Computer Science: The Ever-Expanding Sphere

Ed Lazowska

Bill & Melinda Gates Chair in

Computer Science & Engineering

University of Washington



UCSD Computer Science and Engineering

December 2014



From: Jeanne Ferrante

Date: Tue, Sep 16, 2014

Subject: Distinguished Lecture Visit to UC San Diego

To: Ed Lazowska

Hello Ed,

Our CSE department would like to invite you to visit as part of our Distinguished Lecture Series to give a talk on your department's experience in growing diversity - we are both interested in demographics (increasing the number of women and underrepresented students and faculty) as well as diversity of thought (how your department has benefited from growth in non-traditional areas).

We very much hope that this will interest you. Assuming so, let us know some possible dates for this coming fall or winter quarters. We look forward to seeing you here in San Diego.

Regards, Jeanne

"FLATTERY IS LIKE CHEWING GUM. ENJOY IT BUT DON'T SWALLOW IT."

HANK KETCHAM

© Lifehack Quotes

Neither I nor UW CSE claim any special standing on these topics!

Today: Three perspectives

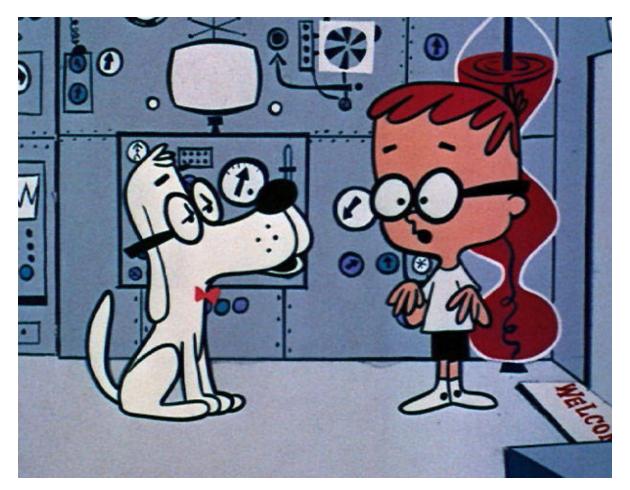
- A perspective on our field
- A perspective on diversity of thought
- A perspective on diversity of demographics
- Discussion!



A perspective on our field

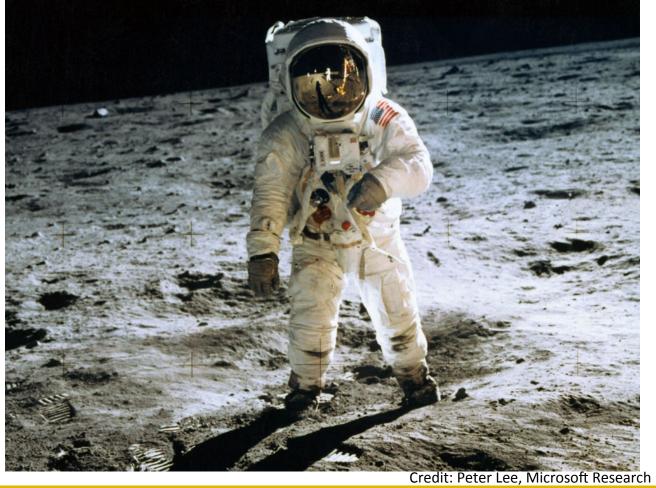


Forty five years ago ...

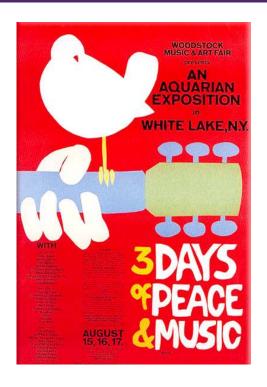






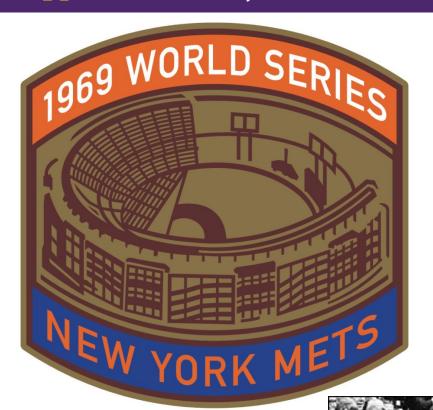


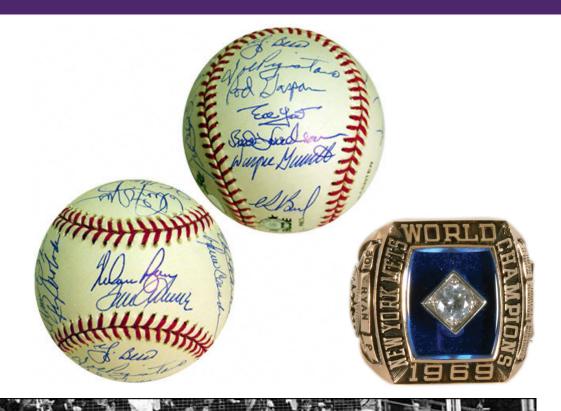








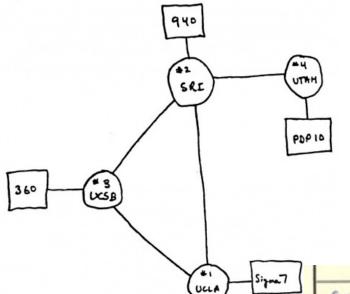








Credit: Peter Lee, Microsoft Research



THE ARPA NETWORK
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		Credit: Peter Lee, Microsoft Researc



With 4+ decades of hindsight, which had the greatest impact?

Unless you're big into Tang and Velcro¹ (or sex and drugs²), the

answer is clear ...



And so is the reason ...



¹ While Tang and Velcro were used extensively on space missions, the common attribution of their invention to NASA is mistaken.

