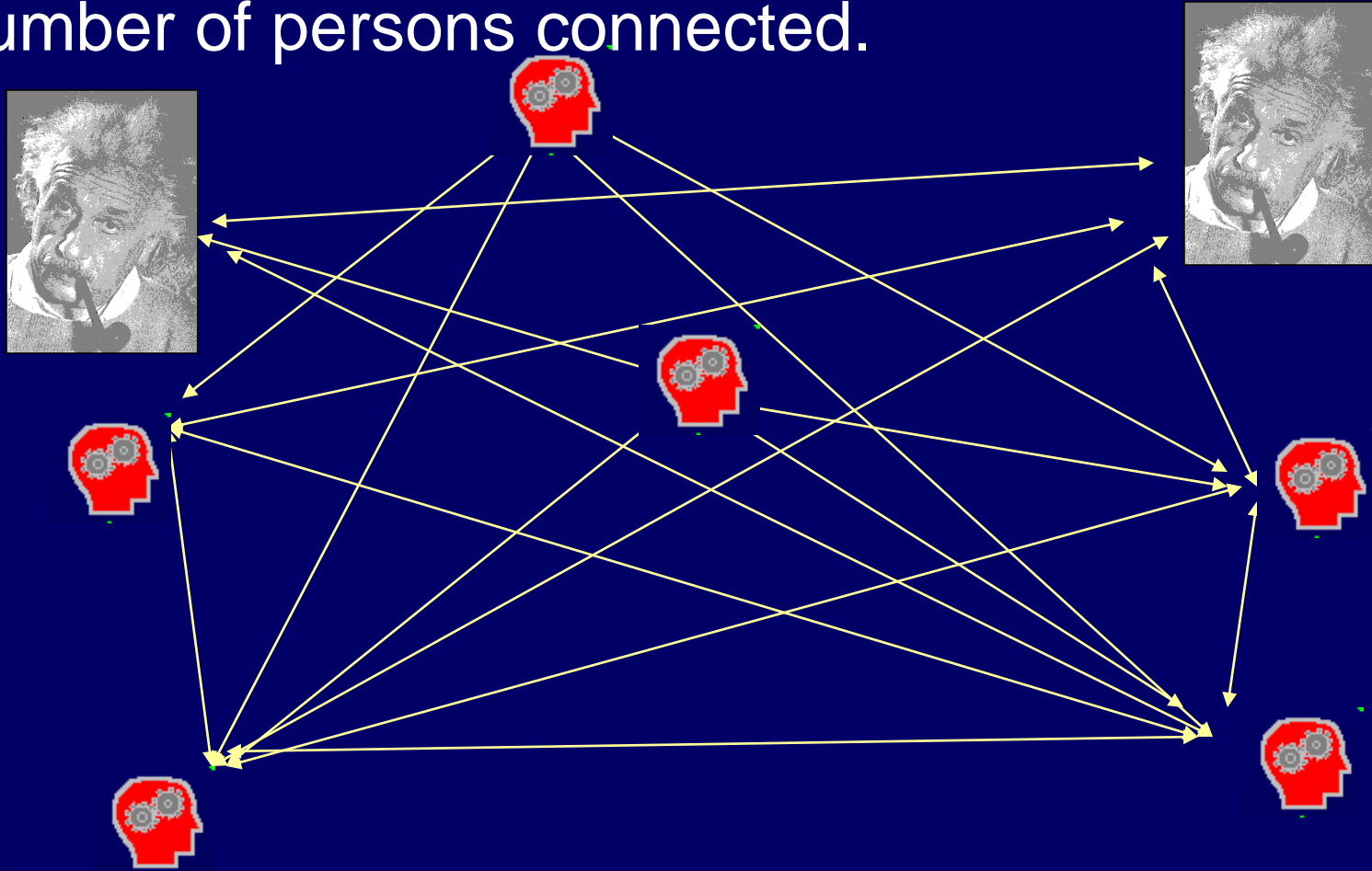
II. Wilson's Favorite Laws!

- II. Bandwidth 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.



UMassOnline.net in AY 2002

- The Online University for Massachusetts: UMassOnline is a collaborative campus project that involves the faculty, staff, and resources of all University of Massachusetts campuses to provide undergraduate and graduate degree programs, special certificate programs, and other non-credit programs to working professionals who could not otherwise attend one of the physical campuses.
- Total Enrollments: 9164
- Tuition Revenue: \$ 6.94 million
- Growth rate: 56.3% per yr
- Grants: \$ 2.43 million
- Undergraduate Programs: 17
- Graduate Programs: 12

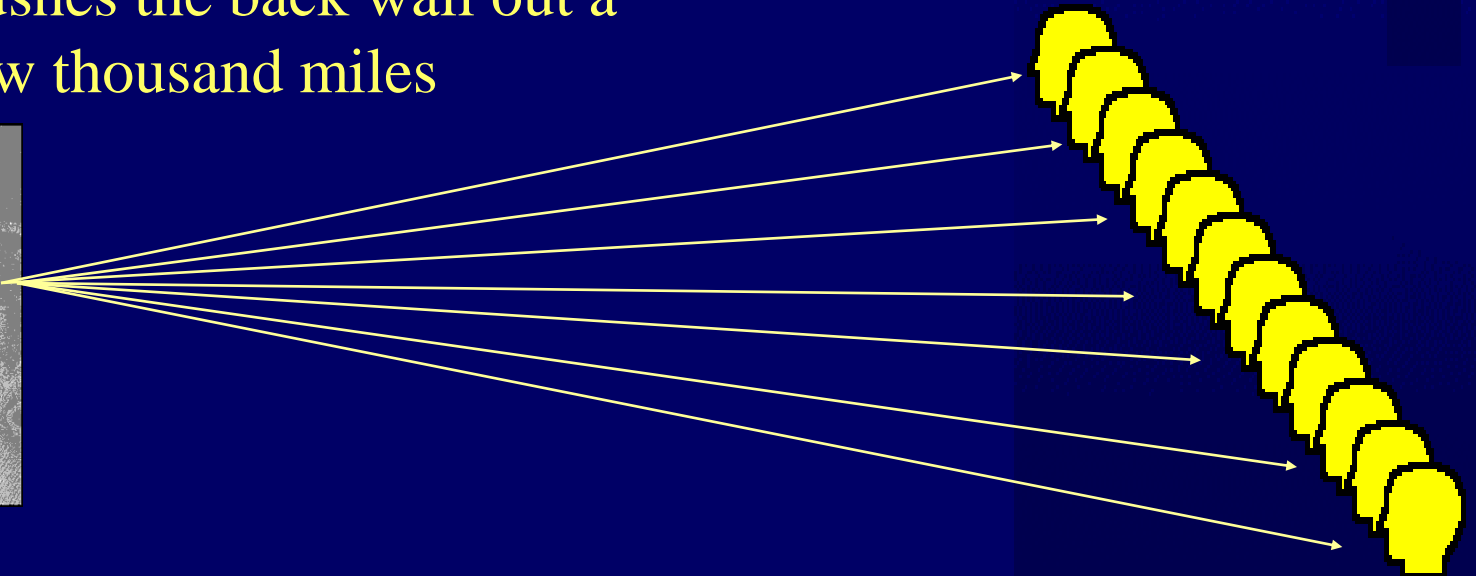
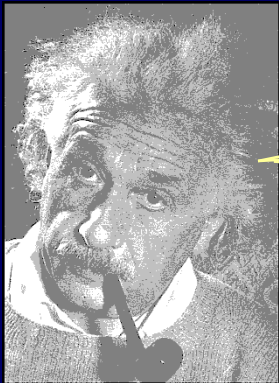
RPI Restructuring strategy: 90-99

- Replace Large Lectures with Studios
- Create 4 X 4 Curriculum
- Expand into new markets with Distributed Learning
- Student Mobile Computing
 - laptops
- Technological Entrepreneurship Curriculum

