American Way of University Education and Research: an Informal Discussion

F.K. Tittel
Electrical and Computer Engineering Department,
Bioengineering Department
Rice Quantum Institute
Rice University, Houston, TX, USA
http://ece.rice.edu/lasersci/

• Rice University
• Who am I
• What is the University
• Engineering Education
• Electrical Engineering
• Technology for Education
• Rice Engineering Experience
• Summary
Rice University, Houston
Rice University, Houston
Rice University, Houston
Rice University, Houston
Duncan Hall, Rice University
Brochstein Pavillion, Rice University,
Rice University, Houston
Rice University, Houston
Rice University, Houston
Who Am I?

- PhD in EE from Stanford University 1958
- Faculty member at Rice University, 44 years
- Research and teaching in Laser Physics and Technology
  - Electromagnetic Field Theory
  - Laser Spectroscopy
- Written over 300 articles and contributed to 5 books
- Visiting faculty at
- Chairman of ECE department at Rice
- Dean of engineering at Rice
- One of the founders of Connexions
- First visited Poland in 1944
Where did the University Come From?

Locations:
- Athens, Greece
- Bologna, Italy
- Paris, France
- Oxford, England
- Berlin, Germany
- China and India

Supported by:
- Public
- Religion
- Government
- Business
What is the University?

The University is an institution where “universal knowledge” is discovered, created, taught, and learned. Types of university are:

- Liberal Arts College (Wellesley, Trinity, Reed)
- Research University (Stanford, Princeton, Rice)
- Technical Institute (MIT, Caltech, GeorgiaTech)
- Multiversity (UC Berkeley, UT Austin, Illinois)
- Public, Private and Corporate
How did the American University come into Being?

- New England Colleges (Harvard, 1636)
- Land Grant College Act of 1862
- Johns Hopkins (Research) University, 1876
- World War II and the Cold War, 1942-1990
- The GI Bill, 1944
- The Information Age, now!
Where is the University Going?

- A new relationship with the public
- A new use of Technology in education
- A new relationship with government and business
- A new model of education and career:
  - must respond to increase in amount of knowledge
  - must respond to rapid obsolescence of knowledge
  - change of faculty role from authority to mentor
  - change from teacher control to shared control
- Must prepare students to learn how to learn
The Research University

Quotation

“We choose to combine basic research, a fair mixture of applied research, training for research, and undergraduate education at the same place, done by the same people, frequently at the same time”
<table>
<thead>
<tr>
<th>Rank</th>
<th>School</th>
<th>Overall Score*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Harvard University, MA</td>
<td>100</td>
</tr>
<tr>
<td>1</td>
<td>Princeton University, NJ</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>Yale University, CT</td>
<td>98.7</td>
</tr>
<tr>
<td>3</td>
<td>Columbia University, NY</td>
<td>97.5</td>
</tr>
<tr>
<td>4</td>
<td>California Institute of Technology</td>
<td>96.8</td>
</tr>
<tr>
<td>5</td>
<td>Massachusetts Institute of Technology</td>
<td>98.1</td>
</tr>
<tr>
<td>6</td>
<td>Stanford University, CA</td>
<td>97.5</td>
</tr>
<tr>
<td>7</td>
<td>University of Chicago, IL</td>
<td>94.7</td>
</tr>
<tr>
<td>8</td>
<td>University of Pennsylvania</td>
<td>94.6</td>
</tr>
<tr>
<td>9</td>
<td>Duke University, NC</td>
<td>94.5</td>
</tr>
<tr>
<td>10</td>
<td>Dartmouth College, NH</td>
<td>94.4</td>
</tr>
<tr>
<td>11</td>
<td>Northwestern University, IL</td>
<td>93.7</td>
</tr>
<tr>
<td>12</td>
<td>Johns Hopkins University, MD</td>
<td>93.5</td>
</tr>
<tr>
<td>13</td>
<td>Washington University</td>
<td>93.1</td>
</tr>
<tr>
<td>14</td>
<td>Rice University, TX</td>
<td>92</td>
</tr>
<tr>
<td>15</td>
<td>Brown University</td>
<td>89.5</td>
</tr>
<tr>
<td>16</td>
<td>Vanderbilt University, TN</td>
<td>89.4</td>
</tr>
<tr>
<td>17</td>
<td>Cornell University, NY</td>
<td>88.5</td>
</tr>
<tr>
<td>18</td>
<td>University of Notre Dame, IN</td>
<td>88.4</td>
</tr>
<tr>
<td>19</td>
<td>Emory University, GA</td>
<td>88.1</td>
</tr>
<tr>
<td>20</td>
<td>University of California, Berkeley</td>
<td>87</td>
</tr>
</tbody>
</table>

* Academic Reputation, student selectivity, faculty resources, financial resources
Electrical Engineering