² While sex and drugs were pervasive at Woodstock, they too were invented previously.

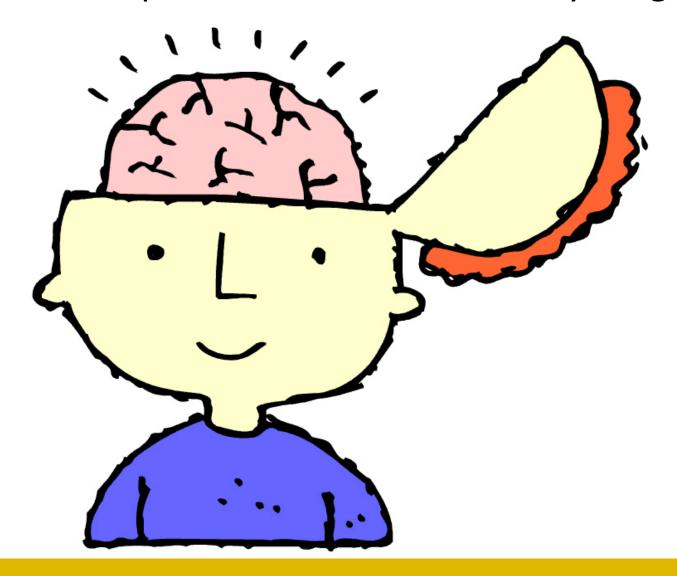
Today, these exponential improvements in technology and algorithms are enabling the "big data" revolution

- A proliferation of sensors
 - Think about the sensors on your phone
- More generally, the creation of almost all information in digital form
 - It doesn't need to be transcribed in order to be processed
- Dramatic cost reductions in storage
 - You can afford to keep all the data
- Dramatic increases in network bandwidth
 - You can move the data to where it's needed



- Dramatic cost reductions and scalability improvements in computation
 - With Amazon Web Services, 1000 computers for 1 day costs the same as 1 computer for 1000 days
- Dramatic algorithmic breakthroughs
 - Machine learning, data mining fundamental advances in computer science and statistics
- Ever more powerful models producing everincreasing volumes of data that must be analyzed

The "big data" revolution is enabling computer scientists to put the "smarts" into everything



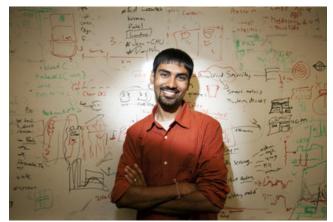
The "big data" revolution is enabling computer scientists to put the "smarts" into everything





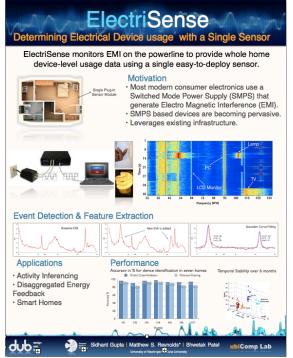
- Smart homes
- Smart cars
- Smart health
- Smart robots
- Smart crowds and humancomputer systems
- Smart education
- Smart interaction (virtual and augmented reality)
- Smart cities
 - Smart discovery "the fourth paradigm"

Smart homes (the leaf nodes of the smart grid)



Shwetak Patel, University of Washington 2011 MacArthur Fellow

MACARTHUR
The John D. and Catherine T. MacArthur Foundation



Supporting the health of your





Smart cars

DARPA Grand Challenge



DARPA Urban Challenge





Smart health



Larry Smarr – "quantified self"



Evidence-based medicine





P4 medicine

Smart robots









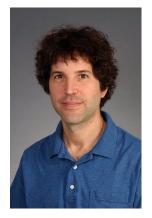




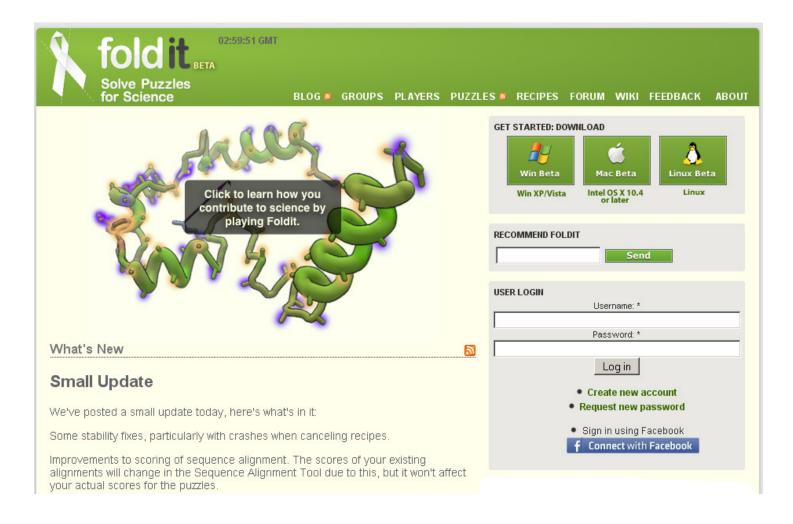
Smart crowds and human-computer systems



Zoran Popovic
UW Computer Science &
Engineering



David Baker UW Biochemistry



Smart education



Zoran Popovic
UW Computer Science &
Engineering





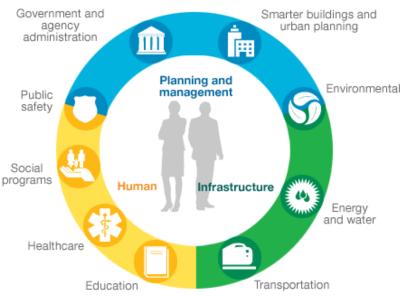


Smart interaction



Smart cities







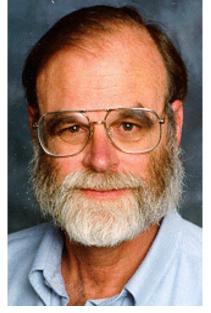
Smart discovery – "the fourth paradigm"

