The Times, They Are A Changing

Dennis J. Frailey
(Retired) Principal Fellow, Raytheon Company
Adjunct Professor of Computer Science, SMU
Frailey@ACM.ORG
Frailey@Lyle.smu.edu

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Outline

- The Need for Change
  - Economic Data
- Resistance to Change
  - Math vs CS
- Changes in What we Teach
  - Changes in Computing / SW Engineering
- Changes in How we Teach
  - MOOCs, flipped classrooms, and beyond
- One Way Forward
  - Cooperation with Industry
  - Academic Freedom vs Voice of the Customer
The Need for Change
In 1913, education was less than 0.2% of a typical family budget.

Durable Goods, Services and Medical Care (since 1967)

By 1967, education was about 0.7% of a typical family budget.

Rates of Growth – 1993-2013

Since 1993, education has grown from ~1.1% to ~2.5% of a typical family budget.

Elements of a Typical US Family Budget 1919 through 2048 (projected)

The Future Family Budget?

- Education
- Housing
- Health Care
The Future Family Home?
Other Factors Motivating Change

- **People are more mobile**
  - They expect to access things from mobile devices and from anywhere

- **Expansion of knowledge**
  - The computing field continues to grow
  - Students can’t learn everything
  - “Just in Time” training and education are more common

- **Expansion of knowledge sources**
  - Internet, for-profit education providers, etc.
  - Students need ways to integrate the knowledge into a cogent understanding
Resistance to Change
John Silbur’s Research on Organizations that Resist Change

- Of 68 institutions that have survived the past 500 years
  - 2 are churches (Catholic, Lutheran)
  - 2 are governments (Iceland, Isle of Man)

Silber, John, “Straight Shooting: What’s Wrong with America & How to Fix it”, 1990
64 are Universities
Choosing a Career in 1966 – Mathematics or Computer Science

Math Faculty
The Math Curriculum

- Real/Complex Analysis
- Topology
- Differential Topology
- Complex Manifolds
- Algebra
- Differential Equations
- Combinatorics
- Probability and Statistics
- Algebraic Number Theory
- Field Theory
- Etc.
What Allen H Brady Taught

- Turing Machines
- Symbolic Logic
- Automata Theory
- Formal Languages
- Computational Complexity

\[ T = (Q, \Sigma, \Gamma, \delta, q_0, B, F) \]

Where:
- \( Q \): Set of states
- \( \Sigma \): Input alphabet
- \( \Gamma \): Tape alphabet (\( \Sigma \subseteq \Gamma \))
- \( \delta \): Transition function
- \( \delta : Q \times \Gamma \rightarrow Q \times \Gamma \times \{L, R\} \)
- \( q_0 \): Start state
- \( B \): Blank symbol
- \( F \): Set of accepting states (\( F \subseteq Q \))
Reasons to Choose Math over Computer Science

Computing lacks the intellectual depth of mathematics and you would waste your talents by going into that field.

Computer science is a fad, likely to die out quickly and you would have a worthless degree.

You can be assured of a stable, interesting, comfortable career in mathematics.
So What Happened?

- PhD in Computer Science in 1971
- Started computing career in 1962 as a Fortran programmer
- Computer Science Professor for 7 years
- Worked in industry for 40+ years:
  - compiler design,
  - computer design,
  - operating systems,
  - many software applications
- Adjunct Professor of Computer Science & Software Engineering for 37 years (so far)
Changes in What We Teach
MECHANICAL ENGINEERING

OFFICERS OF INSTRUCTION
P. W. McFadden, Head of the School


Areas of Graduate Study. Graduate students in mechanical engineering may select a primary area of concentration in one or more of the following areas: automatic control; kinematics; dynamics; vibration; stress analysis; design; cli-
1966-67 Graduate Computer Science Courses

- Computing and Programming Systems
- Advanced Programming Systems
- Information Storage and Retrieval
- Simulation and Information Processing
- Artificial Intelligence
- Numerical Analysis
- Numerical Analysis of Linear Systems
- Mathematical Programming
- Introduction to Logic and Boolean Algebra
- Mathematical Theory of Finite Automata
- Recursive Functions
- Mathematical Logic
- Numerical Solution of Ordinary Differential Equations
- Numerical Solution of Partial Differential Equations
- Theory of Approximation
The Growth of Computer Science

- Computer Science
- Computer Engineering
- Software Engineering
- Information Science
- Information Technology
1966-67 Graduate Computer Science Courses

- Computing and Programming Systems
- Advanced Programming Systems
- Information Storage and Retrieval
- Simulation and Information Processing
- Artificial Intelligence
- Numerical Analysis
- Numerical Analysis of Linear Systems
- Mathematical Programming
- Introduction to Logic and Boolean Algebra
- Mathematical Theory of Finite Automata
- Recursive Functions
- Mathematical Logic
- Numerical Solution of Ordinary Differential Equations
- Numerical Solution of Partial Differential Equations
- Theory of Approximation
2014 Graduate Computer Science Courses

