Some Reflections on C&I Education

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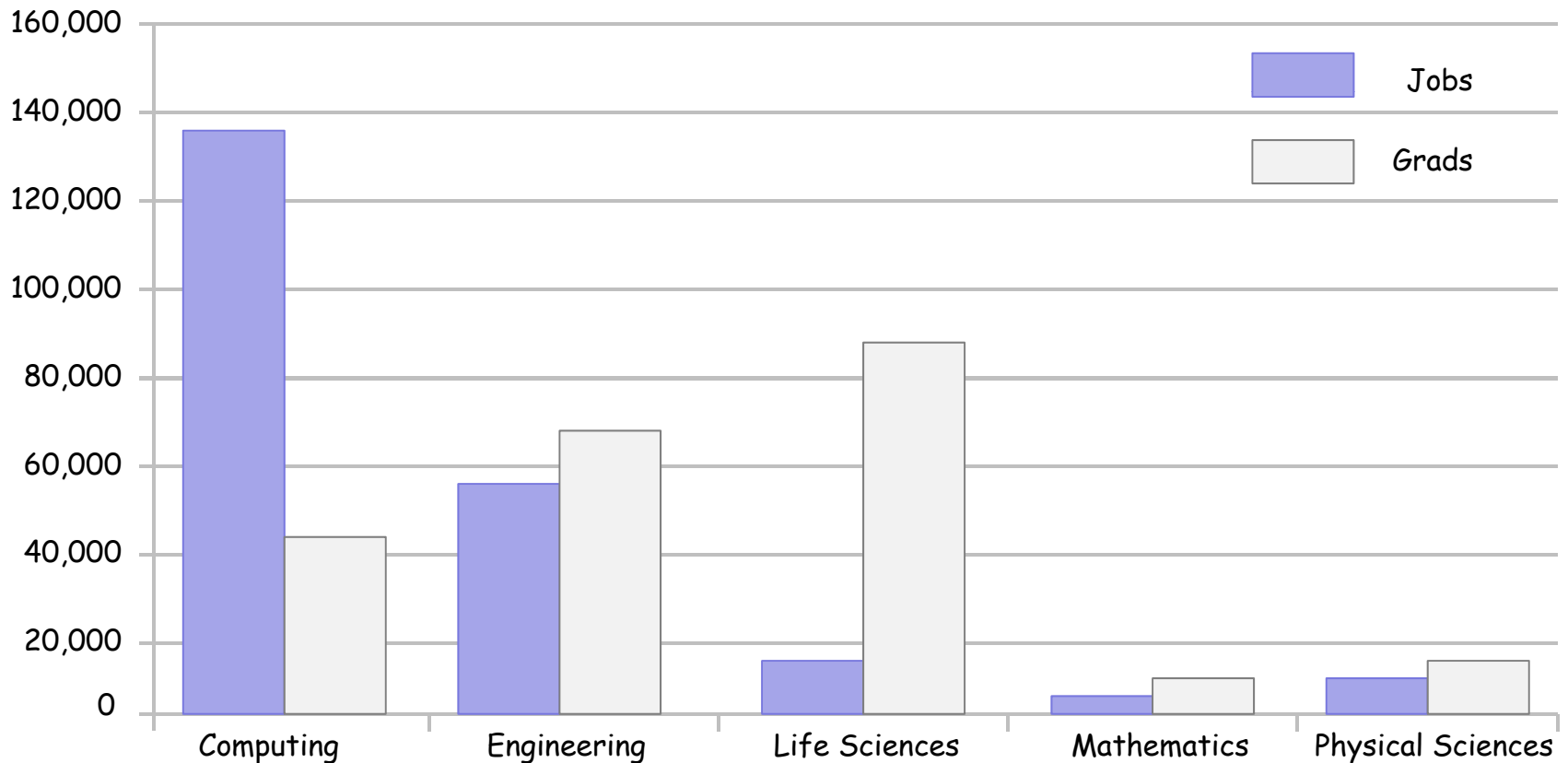
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Roadmap