- 1. Empirical + experimental
- 2. Theoretical
- 3. Computational
- 4. Data-Intensive



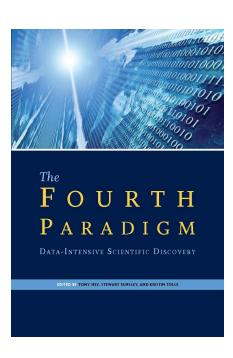


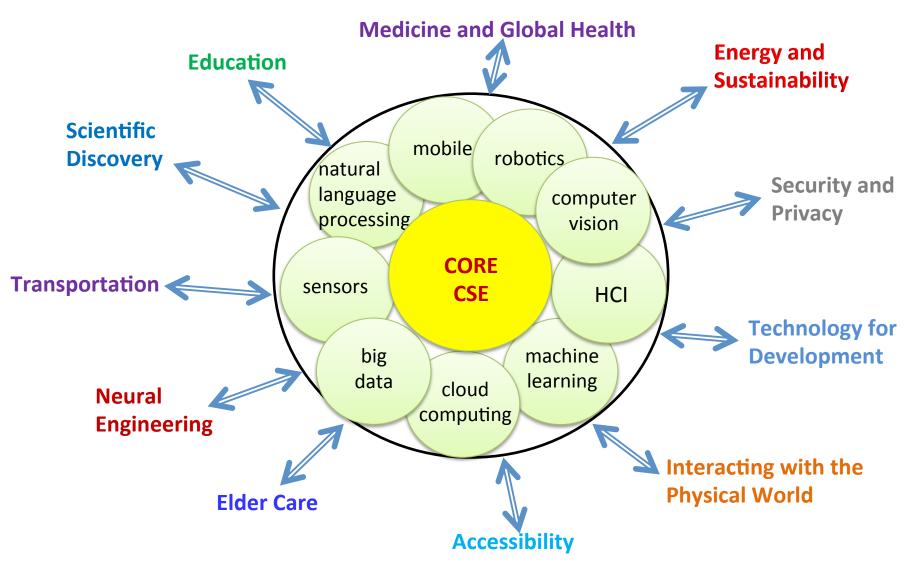




Jim Gray











Medicine and Global Health

Education

Energy and Sustainability

Scientific Discovery

Transportation

Neural Engineering

Elder Care

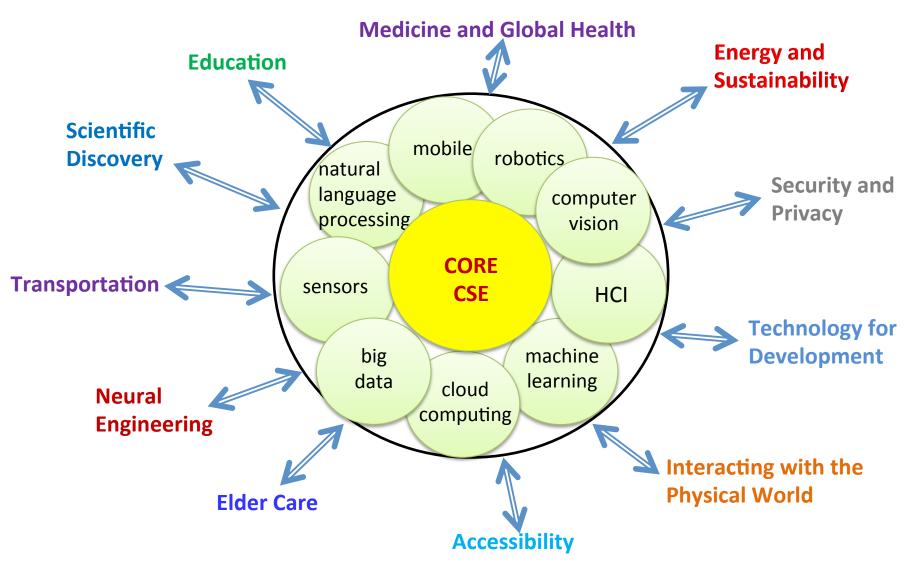
CORE

Security and Privacy

Technology for Development

Interacting with the Physical World

Accessibility



A perspective on diversity of thought



Is this stuff computer science?

Medicine and Global Health

Education Energy and Sustainability

Scientific Discovery

Security and Privacy

Transportation

Technology for **Development**

Neural Engineering

Elder Care

Interacting with the Physical World

Accessibility

sit."

"The last electrical engineer"

"I am worried about the future of our profession. ... I see the world as an inverted pyramid. It balances precariously on the narrow point at the bottom. ... This point is being impressed into

the ground by the heavy weight at the wide top of the inverted pyramid where all the applications reside. ... Electrical engineering will be in danger of shrinking into a neutron star of infinite weight and importance, but invisible to the known universe. ... Somewhere in the basement of Intel or its successor ... the last electrical engineer will

Bob Lucky *IEEE Spectrum*May 1998

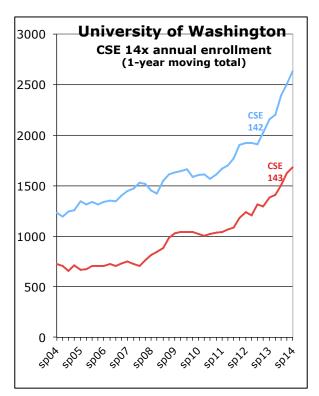


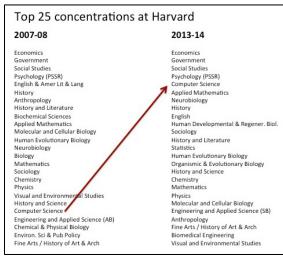
Computer Science: The ever-expanding sphere

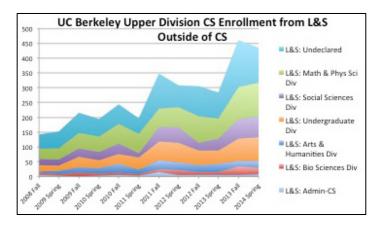


Students are figuring this out!