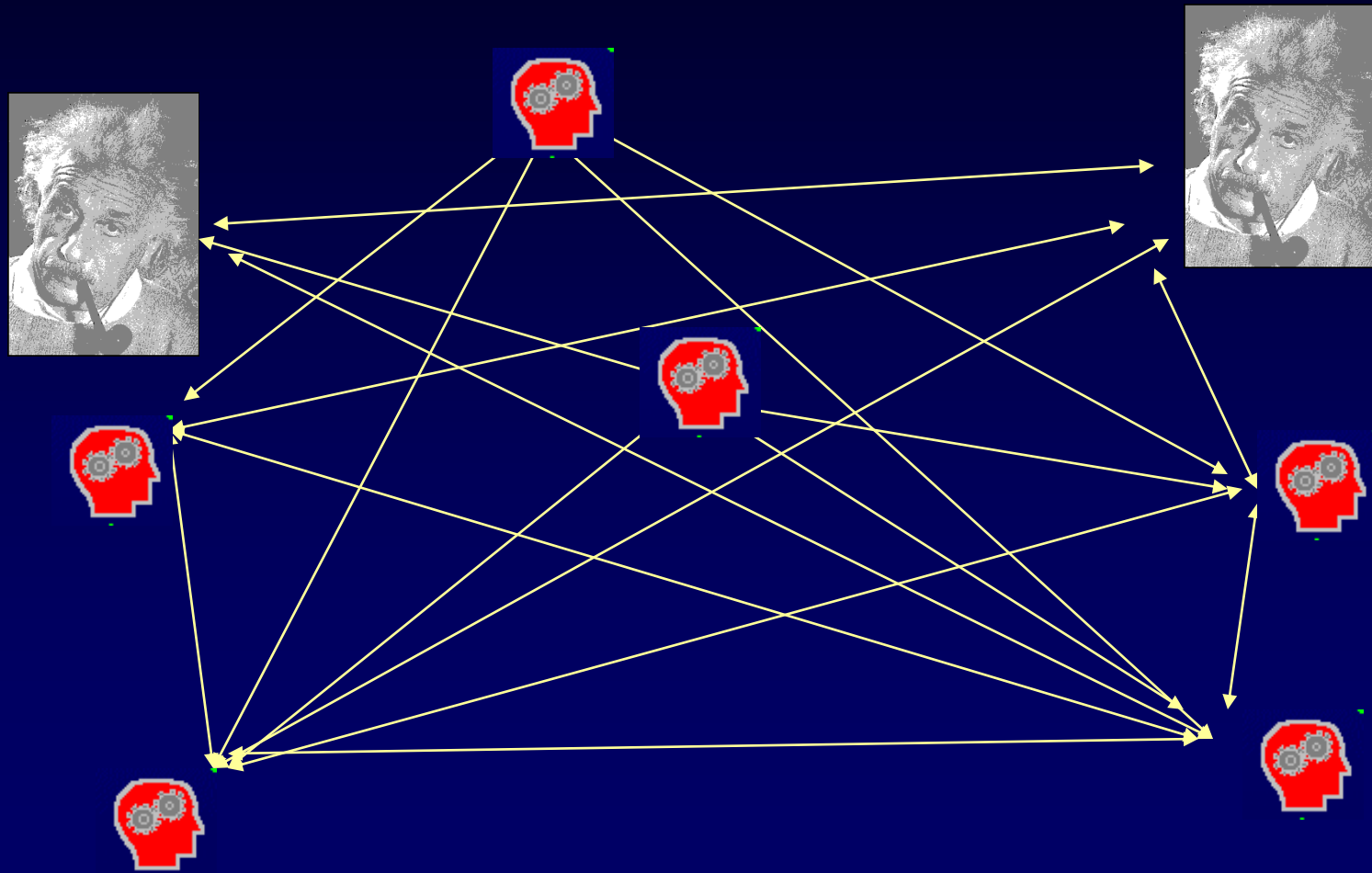


The transmission model

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

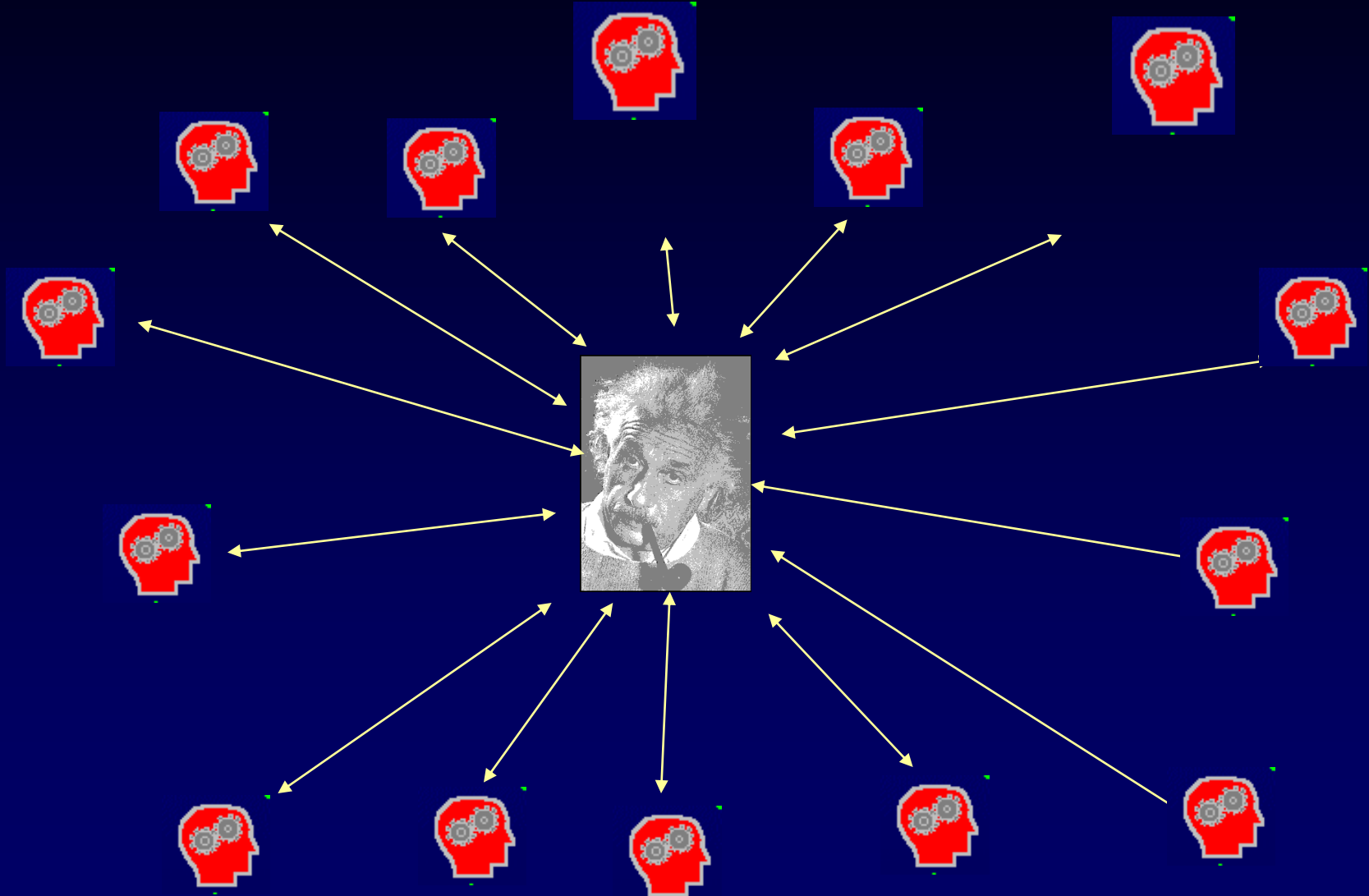


Distributed Collaborative Model

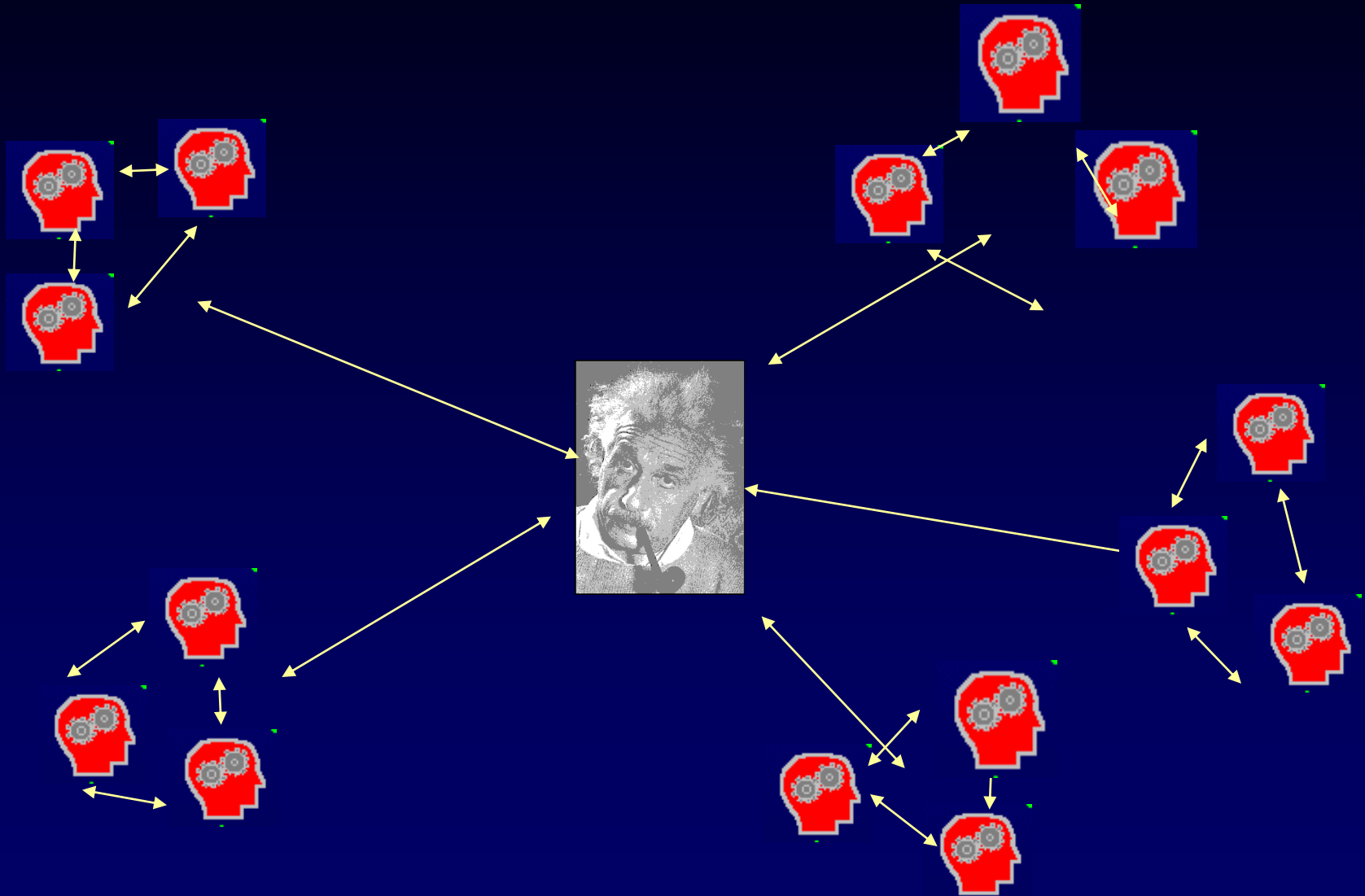


How not to organize online learning.....

“The 24-Hour Professor;” Chronicle of Higher Ed; May 31, 2002