- ## 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
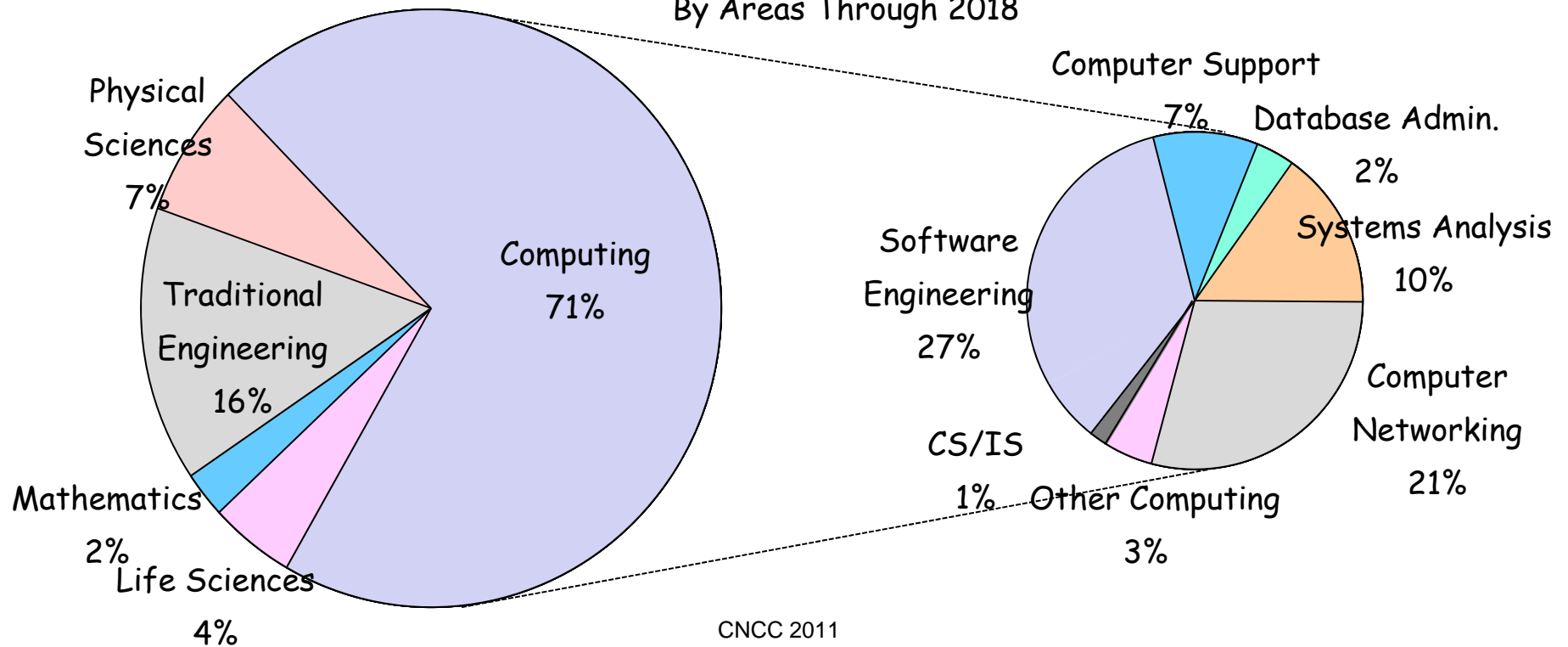 - Final Thoughts

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1. Current Crisis

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

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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

Physical Sciences 7%

Traditional Engineering 16%

Computing 71%

Mathematics 2%

Life Sciences 4%

Computer Support 7%

Database Admin. 2%

Software Engineering 27%

Systems Analysis 10%

Computer Networking 21%

CS/IS 1%

Other Computing 3%

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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)