- Demand is booming at colleges and universities nationwide
 - For introductory courses
 - For the major
 - For upper-division and graduate courses by non-majors





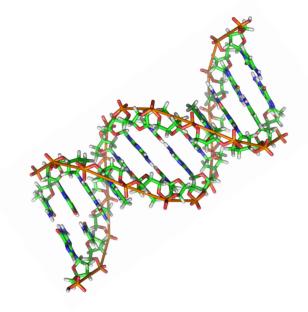


 Students are realizing that every 21st century citizen needs to have facility with "computational thinking" – problem analysis and decomposition (stepwise refinement), abstraction, algorithmic thinking, algorithmic expression, stepwise fault isolation (debugging), modeling

Computational thinking is not "this particular operating system" or "that particular programming language."

Computational thinking is not even
 programming. It's a mode of thought – a way
 of approaching the world.

 Programming is the hands-on, inquiry-based way that we teach computational thinking and the principles of computer science. Students are realizing that computer science is great preparation for anything! Fields from Anthropology to Zoology are becoming information fields, and that those who can bend the power of the computer to their will – computational thinking, but also computer science in greater depth – will be positioned for greater success than those who can't

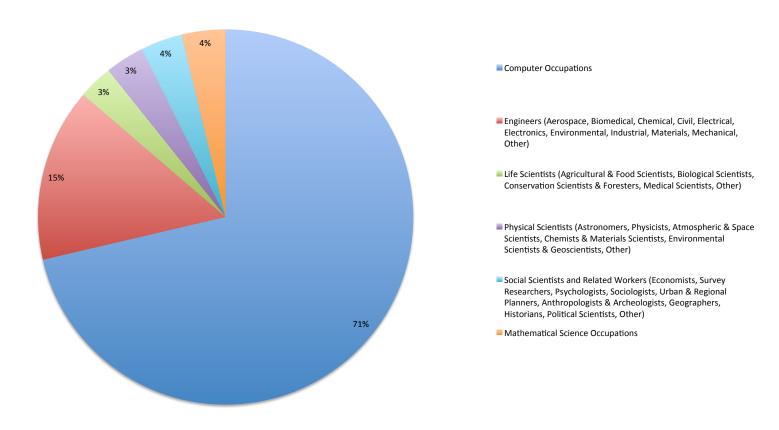


 Students are realizing that computer science is not Dilbert – it's an intellectually exciting, highly creative and interactive, "power to change the world" field

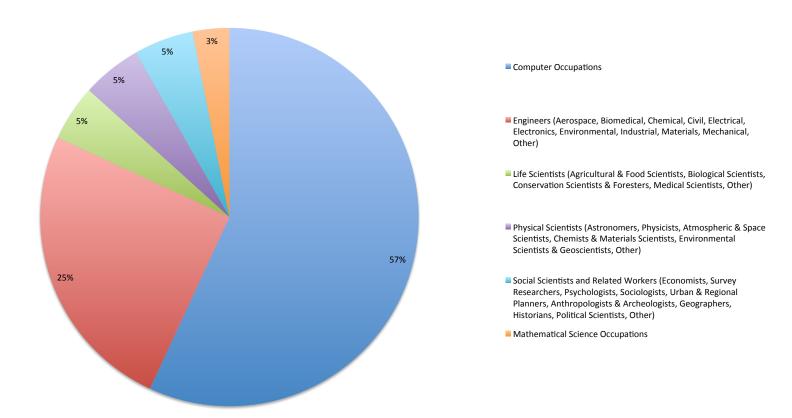


- Students are realizing that nearly all STEM jobs are in computer science
 - While fluency with computational thinking and with computer science are important to all fields, the job prospects in the field of computer science itself are extraordinary
 - The U.S. Bureau of Labor Statistics recently released its job projections for the decade 2012-2022. Computer occupations will be responsible for 71% of all the job growth in all fields of STEM (Science, Technology, Engineering, and Mathematics) – the many dozens of fields that comprise the life sciences, the physical sciences, the social sciences, engineering, and the mathematical sciences – and for 57% of all available jobs, whether newly-created or available due to replacement
 - In Washington State, the workforce gap in computer science is greater than the workforce gap in *all other fields* (not just STEM fields!) combined

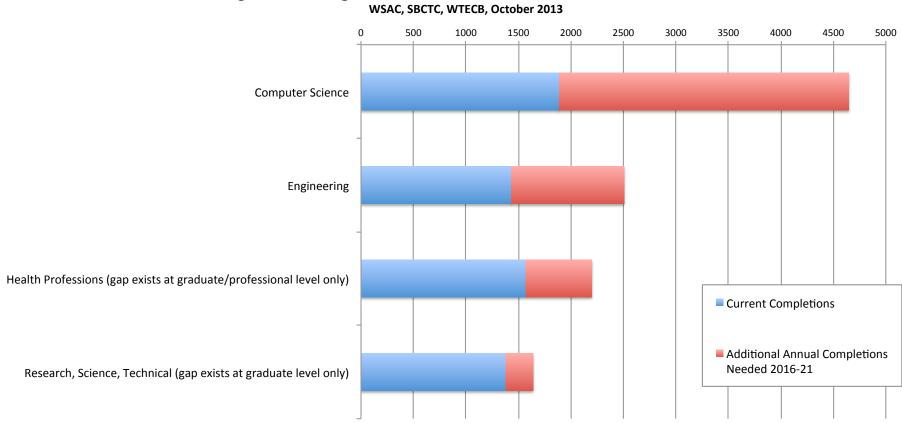
Job Growth, 2012-22 - U.S. Bureau of Labor Statistics Computer Occupations = 71% of all STEM