Collaborative Learning, Peer Learning.....



The Studio Classroom



- Hesburgh Award 1995
- Boeing Outstanding Educator Award 1995
- Pew Prize 1997
- Pew CAT \$8.8 million

The Introductory Course

750 - 1100
Students

Calculus (1100)

Physics (750)

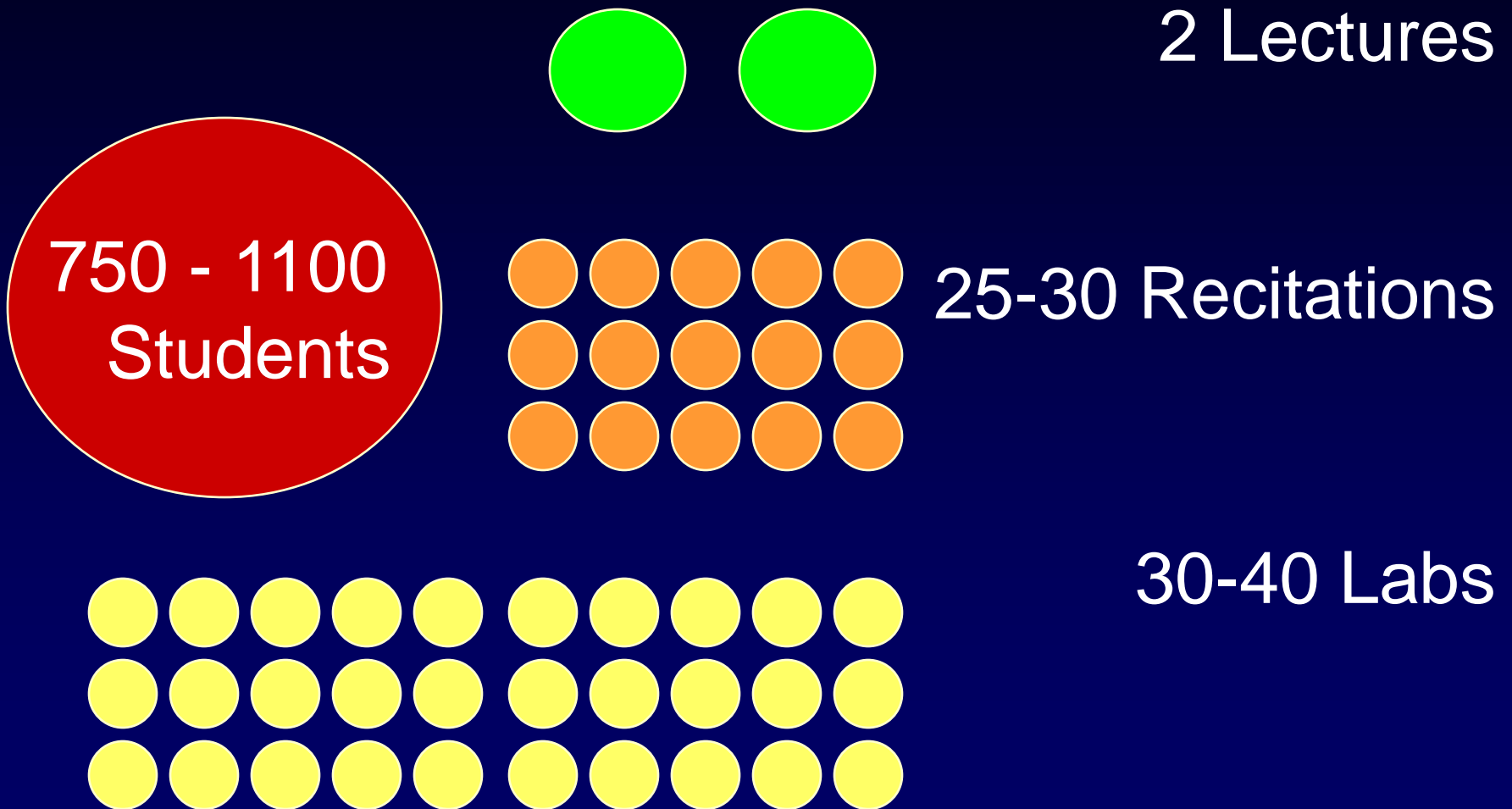
Chemistry (650)

Intro. to Engineering Analysis (650)