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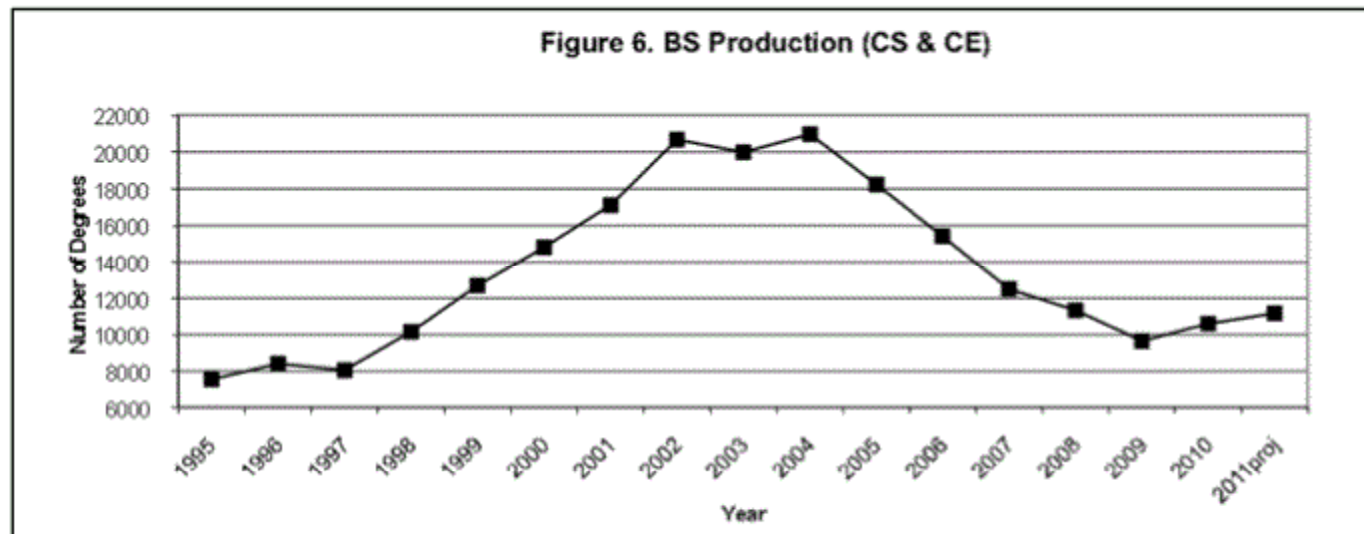
2. Several Initiatives

- 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)

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

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

STANFORD
UNIVERSITY

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Multi-subject: MIT "Computer Sys. Eng."

- 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
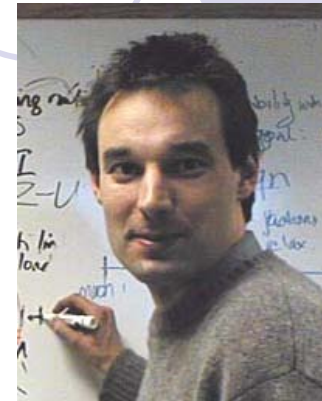
F. Kaashoek
(lecturer)

D. Katabi
(recitation)

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Diversity

Carnegie Mellon

## 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

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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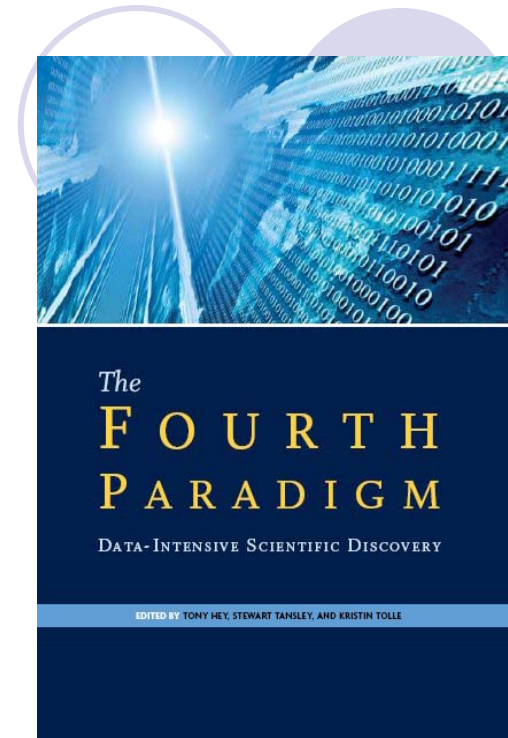
Challenge 2