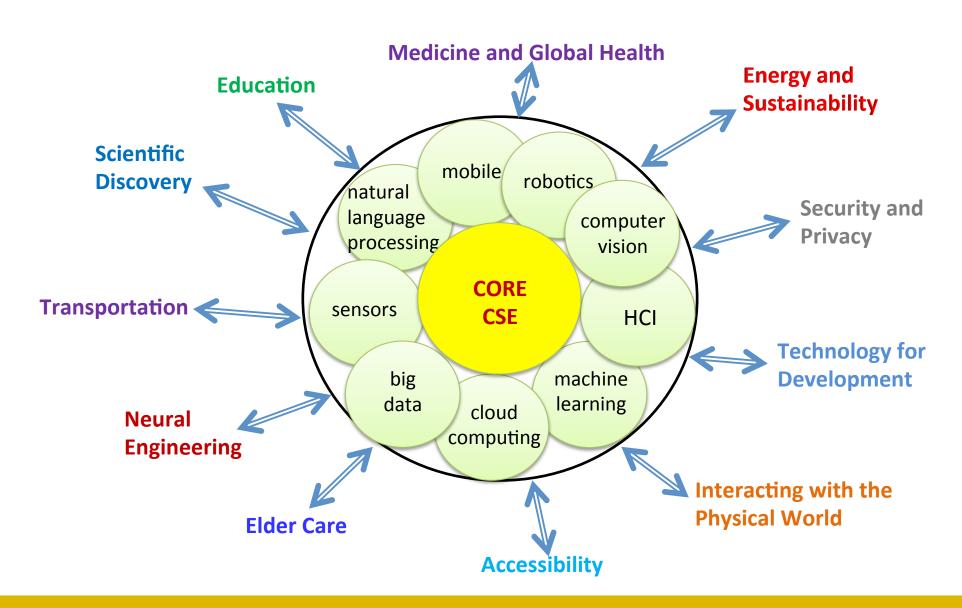
Job Openings (Growth And Replacement), 2012-22 - U.S. Bureau of Labor Statistics Computer Occupations = 57% of all STEM



Washington State High Demand Fields at Baccalaureate Level and Above



A map of UW CSE faculty hires in the past decade





Magda Balazinska – Data Management, Big Data Analytics

Luis Ceze – Computer Architecture

Alvin Cheung – Data Management, Programming Languages, Systems

Mike Ernst – Software Engineering

Shayan Oveis Gharan – Theory of Computation

Shyam Gollakota – Networking, Wireless Systems

Arvind Krishnamurthy – Systems, Networking

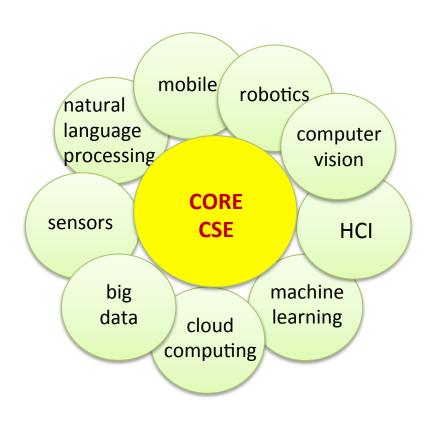
James Lee – Theory of Computation

Anup Rao – Theory of Computation

Zach Tatlock – Programming Languages, Software Engineering

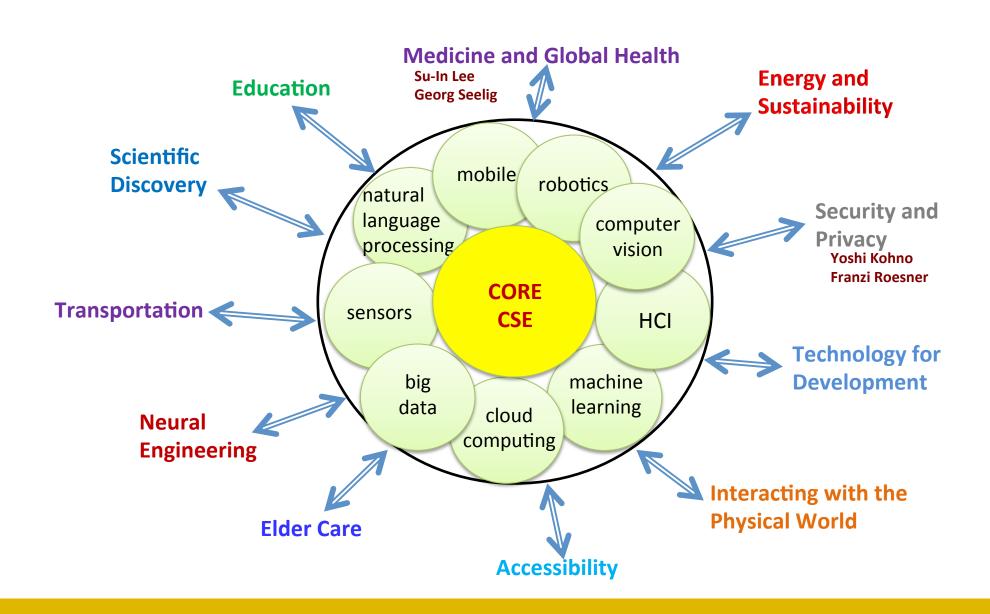
Emina Torlak – Programming Languages, Software Engineering