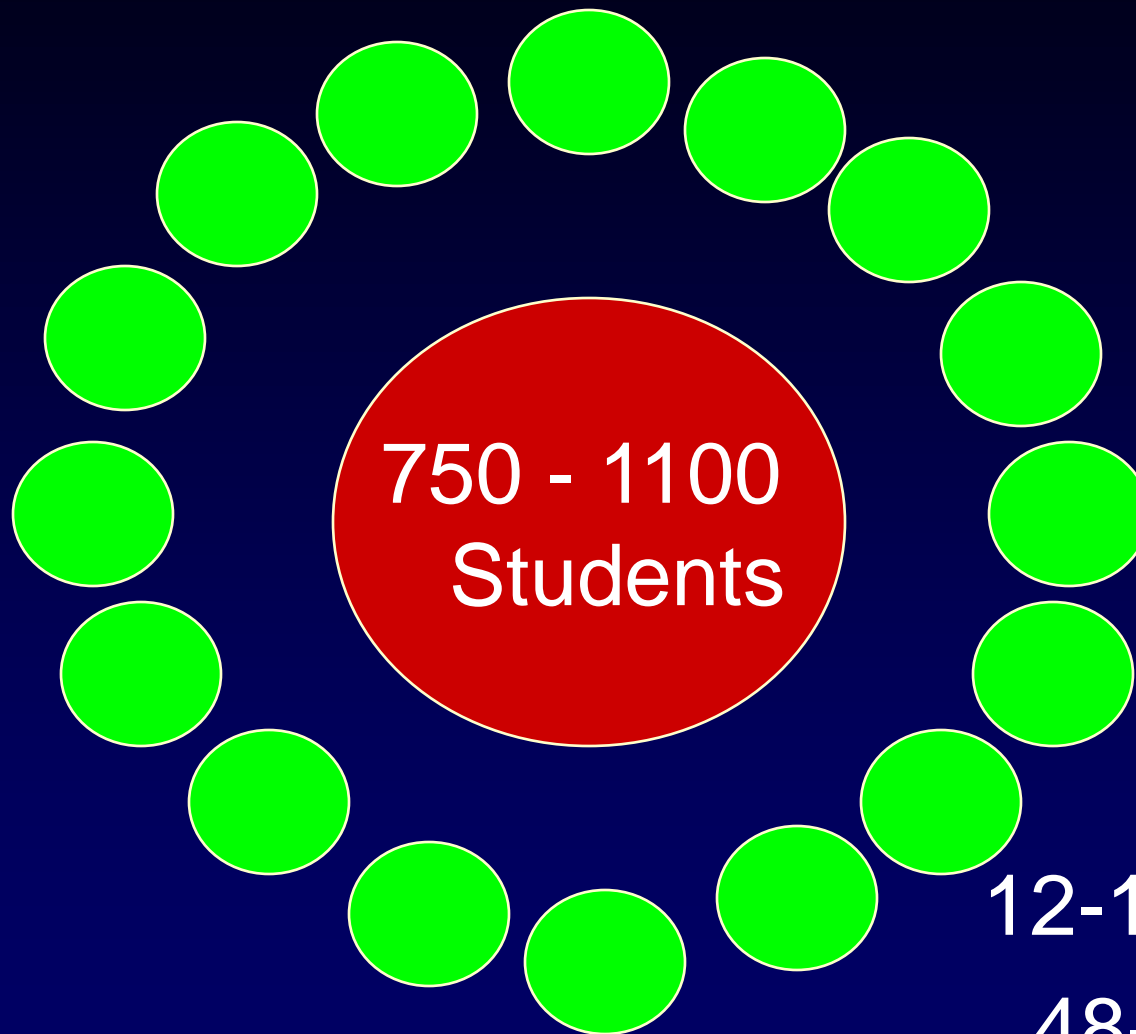
Economics (~300)

(in the beginning)

The Introductory Course



The Introductory Course



750 - 1100
Students

12-15 Studios
48-64 each

The CUPLE Physics Studio



- (20 min) Problems Due - Discussion

- (40 min) Hands-on Group Activity

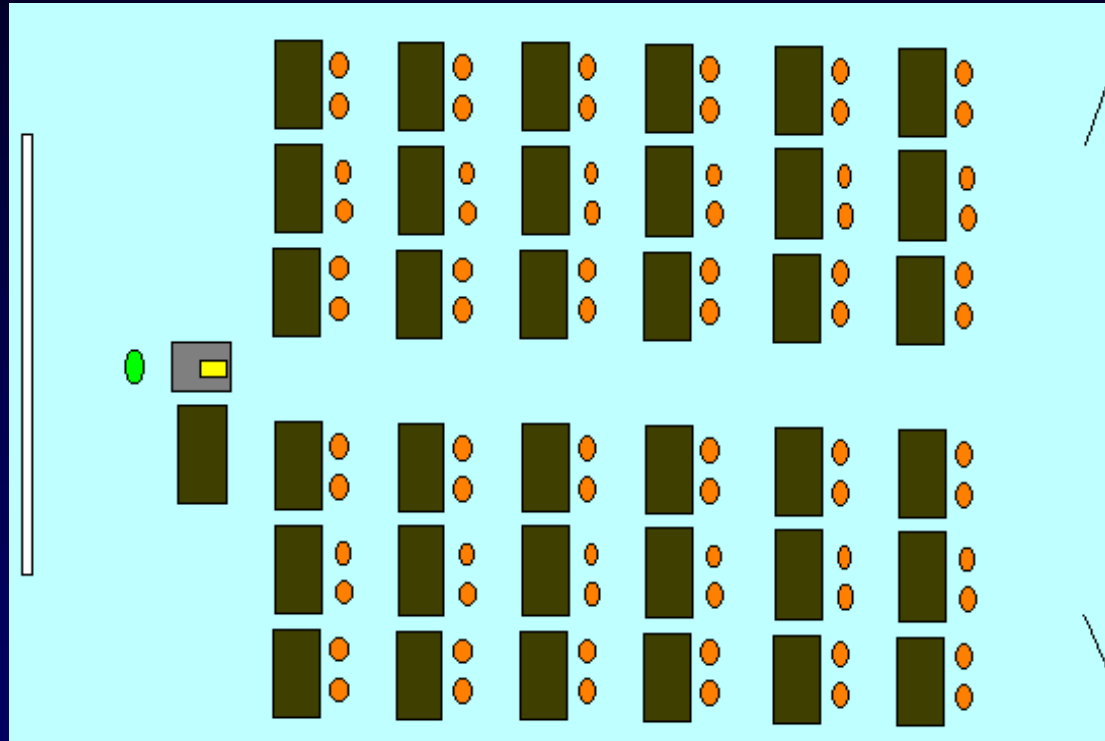
- (10 min) Discussion

- (15 min) Another Group Activity

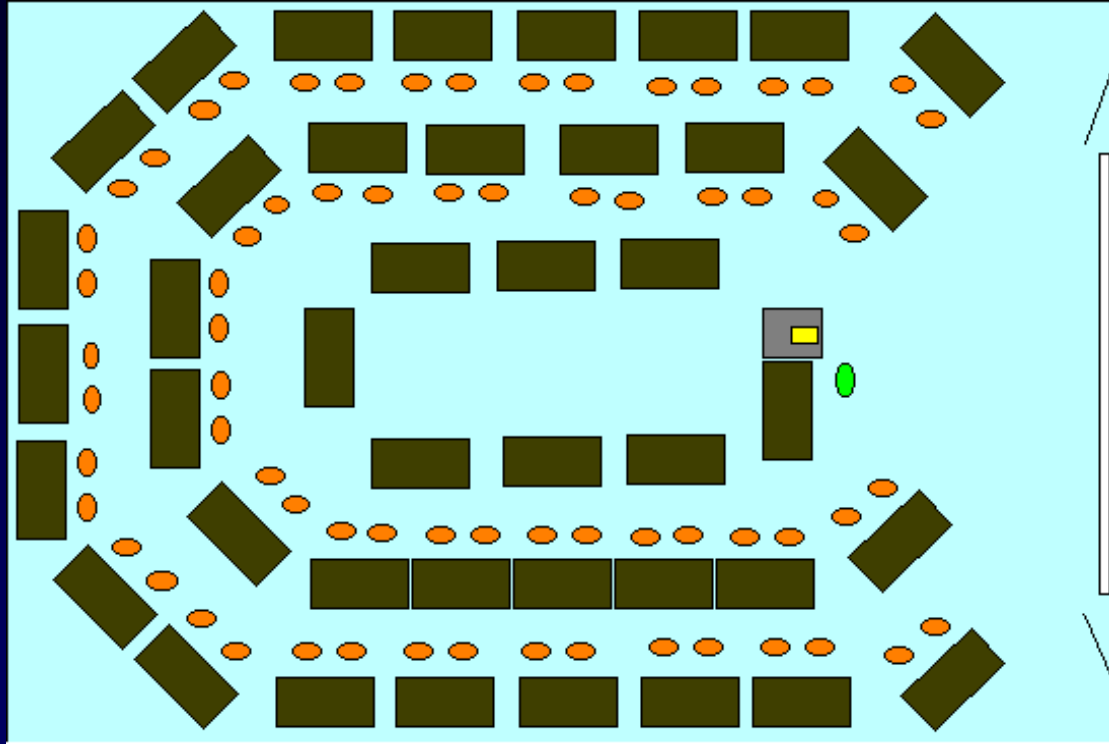
- (15 min) Mini Lecture: Formalism

- (5 min) Conclusion

The Traditional Classroom



The Studio Classroom



The CUPLE Physics Studio

Traditional

- Credit Hours: 4
- Contact Hours 6
 - 2 Hours Lecture
 - 2 Hours Recitation
 - 2 Hours Lab