Electricity transmits energy and information

EE is abstract, therefore, requires
• More mathematics than other subjects
• More physics than many other subjects
• Use of visualization
• Use of simulation
Electrical Engineering

- Applied mathematics
- Applied physics (and Chemistry)
- Design, research

- Computation
- Biology

- Business
- Entrepreneurship
ECE Department Faculty

- 22 tenured/tenure track
- One open position
  - Neuroengineering
- 3 professors in the practice
- 1 research faculty
- 30 joint/adjunct faculty
• Graduate
  ▪ Several external fellowships
  ▪ Graduates placed in academia/industrial R&D
    ➢ UIUC, Michigan, MIT, Georgia Tech, Colorado, …
    ➢ TI, Intel, Nokia, IBM, Google, Microsoft, …
  ▪ Societies
    ➢ SPIE, GSA, GSC, IEEE
• Focus
  ▪ Computer/Neuro engineering and nano-electronics
  ▪ Photonics and nano-engineering
  ▪ Systems
• Annual research expenditure
  ▪ $12M and going up
• Space
  ▪ Duncan hall
  ▪ Abercrombie lab
  ▪ Space sciences
  ▪ Smalley institute
  ▪ The Brockman hall of physics
    ➢ Spring 2011
    ➢ 18,000 sqft (labs and offices) for ECE
Undergraduate Degrees

• Bachelor of Science
  ▪ Astrophysics
  ▪ Biochemistry
  ▪ Cell Biology
  ▪ Chemistry
  ▪ Chemical Physics
  ▪ Earth Science
  ▪ Ecology
  ▪ Evolutionary Biology
  ▪ Physics

• Bachelor of Science Degree in Engineering
  ▪ Chemical Engineering
  ▪ Civil Engineering
  ▪ Computer Science
  ▪ Electrical Engineering
  ▪ Material Science
  ▪ Mechanical Engineering
  ▪ Bio Engineering
Technology for Education

- Matlab, Mathematica, Maple, LabView
- OpenCourseware (OCW), Connexions, Wikipedia, Google
- Sakai (a community of educators collaborating to open software that advances teaching and research)
- Moodle (course and learning management system)
- Desktop, laptop, hand-held, mobile smart phone plus Internet; social software systems; tablet devices
Curriculum in Signal Processing

- Mathematics
- Signals and Systems
- Signal processing theory and systems
- Communications theory and systems
- Control theory and systems
- Applications and research
Education in the New System

Shift emphasis from
– Training to education
– Teaching to learning (teacher to student)
– Passive to active (and interactive)
– Process to concept (concept inventory)
– Understand to discover

Need research in learning technical material
Technology for Education

• Matlab, Mathematica, Maple, LabView

• OCW, Connexions, Wikipedia, Google

• Sakai, Moodle

• Desktop, laptop, hand-held, mobile phone plus Internet; social software systems
Open Educational Resources

The Open Educational Resource (OER) movement was inspired by the Open Source movement in software.

- Open Course Ware “OCW” (MIT)
- Connexions “Cnx” (Rice)
- Wikipedia (Wikibooks, etc.)
- Creative Commons “CC” (Stanford, Duke)
- Curriki, PLoS, EOL, Shuttleworth's Siyavula Project, CK-12 Project, OSI, etc.
Books and On-Line Use with XML

Books from Connexions:
• Personalized, on-demand printing, up-to-date, inexpensive, collaboratively authored, allows pre and post publication review, never “out of print”, “Long tail” publications. One button buy

On-Line use of Connexions:
• Allows modern pedagogy: concept-based, problem solving-based, discovery-based learning. Dynamic, interactive, linked, adapts to learning style, student and author driven, allows “assessment and evaluation”, problem sets
Connexions Now

Usage

Repository: 7250 modules, 20,000 revisions, 405 courses or books, 7200 author accounts, 147 countries, print-on-demand books

In Oct. 2008: 17M hits, 1.0M pages views, 520K unique users from 157 countries

Globalization

Europe: Germany, Norway, England, etc.

Asia: China, India, Pakistan, Japan, Vietnam, Korea

Africa: South Africa

LACCEI: (conversation with Mexico, Argentina, Brazil, Chile, and Uruguay started)
Engineering Education

• Curriculum will assume several careers for a person
• Will assume life-long learning and availability of distance learning
• Will prepare a person for management and leadership
• Will make use of internships and summer jobs
• Greater importance will be placed on writing and communication skills
• Education will use collaboration with other universities, industry, and business
• Greater use will be made of technology in education
• The need for both depth and breadth implies a new
Open Educational Resources

The Open Educational Resource (OER) movement was inspired by the Open Source movement in software.