- Systems I and II
- Databases
- Simulation and Modeling
- Artificial Intelligence
- Numerical Computing
- Algorithms
- Bioinformatics
- Complexity
- Distributed Systems
- Geometric Modeling, Visualization & Graphics Recursive Functions
- Distributed Systems
- Data Mining
- Parallel and Distributed Computing Theory of Approximation
- Security
- Software Engineering
# The Changes in Computing

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<tbody>
<tr>
<td><strong>Hardware</strong></td>
<td>Vacuum Tubes</td>
<td>Transistors</td>
<td>Integrated Circuits</td>
<td>LSI</td>
<td>VLSI</td>
<td>ULSI Nano-systems</td>
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<td><strong>Technology</strong></td>
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<td><strong>Programming</strong></td>
<td>Binary Assembly</td>
<td>Fortran Cobol</td>
<td>Pascal Algol</td>
<td>Ada Lisp</td>
<td>C++ GUI Java</td>
<td>C# PhP XML J2EE, EJB</td>
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<td><strong>Languages</strong></td>
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<td><strong>Computing</strong></td>
<td>1 user Mainframe</td>
<td>Batch Time Sharing</td>
<td>Personal Computer</td>
<td>LAN, WEB .NET, SOA</td>
<td>Mobile</td>
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<td><strong>Paradigm</strong></td>
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<td><strong>Operating</strong></td>
<td>none</td>
<td>1 user</td>
<td>multi user</td>
<td>multi user linked</td>
<td>networked Web, Open source</td>
<td>Cloud, Android, iPhone</td>
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<td><strong>System</strong></td>
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<td><strong>Data Base</strong></td>
<td>none</td>
<td>Linear (tapes)</td>
<td>Hierarchical</td>
<td>Relational Object Oriented</td>
<td>SQL, X Query SQLJ, OLAP, JDBC</td>
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<td><strong>Methods</strong></td>
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<td><strong>Software</strong></td>
<td>pad and pencil</td>
<td>Flow Charts</td>
<td>Structured Design</td>
<td>Data Flow Object Oriented</td>
<td>RAD, XP, RUP MDE</td>
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<td><strong>Design</strong></td>
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Computing is a Changing Field

- Every ten years the field is very different
- The half-life of computer knowledge is five years
- One must plan on a career of continuous learning
Changes in How We Teach

Challenges/Opportunities
- Cost/Productivity
- Effectiveness
- Global Reach & Needs

Assets
- Technology
- Creativity
- Software Engineers
Cost and Productivity
Classroom Evolution
Classroom Evolution
Classroom Evolution
Classroom Evolution
Classroom Evolution
Classroom Evolution
Classroom Evolution?
Distance Education
Distance Learning: A History of Flexibility

- **1728**: The first recorded instance of distance learning occurs in Boston, USA, when a "Calab-Phillips" advertises private correspondence courses in shorthand in the Boston Gazette.
- **1840s**: Sir Isaac Pitman runs correspondence courses teaching his revolutionary shorthand system. Pitman shorthand is still widely used today.
- **1858**: The University of London becomes the first university to offer distance learning degrees.
- **1869**: Harold Wilson's Labour Government founds the Open University in 1969. It becomes the first institution to deliver ONLY distance learning, primarily using radio and television broadcasts to deliver content.
- **1918**: The University of the Cape of Good Hope becomes The University of South Africa. Today, it is the largest university in Africa and is a dedicated distance learning institution.
- **1969**: Having pioneered the use of the term, the University of Wisconsin begins recording lectures and sending them to students in phonograph form.
- **1970**: Athabasca University (Canada's Open University) was founded.
- **1974**: FernUniversität in Hagen (Germany's Open University) was founded.
- **1995**: At Penn State University in the US, Jonker Madsen teaches the first course delivered over distance via the web. It is called "Computer on Art".
- **2009**: Tim Berners-Lee proposes the development of an online document sharing system which he described as a "web of notes with links". This became the World Wide Web.
- **2012**: Nearly 400,000 students study by distance learning in the UK, while one-third of all undergraduates study part-time.
- **2013**: UK Government makes student loans available to distance learning and part-time undergraduate students for the first time.
- **2019**: The term "learning" is coined.

Sources:
2. http://www.historyofeducation.org/history/historical_events/1840s_correspondence_courses/

*It’s been around for a while*
Student Observations

Recorded is better than live because I can watch it any time I want to.

I can rerun the recording if I did not understand.

Better Organized

I can schedule around personal obligations.
IT BEGAN IN CANADA...

"IT'S DISRUPTING EVERYTHING!

"IT'S A TSUNAMI OF POORLY UNDERSTOOD PEDAGOGY!"