Studio

- Credit Hours: 4
- Contact Hours 4



Studios in ECSE

- Circuits Studio - 1500 ft²- 42 Students
- Instrumentation Studio - 1200 ft² - 36
- Computer Studio - 1200 ft² - 36
- Control Studio - 1500 ft² - 44
- LITEC Studio - 3600 ft² - 72
- 12 More Around Campus
 - plans for 10 more



ECSE Studio Courses

Some Examples

- Computer Components and Operation
- Computer Architecture, Networks and Operating Systems
- Laboratory Introduction to Embedded Control
- Electric Circuits
- Analog Electronics
- Microelectronics Technology
- Digital Electronics
- Electronic Instrumentation
- Fields and Waves I
- Signals and Systems
- Discrete Time Systems
- Control Systems Engineering
- And more...



ECSE Studio Approach

- 2 Hour Classes, 2-3 Times Per Week
- Several Activities Each Class
 - Mini-Lectures
 - Discovery Exercises
 - Simulation Activities
 - Interactive Discussions
 - Hands-On Experimentation
 - Analytic Problems



Physics Studio Tools

- Microcomputer Based Laboratories
 - not simulation! Data acquisition.
- Video Tool
- Interactive Lecture Demonstrations
- Simulations
- problem solving

First Day Physics

- Students running back and forth in front of the computer!
- MBL: distance, velocity, acceleration and time.
- Mouse Mechanic:
 - <http://cde.rpi.edu/MouseMechanic.html>

Simulations

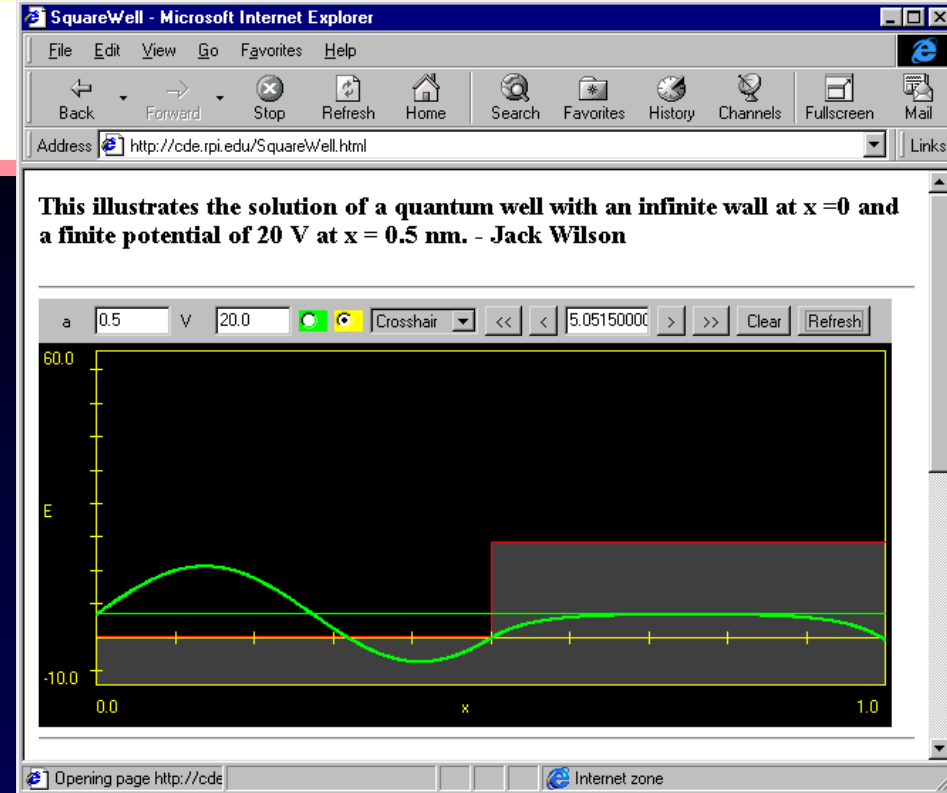
- Used with real experiments

- Quantum Well

 - <http://cde.rpi.edu/SquareWell.html>

- The Pendulum

 - <http://cde.rpi.edu/Pendulum.html>



Student Mobile Computing

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

Metrics

- Student performance on traditional tests
- Student attendance
- Student performance on cognitive tests
- Student performance on problem solving
- Student attitudes toward the courses
- Student retention
- Faculty attitude toward the courses
- Student success in later classes

Results

- Significant improvement: Student Satisfaction
- Significant improvement: Faculty Satisfaction
- Equal or better performance on regular exams.
- Year long Rutgers led evaluation
- Significant Attendance increase
- Cost containment- Tom Ratchford question
- Ongoing longitudinal study

Results Specific to ECSE

- Much Better Attendance
- Course Ratings Improved
- Instructor Ratings Improved
- Some Improved Learning
- Improved Computer/Hands-On Skills
- Students and Faculty Love It!!

The Studio at other Universities

- **The University of Amsterdam** (<http://www.science.uva.nl/research/amstel/>)
- **Penn State University** (<http://www.science.psu.edu/facaffairs/strategic.htm>)
(<http://www.psu.edu/ur/archives/news/GE.html>) (<http://dps.phys.psu.edu/about.htm>)
- **Arizona State University** (<http://www4.eas.asu.edu/phy132/>)
- **Indiana State Univ.** (<http://physicsstudio.indstate.edu/>)
- **Cal Poly San Luis Obispo** (<http://www.cob.calpoly.edu/Evan/polyplan/polyplan.htm>)
(<http://chemweb.calpoly.edu/phys/>)
- **Ohio State University** (http://www.physics.ohio-state.edu/~ntg/26x/2064_pictures.html)
- **The University of Amsterdam** (<http://www.wins.uva.nl/research/amstel/>)
- **The University of New Hampshire** (<http://einstein.unh.edu/academics/courses/>)
- **Curtin Univ. of Tech. (Australia)** (<http://www.physics.curtin.edu.au/teaching/studio/>)
- **Univ. Of Mass. –Dartmouth** (<http://www.aps.org/meet/CENT99/BAPS/abs/S3455002.html>)
- **The Colorado School of Mines** (<http://einstein.mines.edu/physics100/frontend/main.htm>)
- **Acadia Univ. (Canada)** (<http://ace.acadiau.ca/math/boutilie/>)
- **Santa Barbara City College**
(http://www.cs.sbccc.net/physics/redesign/final_report/reportb.html)