Xi Wang – Systems, Programming Languages, Security

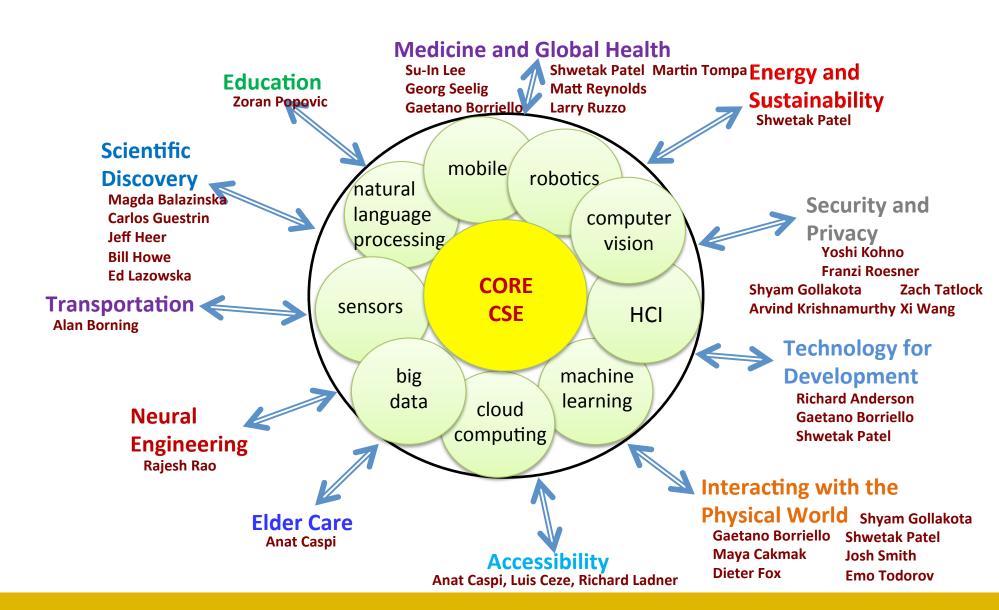


Maya Cakmak - Robotics Yejin Choi – Natural Language **Processing** Ali Farhadi - Computer Vision, Machine Learnin James Fogarty - HCI Carlos Guestrin - Machine Learning Jeff Heer – Visualization, HCI Ira Kemelmacher-Schlizerman -**Computer Vision** Yoky Matsuoka - Neurobotics, Sensing Shwetak Patel - Sensing Matt Reynolds - Sensing Josh Smith - Sensing Noah Smith - Natural Language **Processing Ben Taskar** – Machine Learning **Emo Todorov** – Robotics Luke Zettlemoyer - Natural Language Processing, Machine

Learning



UW CSE faculty in "grand challenge" areas



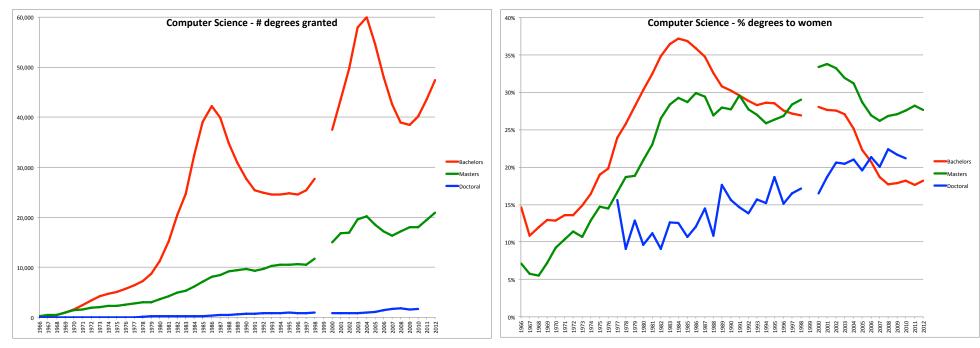
UW CSE faculty in "grand challenge" areas **Medicine and Global Health Shwetak Patel Martin Tom** Su-In Lee **Education Georg Seelig Matt Reynolds Zoran Popovic Gaetano Borriello Larry Ruzzo** Scientific mobile **Discovery** roboti natural Magda Balazinska Security and language mputer **Carlos Guestrin Privacy** Jeff Heer processing vision Yoshi Kohno **Bill Howe** Franzi Roesner **Ed Lazowska Shyam Gollakota Zach Tatlock Transportation Arvind Krishnamurthy Xi Wang** HCI **Alan Borning Technology for** machine Development **Richard Anderson** data learning cloud **Gaetano Borriello** computing **Shwetak Patel** Interacting with the **Physical World Shyam Gollakota Elder Care** Gaetano Borriello Shwetak Patel **Anat Caspi Maya Cakmak Josh Smith** Accessibility **Dieter Fox Emo Todorov** Anat Caspi, Luis Ceze, Richard Ladner

A perspective on diversity of demographics



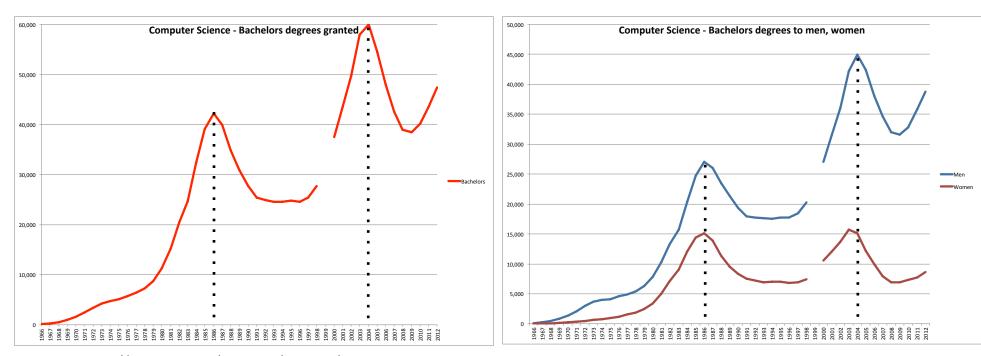
First, the data ...