DAY OF THE MOOC

STARRING: George SIEMENS, David WILEY, Dave CORMIER and Stephen DOWNES

Connectivists Unleashed a Force They Cannot Control!

Effectiveness
Innovations in Distance Education

- **DuoLingo.com**
  - Language education
- **Code.org**
  - Programming education
- **TED.com and TED-ed.com**
  - TED is a nonprofit devoted to spreading ideas, usually in the form of short, powerful talks (18 minutes or less).
  - TED-ed is developing courses based on TED topics
- **...**
My Lessons Learned about Distance Education

▪ Audio is More Important than Video
  – They don’t care what you look like
  – But they have to clearly understand what you say

▪ “Real” Time Isn’t Very Important
  – Students prefer the ability to time shift

▪ You Have to be Well Prepared
  – Materials ready in advance
  – FAQs and other helpful aids

▪ You have to Change the Way You Teach
  – Flexible schedules and due dates
  – Assignments tailored to the needs of distance students
  – Lots of grading and interactive support
Classroom Flipping
We Must Innovate!

- Re-invent
- Re-engineer
- Re-think the way we educate
- ... or someone else will do it for us
  - they already are!

What We Teach
How We Teach
Challenges
The Change Process?
The Change Process

The Kübler-Ross change curve

It gets worse before it gets better
One Way Forward
Cooperation Between Universities and Industry

- **U. of Maryland w Northrop Grumman**
  - New specialization in Cyber Security
  - (A special track in the Computer Science program)

- **Ohio State U w IBM**
  - Big Data Analytics center

- **Murray State University, Kentucky w Local Industry**
  - Retooled Engineering Program

- **State University of New York w Private Donors**
  - College of Nanoscale Engineering

  - Wall Street Journal, April 8, 2014, pp A1, A4
Q&A

▪ What’s different about these programs?
  – Aimed at undergraduates

▪ Why are corporations doing this?
  – They are “concerned about a mismatch between their needs and graduates’ skills”

▪ What are the benefits to students?
  – “Pathways to good internships and high paying jobs.”
What About Academic Integrity?

**Academic Integrity**
- Freedom from bias and biased influence
- Research integrity
- Honesty and rigor in the pursuit of knowledge
- Adherence to Moral and ethical principles
- Honor codes

**Voice of the Customer**
- Understanding the customer’s needs, expectations, preferences and aversions
- Proper prioritization
- Common language with customer
- Avoiding “engineering arrogance”
Engineering Arrogance

The tendency of engineers to think they know better than the customer.
A Little Bit of History

- In the 1970’s many universities used “dumb” terminals to access “minicomputers” or “mainframe” computers.

- Many of those terminals were Teletypes, which had no graphics capability and whose keyboards resembled those of typewriters.
First Generation Video Terminals

- Keyboards resembled typewriter keyboards
- Did not have cursor control keys.
Typical Cursor Control in Early Video Terminals

- “control” U for “up”
- “control” D for “down”
- “control” L for “left”
- “control” R for “right”
Bit Mapped Graphics

- These terminals used “bit mapped” graphics

- Due to limitations on memory size and speed, they displayed mostly text

- More sophisticated graphics were difficult to display
Vector Graphics Terminals

- Could draw lines and other primitive geometric shapes automatically
  - Lines
  - Curves
  - Polygons
  - ...

- But they were very expensive.
  - Too expensive for most consumer applications
  - Few students had access to them

- And the early ones still lacked cursor control keys
Logo and Turtle Graphics

- In the 1960’s, the MIT AI lab developed a graphics programming language called Logo
- ... and a method of drawing pictures called Turtle Graphics
- ... resulting in software that would allow drawing of pictures on the screens of vector graphics terminals
Logo and Turtle Graphics on Texas Instruments’ Home Computer

- Intended for young children
- To draw pictures on an inexpensive computer with bit mapped graphics.

- In the 1970’s, TI contracted with MIT to port the LOGO language and many applications to a home computer
Emerging Personal Computers had Cursor Control Keys

But the MIT students and faculty initially refused to support cursor control keys because “‘control’ R is more intuitive than the cursor control key”

Two Keys instead of One?
Our Students WILL Make it Happen.
A Special Opportunity for Software Engineers

- We are immersed in the technology
- We understand the problems
- We know how to make applications faster, smaller, & more efficient
- We use techniques such as re-engineering, optimization, etc.
- And our students are sometimes further ahead than their teachers!
Concluding Remarks

✓ Education must innovate and change

✓ Software engineers and software engineering educators are uniquely well qualified to help make this happen
  ➢ We know the technology
  ➢ We understand processes

✓ If we don’t, somebody else will

✓ We can lead the way
As the present now
Will later be past
The order is rapidly fadin'
And the first one now
Will later be last
For the times they are a-changin'.

Bob Dylan, 1964
Questions?