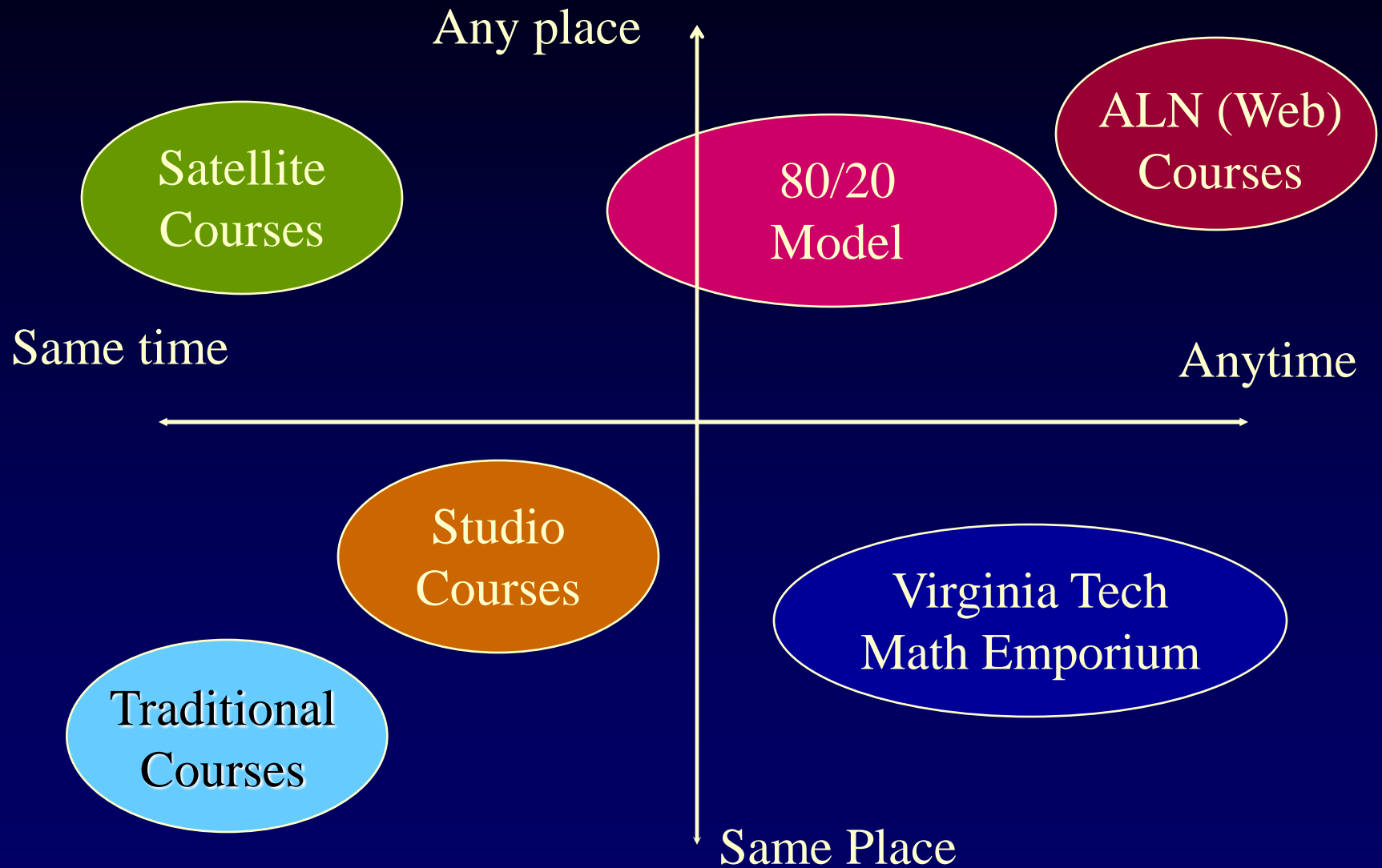
The Forty Year Degree

- Christopher Galvin,
President Motorola:
- We are not hiring any more graduates with four year degrees.
- We want employees with forty year degrees

Robert Jones was asked the question about whether to extend study to contract it.
---Answer: both



The Studio at a Distance



Studio at a Distance

- Delivery on standards based multimedia PC's equipped for live video/audio interactions and connected to a robust ip multi-casting network.
- A mix of synchronous and asynchronous activity.
- Use of Web and/or CD-ROM based multimedia materials.
- Use of professional quality software tools for CAD, symbolic math, spreadsheets, word processing, etc.
- Live audio and/or video interactions among the students and with faculty.
- Email interactions among the students and faculty.
- Small group discussions.
- Collaborative software for application sharing over the network.
- Access to rich resources on the network.
- Ability to “pass the floor” to students to allow them to lead the class through an activity.
- Course administration software to track student progress.
- Classes with a mix of students in traditional and workplace settings.
- Classes with a global perspective and global audience.

Our Strategies

- Follow our corporate partners throughout their own globalization process
 - ex: GM into Mexico, Luxembourg and elsewhere
- Focus on Engineering, Management and Technology, Computer Science, and Information Technology
- Offer old, new, and leading edge technologies.

- 10 Years +
- '93 Telecon "Best Distance Learning Program"
- '96 USDLA Industry-University Collaboration
- 944 Students in Credit/Degree Courses
- Several hundred more in short courses
- Bringing education to the workplace
 - (GM, IBM, Lockheed Martin, AT&T, Lucent, Con Ed, GE, UTC, Pratt & Whitney, Ford, Intel, Applied Materials, Matsushita, Bugle Boy, Albany International, Key Bank, +++++)

- Professional Education for Engineering and Applied Science
 - M.S. & Ph.D. in Electrical and Computer Engineering
 - M.S. in Engineering Management
 - M. S. in Computer Science
 - Ripples and MANIC (<http://manic.cs.umass.edu/>)
 - Founding Member of NTU
 - (National Technological University)
- <http://peeas.ecs.umass.edu/fall2002/degreeinfo/index.html>

UMassOnline.net

- Built upon the successes of the 5 campuses.
- Is already the largest on-line university in New England
 - 9164 enrollments in AY 2001-2002
- Portal: www.UMassOnline.net
 - Launched in spring 2001
- Closely coupled to the University mission
- Operates over the M.I.T.I. (Massachusetts Information Turnpike Initiative)
- Received \$ 2.25 million IT Bond funding to create statewide platform in partnership with M.I.T.I.
 - Eventually open to all state institutions

Investing and Developing Programs

- Twenty five degree and certificate programs
 - Bachelor's, Master's, and Certificate programs
 - 12 new programs this fall
- Three of our programs have been recognized by US News and World Report as top on-line programs in the October 15, 2001 issue.
 - MBA – UMass Amherst
 - MEA – UMass Lowell – Ed. Administration
 - MPH – UMass Amherst- Public Health

Serving Community Needs

- BSIT *
- MSIT
- M.S. Joint Comp. Science Comp. Engineering
- Nursing *
- MBA *
- MPH *
- MS Substance Abuse Professionals
- BLA – Liberal Arts *
- Degree Completers and many others

Graduate Programs

- Master of Education for Science Teachers Program (Amherst)
- M.S. in Computer Science and Computer Engineering (Amherst)
- Master of Education in Counseling: School Guidance (Boston)
- Master of Ed. in Counseling: Mental Health Counseling (Boston)
- Master of Science (Nursing) Community/School Health (Amherst)
- Master's Degree in Educational Administration (M.Ed.) (Lowell)
- MBA Professional Program (Amherst)
- MPH in Public Health Practice (Amherst)
- Certificate: Adapting Curriculum Frameworks for All Learners (Boston)
- Certificate in Clinical Pathology (Lowell)
- Certificate in Foundations of Business (Lowell)
- Certificate in Instructional Technology Design (Boston)
- Certificate in Photonics and Optoelectronics (Lowell)

Undergraduate Degree Programs

- Bachelor of Liberal Arts (Lowell)
- Bachelor of Science in Hotel, Restaurant, and Travel Administration (Amherst)
- Bachelor of Science in Information Technology (Lowell)
- Bachelor's Degree in Information Technology: Business Minor (Lowell)
- RN to Bachelor of Science (Nursing) (Amherst)

Other Undergraduate Programs

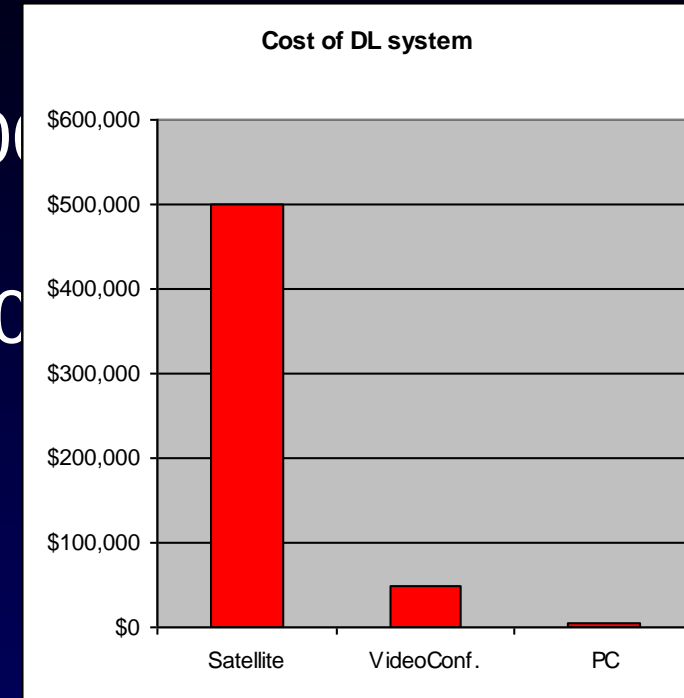
- Associate of Science in Information Technology (Lowell)
- Certificate in Communication Studies (Boston)
- Certificate in Contemporary Communications (Lowell)
- Certificate in Data/Telecommunications (Lowell)
- Certificate in Fundamentals of Information Technology (Lowell)
- Certificate in Intranet Development (Lowell)
- Online Communications Skills Certificate (Dartmouth)
- Certificate in Multimedia Applications (Lowell)
- Certificate in Community Media and Technology (Boston)
- Criminal Justice Series (Amherst)
- Certificate in UNIX (Lowell)
- Fundamentals of Arts Management Certificate Program (Amherst)
- Certificate in Plastics Technology (Lowell)
- Certificate in Technical Writing (Boston)