- **Open Course Ware “OCW”** (MIT)
- **Connexions “Cnx”** (Rice)
- **Wikipedia** (Wikibooks, etc.)
- **Creative Commons “CC”** (Stanford, Duke)
- **Curriki, PLoS, EOL, Shuttleworth's Siyavula Project, CK-12 Project, OSI, etc.**
What is Connexions?

1. A **repository** of modules of information available through the **web** on the Internet
   - Modules (and collections) encoded in XML, one concept, a few pages, a quantum of information

2. A set of **tools** for authoring, maintaining and using the content of the repository
   - Module **editor**, importer, course or book **composer**, repository organizer, **Creative Commons** license, tools for printing **books**

3. A **community** of **people** who share educational interests and information
   - Interest groups (authors, instructors, students),
Fundamentals of Signal Processing

Start Course

Course Author: Minh Do
Course Description: Presents fundamental concepts and tools in signal processing including: linear and shift-invariant systems, vector spaces and signal expansions, Fourier transforms, sampling, spectral and time-frequency analyses, digital filtering, z-transform, random signals and processes, Wiener and adaptive filters.

Contributing Authors: Anders Gjendemsjo, Benjamin Fite, Clayton Scott, Don Johnson, Douglas L. Jones, Hyeokho Choi, Ivan Selesnick, Justin Romberg, Melissa Selik, Michael Haag, Minh Do, Ricardo Radaelli-Sanchez, Richard Baraniuk, Rob Nowak

Rice University
Connexions Now

Usage

Repository: 16,370 modules, 30,000 revisions, 1001 courses or books, 10,200 author accounts, 147 countries, print-on-demand books

In Oct. 2008: 17M hits, 1.0M pages views, 520K unique users from 157 countries

Globalization

Europe: Germany, Norway, England, etc.

Asia: China, India, Pakistan, Japan, Vietnam, Korea

Africa: South Africa

LACCEI: (conversation with Mexico, Argentina, Brazil, Chile, and Uruguay started)
Next-gen “computer”

twitter

facebook

flickr

Picasa

amazon mechanical turk

Artificial Artificial Intelligence
Need new “programming” paradigm

• Existing paradigms
  – C++/Java written by Professionals

• Possible new paradigms
  – Intention, interest described by Homer
Need a new “smartphone”
Need a new “smartphone”

• Existing smartphones
  – personal computer

• Possible new smartphone
  – sensor, actuator
  – interface between physical and digital worlds
To summarize

• Two principles
  – Hardware is cheap and getting cheaper
  – Human is precious

• We must rethink “computers” every 6 years

Fabulous RECG students:
  Ahmad Rahmati, Mian Dong, Jiayang Liu, Hasan Dumanli, Xiaozhu Lin,
  Hang Yu, Ardalan Amiri Sani, Siqi Zhao, Zhen Wang, Clay Shepard,
  Robert LiKamWa, and Jeff Bridge

Fabulous Rice collaborators:
  Behnaam Aazhang, Joe Cavallaro, Rudy Guerra, Edward Knightly, Phil Kortum,
  Doug Natelson, Ashu Sabharwal, Vivek Sarkar, James Tour, Wotao Yin
Why Rice Engineering?

- Design
- Research
- International Experience
- Civic Engagement
- Communication
- Leadership
DEPARTMENTS

BIOENGINEERING
COMPUTATIONAL AND APPLIED MATHEMATICS
CHEMICAL AND BIOMOLECULAR ENGINEERING
CIVIL AND ENVIRONMENTAL ENGINEERING
COMPUTER SCIENCE
ELECTRICAL AND COMPUTER ENGINEERING
MECHANICAL ENGINEERING AND MATERIALS SCIENCE
STATISTICS

FUNDAMENTALS
CIVIC ENGAGEMENT

Engineers Without Borders in Nicaragua

DREAM Project

Wireless access in Pecan Park

Washington D.C. Interns 2011
COMMUNICATION

Classroom Presentations

Oral Presentation Coaching

Poster Sessions

EWB National Conference
Rice Center for Engineering Leadership
Mission: Graduate engineers who will be leaders in engineering, research, business and public policy.

rcel.rice.edu
ALUMNI

Sandra Johnson Baylor  
Manager, IBM Linux Technology Center

Lynn Elsenhans  
CEO, Sunoco

Christine Ehlig-Economides  
A.B. Stevens Endowed Professorship, Texas A&M; Member NAE

Rakesh Agarwal  
CEO, Snapstream

Mark Hall  
Consultant  
Former technical director, Sony Pictures

John Doerr  
Venture Capitalist  
Lotus, Sun, Compaq, Amazon, Netscape, Google
Rice Engineering Experience

• Prepares you for your future
  – Learn how to learn
  – Develop leadership abilities
  – Develop communications skills
  – Design systems and devices to solve real-world problems
  – Understand engineering in global/social context
  – Create new knowledge through research