- 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!
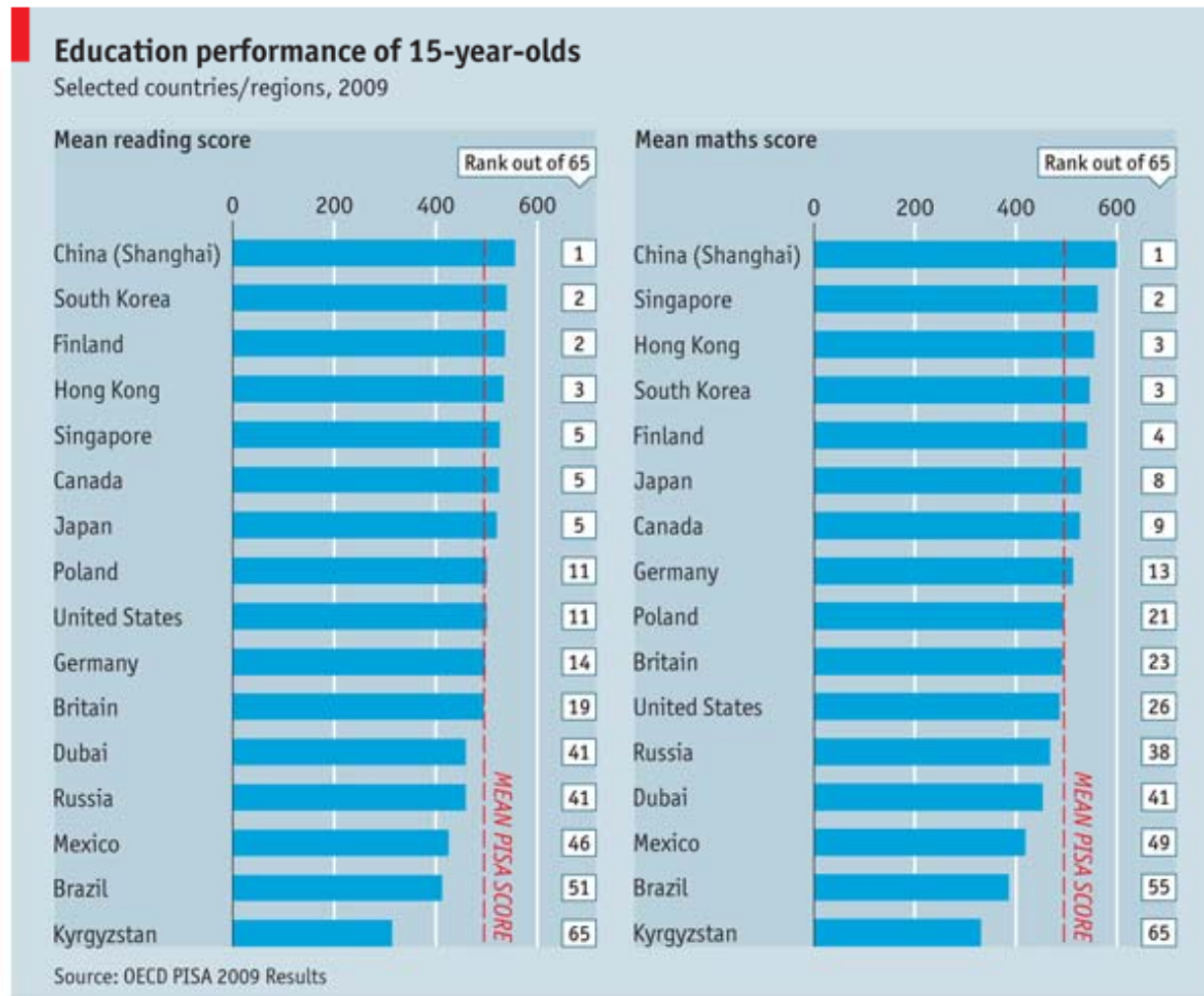

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4. Chinese vs. U.S. Ed. System

- ## 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

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Shanghai Kids
First class city, first class education

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

Mean reading score — Rank out of 65

Country	Rank
China (Shanghai)	1
South Korea	2
Finland	2
Hong Kong	3
Singapore	5
Canada	5
Japan	5
Poland	11
United States	11
Germany	14
Britain	19
Dubai	41
Russia	41
Mexico	46
Brazil	51
Kyrgyzstan	65

Mean maths score — Rank out of 65

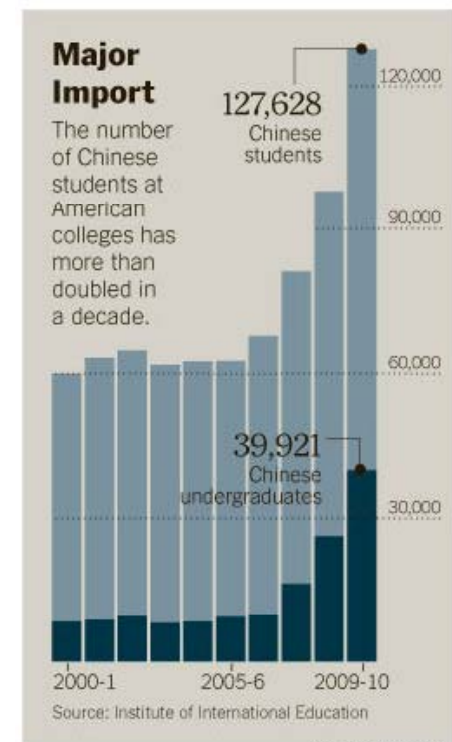| Country	Rank
China (Shanghai)	1
Singapore	2
Hong Kong	3
South Korea	3
Finland	4
Japan	8
Canada	9
Germany	13
Poland	21
Britain	23
United States	26
Russia	38
Dubai	41
Mexico	49
Brazil	55
Kyrgyzstan	65

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

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The New York Times   October 31, 2011

Major Import

The number of Chinese students at American colleges has more than doubled in a decade.