Technologies in Use

- Satellite Video
- ISDN Videoconferencing
- CD-ROM Creation
- Mail out materials (including videotapes and/or CD's)
- World Wide Web materials
- Asynchronous Tools: Prometheus and IntraLearn
- Streaming Video
- Live-Online Learning (LearnLinc or Centra)
 - Desktop Video (multicast)
 - Network based materials management
 - Classroom management

Distance Learning Technologies

- Satellite Video (\$500,000)
- ISDN Videoconferencing (\$50,000)
- PC Collaborative (\$2,000)
- Web Based Asynchronous (\$2,000)



- Example: ILINC **LearnLinc**
 - Live Internet Audio (optional Desktop Video - multicast)
 - Network based materials management
 - Classroom management

Introduction to eBusiness



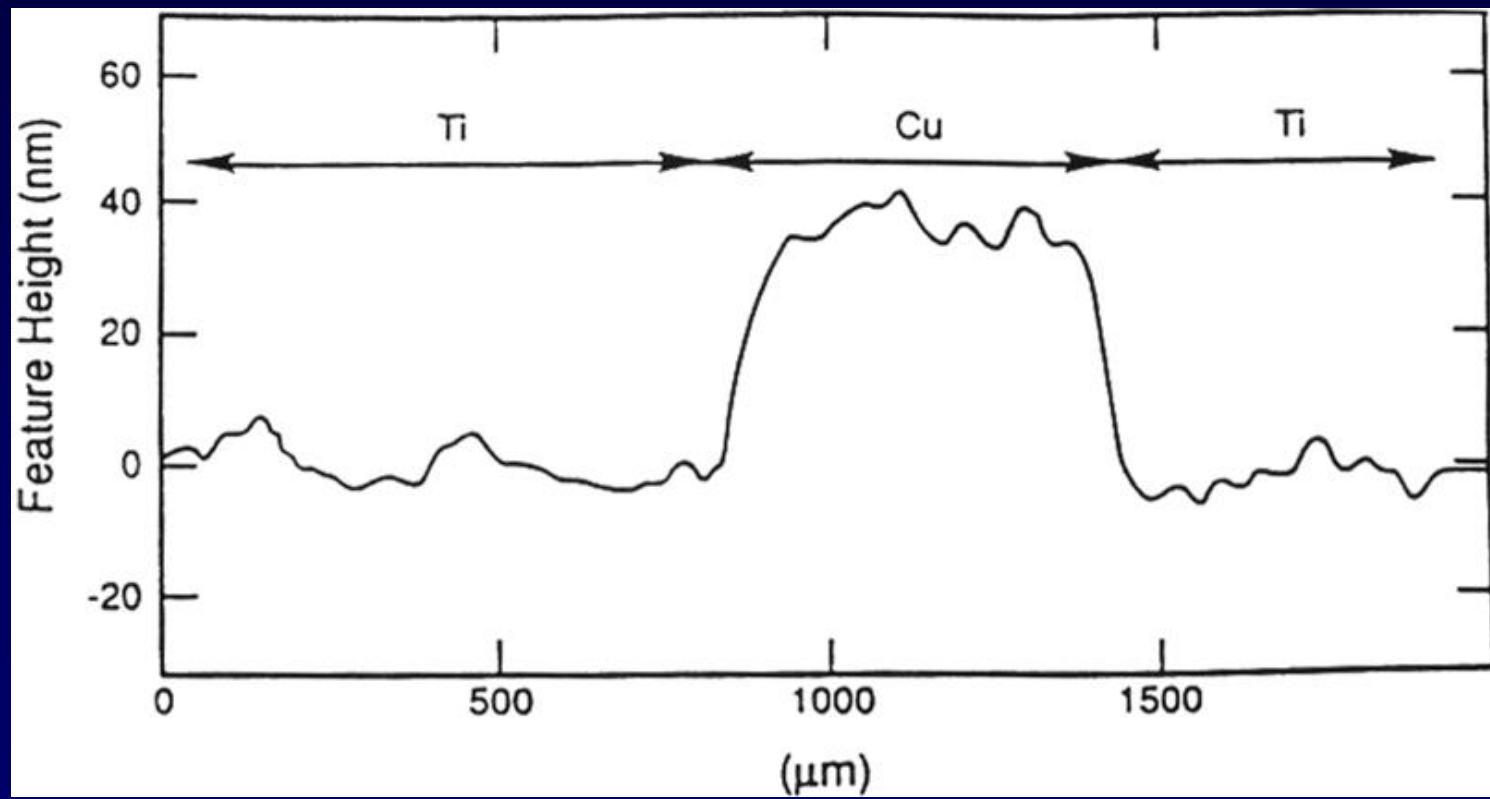
- One night per week from 6:30-8:30 pm
 - Fall 2000: 50 On Campus & 75 Off Campus Students
 - Spring 2001: 75 overflow students (25 on and 50 off)
 - IBM, Ford, GE, Lockheed Martin, Pratt and Whitney, Ford, Consolidated Edison, NY Power, J. P. Morgan, Carrier, Otis, etc.
 - Extensive Website:
 - <http://www.jackmwilson.com/eBusiness/Syllabus-Spring2001/>
 - MBA, MSIT, MS in Engineering Science
 - miniLectures, Discussion, Student presented cases, & asynchronous interactions

Chemical Mechanical Planarization

- RPI/Intel/Applied Mat./ Matsushita/IBM
- Murarka, Schowalter, Duquette
 - (Introduction to Copper Metalization)
 - (Wall Street Journal article)
- Month long course to engineers and scientists in the workplace.
- Video/Audio/ILINC Web data Conf.
 - ISDN and Internet
 - ProShare, PictureTel, Panasonic multipoint

Chemical Mechanical Planarization

- Profilometer trace showing dishing of the titanium liner relative to the adjacent recessed copper metal. An electrochemical interaction between the copper metal and the titanium accelerated the normally low polish rate of titanium to produce the negative dishing.



NTU-Rensselaer Course

Hands-On World Wide Web

- 1998
- 8000 participants at 500 sites
- Satellite broadcast
- Hands On Exercises
- Synchronous Tutoring
- Asynchronous support
- “Most successful NTU course ever”
- “The future of satellite based education.”
 - Lionel Baldwin, President, NTU



Rensselaer and Hong Kong City U.

- Survival Skills for Astrophysics
- Professor Chun Ming Leung
 - Graduate Students in Astrophysics
 - Video/Audio/ ILINC Web Data Conf.
 - Both ISDN and Internet connection
 - 7 am Eastern (6 Hong Kong)
 - Student Collaborative Presentations
 - One Semester length

Remote Physics Course

- Introductory Calculus Physics
- Live On-line
 - Delivered via ILINC **LearnLinc**
- Cobleskill High School in rural upstate NY
- Collaborative between the physics teacher at Cobleskill and faculty and graduate students at Rensselaer



LearnLine Client

File Run Tools Help

Nichole



Live from: San Francisco, CA

Mute

People

Name

- Isaiah Beres
- Owen Carter
- Tom Elliot
- Wally Emerson
- Ben Frank
- Geoff Gamache
- Alicia Hoffman

Agenda

2 25

0 Not much progress

5 Still working

7 Almost finished

13 Completed



Note: Yes. Could you please review the chapter on formating graphs in Excel?

Raise your hand when you see the AppShare window.