• Computer science degrees granted; % to women



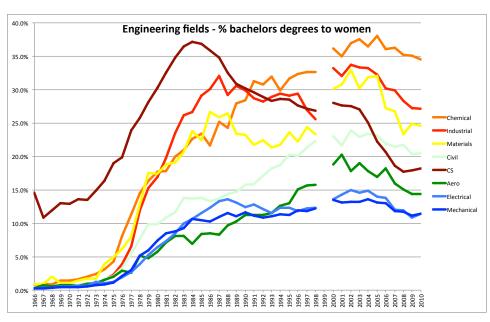
Data from http://www.nsf.gov/statistics/seind14/ + NCES 2012 and 2013 digest tables

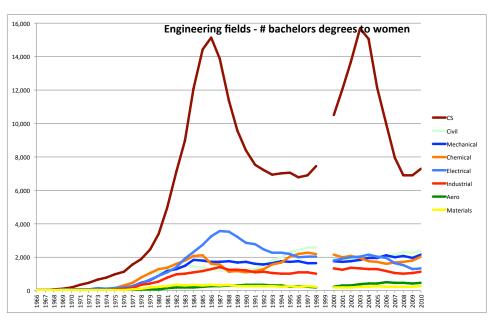
A closer examination of Bachelors degree trends



Data from http://www.nsf.gov/statistics/seind14/ + NCES 2012 and 2013 digest tables

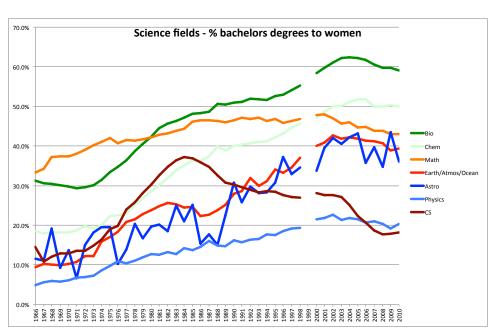
Compared to engineering fields

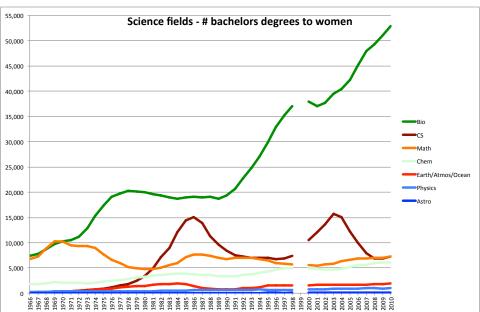




Data from http://www.nsf.gov/statistics/seind14/

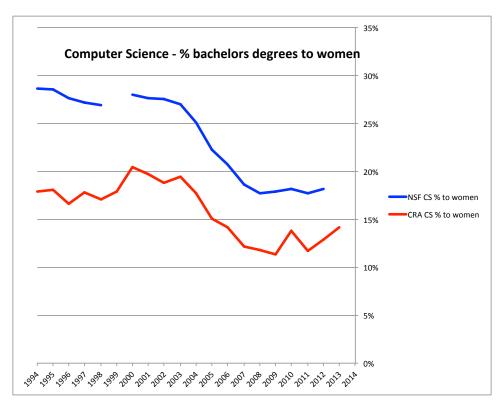
Compared to science fields





Data from http://www.nsf.gov/statistics/seind14/

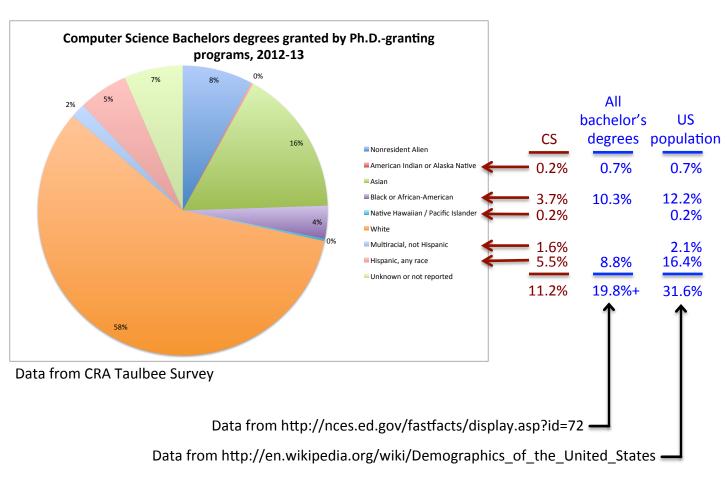
Research-intensive universities vs. all institutions



Data from http://www.nsf.gov/statistics/seind14/ and CRA Taulbee Survey

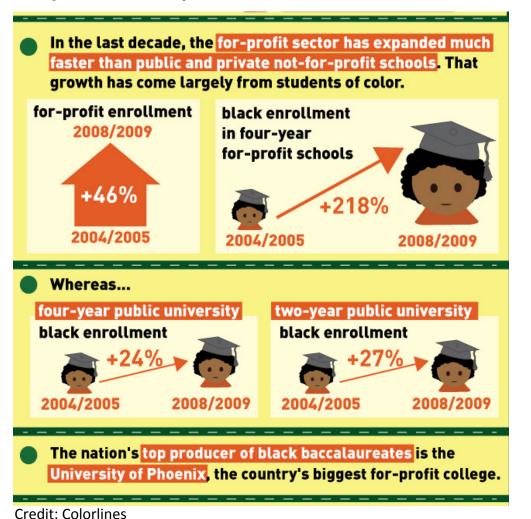
[Caveat: There are various flaws in this comparison due to data issues. The disparity exists, but is not as large as indicated]

Race and ethnicity



[Not fair comparisons for numerous reasons]

