Some Reflections on C&I Education

Jie Wu
Computer and Information Sciences
Temple University
Roadmap

- **Current Crisis**
  - IT Market Demand
  - CS Enrollment

- **Several Initiatives**
  - NSF: BPC-A and CE21
  - ACM: CSTA

- **C&I Curricula**
  - ACM (AIS and IEEE) Curriculum 2013
  - Multi-subject and Cross-disciplinary

- **Chinese vs. U.S. Ed. System**
  - Final Thoughts

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1. Current Crisis

- IT job growth projections out-pace student interest in computing majors by a factor of 5.5

<table>
<thead>
<tr>
<th>Major</th>
<th>Jobs</th>
<th>Grads</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computing</td>
<td>140,000</td>
<td>60,000</td>
</tr>
<tr>
<td>Engineering</td>
<td>60,000</td>
<td>20,000</td>
</tr>
<tr>
<td>Life Sciences</td>
<td>80,000</td>
<td>40,000</td>
</tr>
<tr>
<td>Mathematics</td>
<td>160,000</td>
<td>60,000</td>
</tr>
<tr>
<td>Physical Sciences</td>
<td>120,000</td>
<td>40,000</td>
</tr>
</tbody>
</table>
In High School

- Participation in all STEM disciplines (science, technology, engineering, and mathematics) is increasing, except in the field of computer science.

Percentage of New STEM Jobs By Areas Through 2018

- Computing: 71%
- Computer Support: 7%
- Database Admin.: 2%
- Systems Analysis: 10%
- Computer Networking: 21%
- Software Engineering: 27%
- CS/IS: 1%
- Other Computing: 3%
- Physical Sciences: 7%
- Traditional Engineering: 16%
- Mathematics: 2%
- Life Sciences: 4%

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In College

- Since 2000, the number of majors in computing is down 70% overall, and the number of women is down 80%
- CS is threatened by one of its own innovations – using the internet for offshore job outsourcing

Figure 6. BS Production (CS & CE)
2. Several Initiatives

- Broadening Participation in Computing Alliance (BPC-A)
  - BPC-A addresses issues across K-16

- Computing Education for the 21st Century (CE21)
  - Effective teaching and learning in computing
  - NSF-initiated CS 10K project: 10,000 high school teachers to teach AP exam in CS by 2013

- Cyberlearning: Transforming Education (CTE)
ACM: CSTA

- **Computer Science Teachers Association (CSTA)**
  - Evolved from ACM's K-12 task force
  - Working on revising the model curriculum
  - Computing education for students ages 5-18 (K-12)

- **Learn from the successful stories of**
  - National Science Teachers Association (NSTA)
  - National Council for Teachers of Mathematics (NCTM)

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Challenge 1

- Changing the perception of CS as a service discipline
- Branding CS discipline
- Attaching more participants in CS STEM
3. C&I Curricula

- Diversification of C&I education
  - Past foundation
    - mathematical logic
    - mathematical engineering (M. Snir)
  - Current foundation
    - mathematics, statistics, cognitive sciences,
      social sciences, physical sciences, etc.

- More multidisciplinary and cross-disciplinary applications
  - Double major, CS-major X-minor, and X-major CS-minor
ACM (AIS and IEEE) Curricula

- Curriculum 65
  - Prelim. recommendation
- Curriculum 68
  - Algorithmic thinking
- Curriculum 78
  - Programming skills
- Curriculum 91
  - Multiple core
- Curriculum 01
  - Multiple tracks
- Curriculum 13 (cs2013.org)
  - Outward looking

- Curriculum 05
  - Computer Engineering
  - Computer Science
  - Information Systems
  - Information Technology
  - Software Engineering
  - Multiple Introductory Seq.
    - Imperative-first
    - Object-first
    - Functional-first
    - Algorithm-first
    - Hardware-first

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Computing Education Matters

- **ACM Symposium on Computer Science Education (SIGCSE 2011)**
  - Special session: the CS 10K project
  - Panel: Successful K-12 outreach strategies
  - Technical paper: Tutoring for retention
  - Panel: Top issues in providing successful undergraduate research experiences
  - Town meeting: expanding the women-in-computing community
  - Panel: Curriculum 2013 reported from ACM/IEEE joint task force

- **ACM Journal of Educational Resources in Computing**
- **ACM Transactions on Computer Education**

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Distance and Online Education

- **Substitution (disruptive) process?**
  - Problematic remote assessment

- **Facilitate better interaction**
  - Student-student
  - Student-faculty

- **Offer self-service education**
  - Student-pull (on-line)
  - Lecturer-push (in-classroom)

- **Recent online educational innovations**
  - iTunes U
  - MIT's OpenCourseWare
  - Chinese college courses online: www.icourses.edu.cn

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Distributed Ed: Stanford “Intro to AI”

- S. Thrun (Stanford) and P. Norvig (Google)
- Free and online worldwide from Oct. 10 to Dec. 18, 2011
- Delivering lectures on youtube
- Earning class certificate once passed

- Intro & complexity
- Tech trends
- Naming
- Enforcing modularity
- Operating systems
- Concurrency
- Threads
- Performance
- Networks
- Layers
- Routing
- End-to-end
- Sharing networks
- Distributed naming
- Fault tolerance
- Atomicity
- Recovery
- Isolation
- Multi-site atomicity
- Consistency and replication
- Security
- Message authentication
- User authentication
- Certification