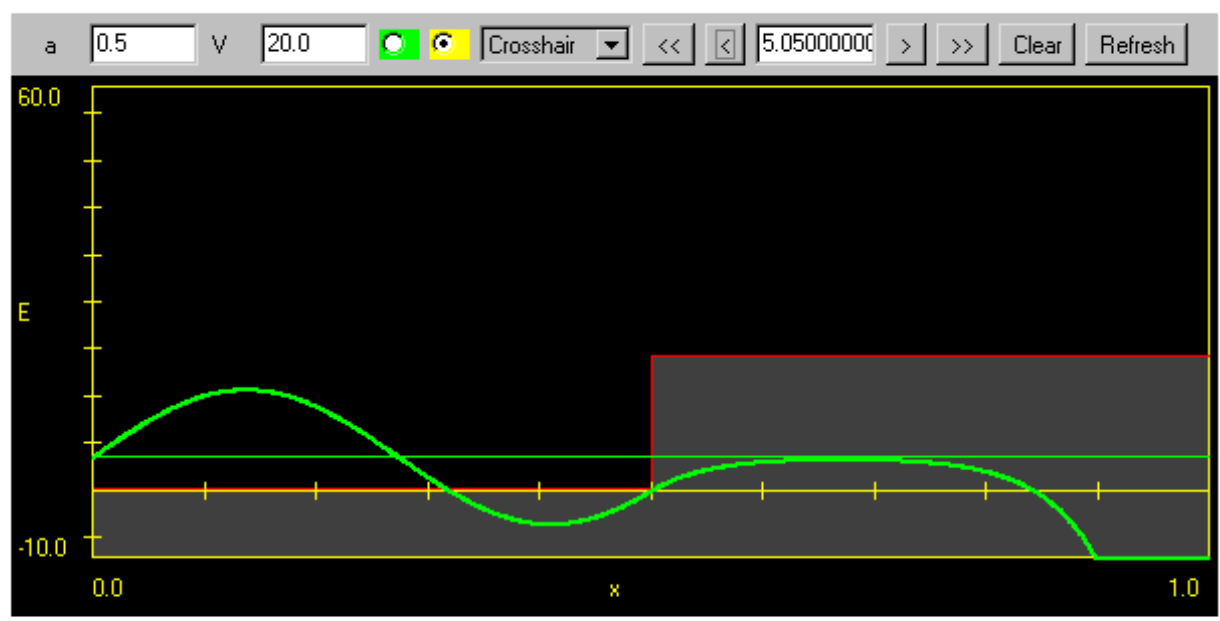
SquareWell - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Refresh Home Search Favorites History Mail Print Edit Discuss

Address <D:\JavaPrograms\cde\SquareWell.html> Go Links

This illustrates the solution of a quantum well with an infinite wall at $x=0$ and a finite potential of 20 V at $x=0.5$ nm. - Jack Wilson



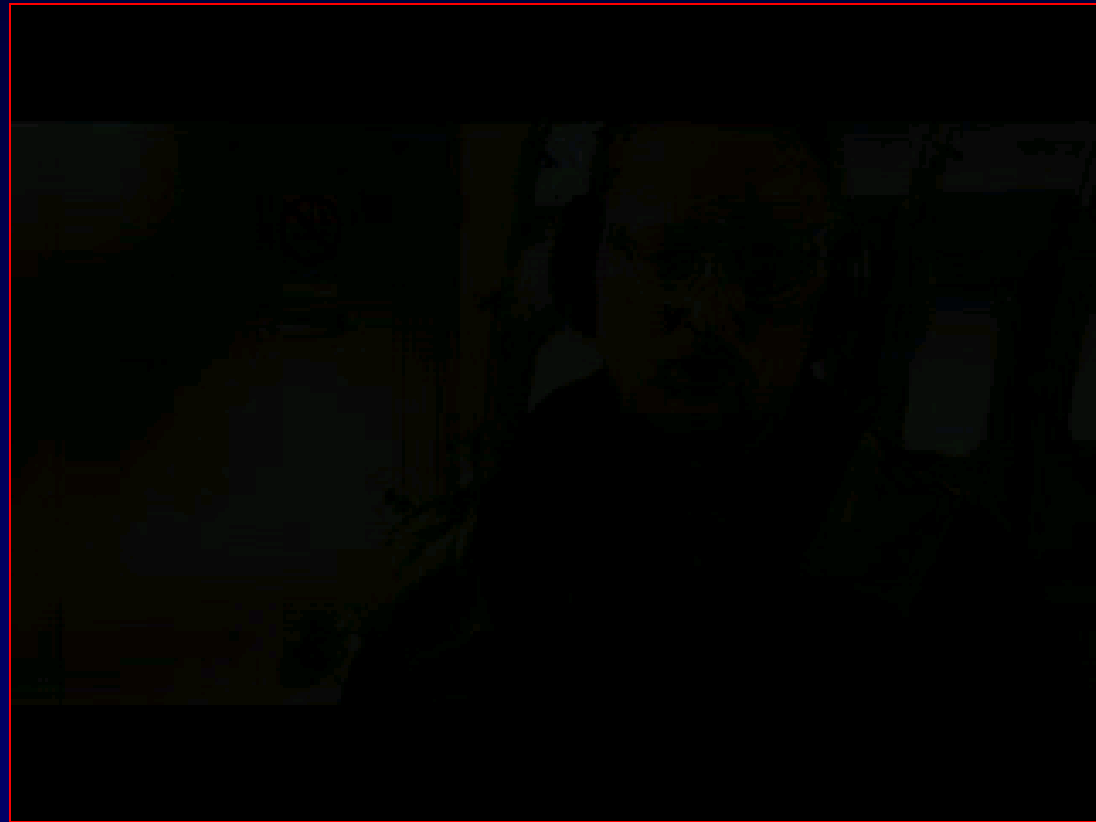
Author: Jack Wilson

Using the buttons to each side of the Energy window, you can adjust the energy of the particle in the well to see if the energy leads to a bound state. In a bound state the wavefunction will satisfy the boundry condition at infinity (on the right). It must go to zero to do that. You should find several bound states of the particle for the energy selected here.

Notice that you can select various annotation possibilities, including "Crosshair," "Derivative," "Integral," and "Chalk." You can use each one in combinations with the mouse and mouse button.

Are you feeling a bit overwhelmed?

- The restructuring of the curriculum cannot be allowed to disrupt the students' experience
- Ever feel like you are building a plane in flight?



TEEE Ten Commandments

1. Restructure around the learner. Neither over-emphasize nor under-emphasize technology.
2. Build upon research results, which inform design; don't try to reinvent the wheel.
3. Remember that technology has an intrinsic educational value beyond helping students learn better.
4. Do systematic redesign and not incremental add-ons. There is always a tendency to just add on a few computer experiences to everything else. By definition this costs more, is more work for faculty, and adds to the students' burden. An innovative approach changes rather than adding poorly integrated exercises.
5. Benchmark your plans and build upon examples of systematic redesign. Do not automate the lecture. Find the best examples and build upon them.

* TEEE – Technology Enhanced Engineering Education

TEEE Ten Commandments

6. Count on Moore's law ("What is hard today is easy tomorrow").
 - For example, CPU power and bandwidth have consistently improved.
7. Cost is an important aspect of quality. There is no lasting quality if there has been no attention to cost.
 - There are more than enough examples of expensive high quality solutions.
We need more examples of inexpensive high quality solutions!
8. Avoid pilots that linger. Design for a large scale and pilot projects only as a prelude to scaling up.
 - It is easy to design innovative educational experiences that work for small groups. It is harder to address the needs of the 1000 students taking calculus I at the large research university. The Emporium is a great example.
9. Develop a balance between synchronous and asynchronous distributed learning.
10. There is no longer any way to do good scholarship without technology, and there is no longer any way to teach good scholarship without technology.

* TEEE – Technology Enhanced Engineering Education

Helpful links

- UMassOnline: www.UMassOnline.net
- Pew Center for Academic Transformation
 - Center.rpi.edu
- Pkal; www.pkal.org
- Hesburgh awards – faculty dev. Focus
- Pew Prizes – institutional focus
- EDUCAUSE- www.educause.org
 - Technology focus
- Syllabus – www.syllabus.com
- EdMedia -
- TLTR and Flashlight

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The End