127,628 Chinese students

39,921 Chinese undergraduates

120,000
90,000
60,000
30,000

2000-1   2005-6   2009-10

Source: Institute of International Education
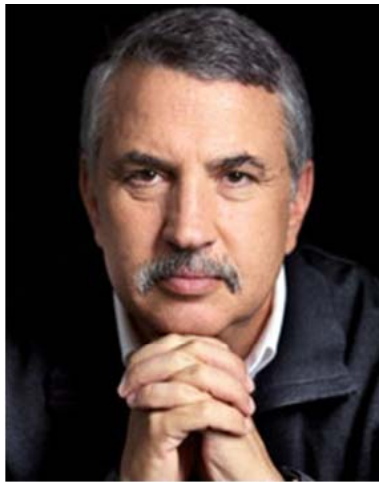
THE NEW YORK TIMES

Elite to Mass to Universal

- Almost all schools follow similar curricula
- Almost every child in China learns one classical musical instrument
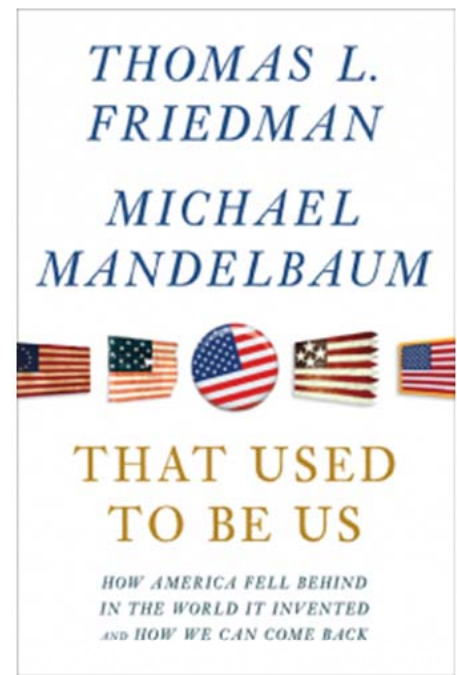 - … but, there are only 2 or 3 thousand die-hard classical music fans in Beijing!

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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

THOMAS L. FRIEDMAN

MICHAEL MANDELBAUM

THAT USED TO BE US

HOW AMERICA FELL BEHIND IN THE WORLD IT INVENTED AND HOW WE CAN COME BACK

(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, extra-curricular activities, etc.

- Different types
  - Vocational technical institutions, community colleges, universities, and professional schools