F. Kaashoek (lecturer)

D. Katabi (recitation)

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Diversity

CMU (School of Computer Science): Department, Institute, and Center
- Computer Science Dept.
- Human-Computer Interaction Institute
- Institute for Software Research
- Language Technologies Institute
- Lane Center for Computational Biology
- Machine Learning Department
- Robotics Institute

CMU Ph.D. Programs
- Computation, Organizations and Society
- Computational Biology
- Computer Science
- Human-Computer Interaction
- Language and Information Technologies
- Machine Learning
- Machine Learning and Public Policy
- Machine Learning and Statistics
- Robotics
- Software Engineering

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The Bigger Picture

- **CS role in four scientific paradigms**
  - **Theory**: The primary scientific paradigm
  - **Experimentation**: The use of apparatus, artifacts, and observation to test theories and construct models
  - **Computation (1980s)**: A specialization of experimentation with tools focused around numerical techniques afforded by computers
  - **Data-driven (2010s)**: data and the computational systems needed to manipulate, visualize, and manage large amounts of scientific data

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Challenge 2

- Expanding C&I curricula while maintaining its core
- Utilizing IT technology for effective teaching and learning
- Educating CS students in ways of thinking and problem solving, which characterize CS
Why Picasso & Matisse are Great

- Know how to make appropriate abstraction - very important in CS!
- Many CS students use excessive amounts of math to explain simple things!

- ACM International Collegiate Programming Contest (ICPC)
  - Shanghai Jiaotong University (3 time winners, tied 1st overall)
  - Zhejiang University (2011 winner)

- D. A. Patterson (CACM, 2005): Reflections on a Programming Olympiad
  - Putin met the 2004 winner team
  - U.S. president met football champions
Shanghai Kids
First class city, first class education

Education performance of 15-year-olds
Selected countries/regions, 2009

Mean reading score

<table>
<thead>
<tr>
<th>Country</th>
<th>Rank</th>
<th>Mean PISA Score</th>
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<tbody>
<tr>
<td>China (Shanghai)</td>
<td>1</td>
<td>600</td>
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<tr>
<td>South Korea</td>
<td>2</td>
<td>510</td>
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<tr>
<td>Finland</td>
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<td>460</td>
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<td>Hong Kong</td>
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Mean maths score

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Source: OECD PISA 2009 Results
Amy Chua’s “Tiger Moms”

- Time Magazine, Jan. 2011
  - Is tough parenting really an answer?

- NY Times, Jan. 15, 2011
  - Chinese children typically start their formal education at age two
  - The Chinese tend to favour the U.S. education system for trying to make learning exciting and not just a chore

- NY Times, Nov. 3, 2011
  - The China Conundrum
  - It is difficult to identify good Chinese students from applications
Elite to Mass to Universal

- Almost all schools follow similar curricula
- Almost every child in China learns one classical musical instrument
  - ... but, there are only 2 or 3 thousand die-hard classical music fans in Beijing!
Conflicting Views on Education in U.S.

- Thomas L. Friedman: Five Pillars of Prosperities
  - Public education, modernization infrastructure, open immigration policy, basic R&D, and regulation of private economic activity

(Three-time Pulitzer winner)
Conflicting Views on Education in U.S.

- The debate on “the need of higher education”
  - Bill Gates, Steve Jobs, and Michael Dell never completed their college study
Things Students Learn at College

50% of the learning material for a student’s career future is outside the classroom

45% show no significant gains in critical thinking, analytical reasoning, and written communications during the first 2 years

BUT

- Learn how you learn
- Learn how to think
- Learn self-discipline
- Learn how to communicate effectively

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U.S. Ed. System

- **National priority**
  - Public safety, transportation, energy, education, health, advanced manufacturing

- **Admission criteria**
  - Standardized test, GPA/HPA, extracurricular activities, etc.

- **Different types**
  - Vocational technical institutions, community colleges, universities, and professional schools
Chinese System vs. U.S. System

- Chinese system
  - Highly structured, disciplined learning

- U.S. system
  - Critical thinking and student-centered learning

China and the U.S. should learn from one another and adopt what the other does best!
Merits of U.S. Ed. System

- U.S. system
  - Flexibility of educational system
  - Importance of extra-curricular activities
    - Club activities
    - Sports
    - Volunteering

- Five pillars of learning
  - Learning to know
  - Learning to do
  - Learning to live together
  - Learning to be
  - Learning to transform oneself and society

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Education for Building Character!

- Learning the lesson from the classical music world
- Musicianship with character
- Violinists
  - Past generation: Heifetz, Oistrakh, Menuhin, Kreisler, Elman...
  - Current generation: Perlman, Mutter, Vengerov, Bell, Chang...
Challenge 3

- Developing general education to produce well-rounded citizens
  - Fulfilling individual potential AND
  - Contributing to social transformation
Final Thoughts

- **Education ecosystem**: government, industry, academia, and professional societies
Charles Darwin (Origin of Species)

“It’s not the strongest of the species that survives, not the most intelligent, but the one most responsive to change.”