Education in the United States

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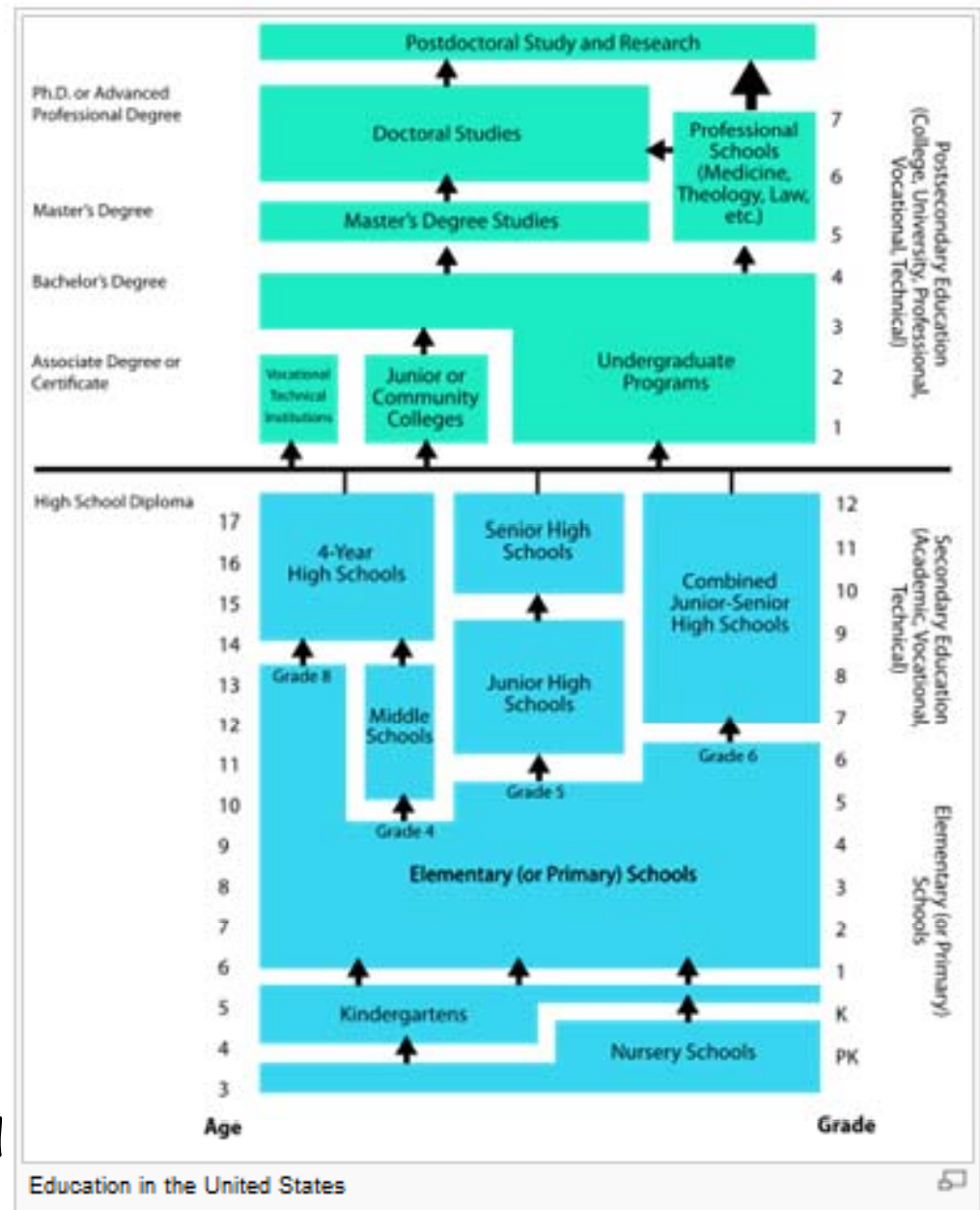
Chinese System vs. U.S. System

- 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...

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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

Professional Societies

Government

Academia

Industry

Problems/Funds/Solutions

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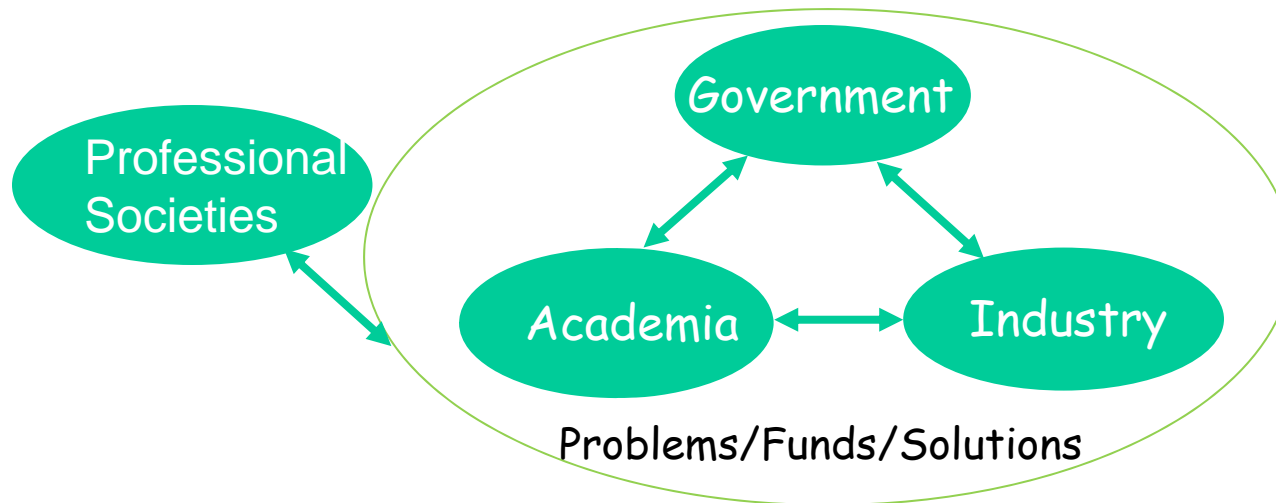
Charles Darwin (Origin of Species)

"It's not the strongest of the species that survives, not the most intelligent, but the one most responsive to change."

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