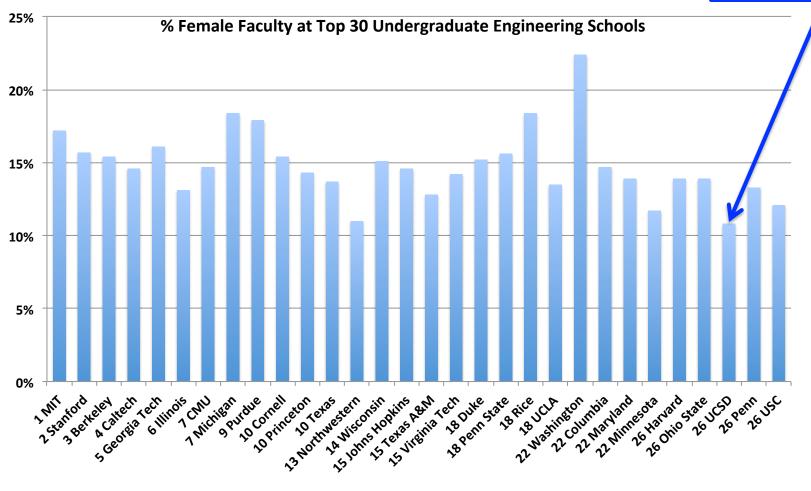
Beyond Computer Science



- In 1972, for-profit institutions accounted for only 18 percent of Bachelors degrees awarded to black students. By 2010 they accounted for 44 percent.
- A recent survey by economist
 Rajeev Darolia shows that forprofit graduates fare little
 better on the job market than
 job seekers with high school
 degrees. Their diplomas are a
 net loss, offering essentially the
 same grim job prospects as if
 they had never gone to college
 plus a huge debt load.

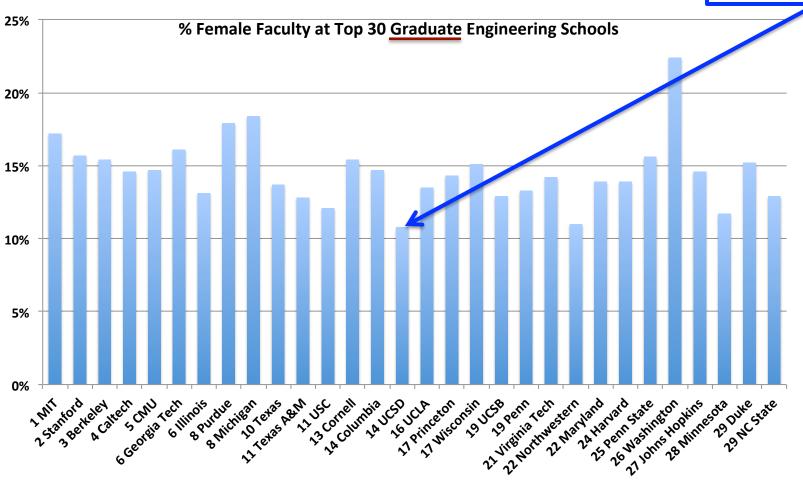
Beyond student demographics





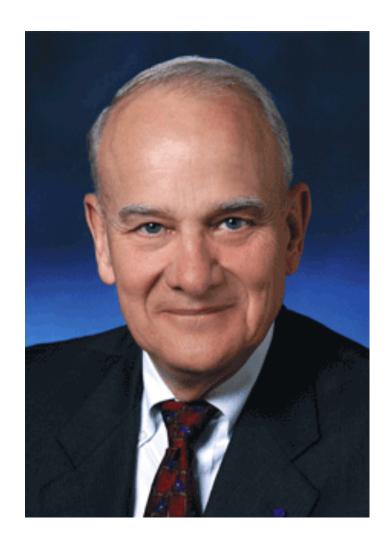
UCSanDiego

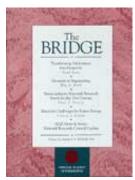
Jacobs School of Engineering



Next, the rationale ...

Channeling Bill Wulf





• For reasons of workforce?





W UNIVERSITY of WASHINGTON







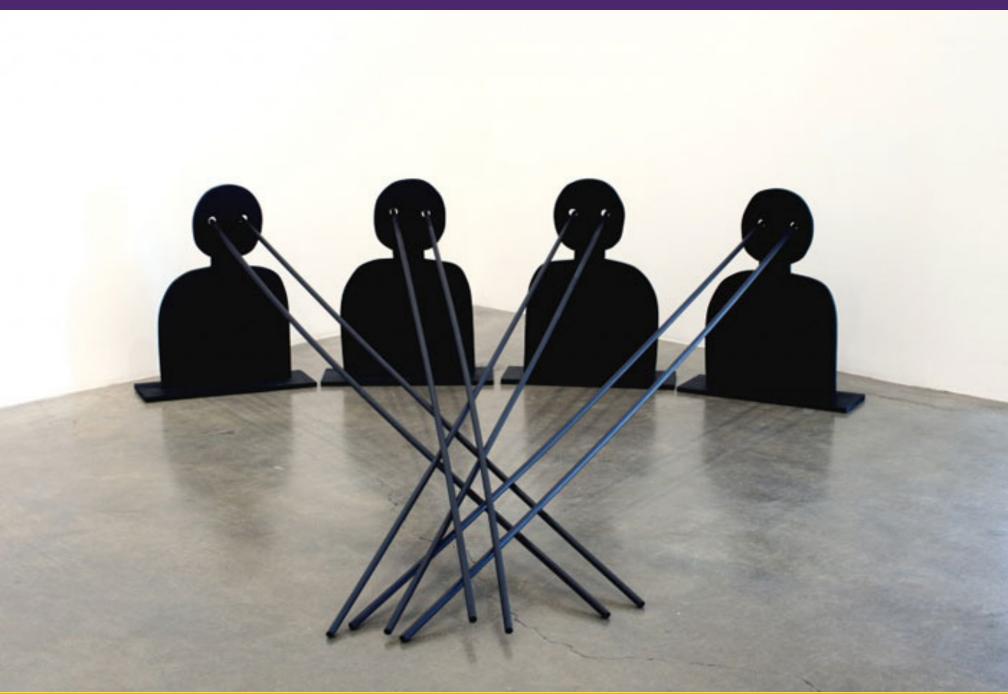


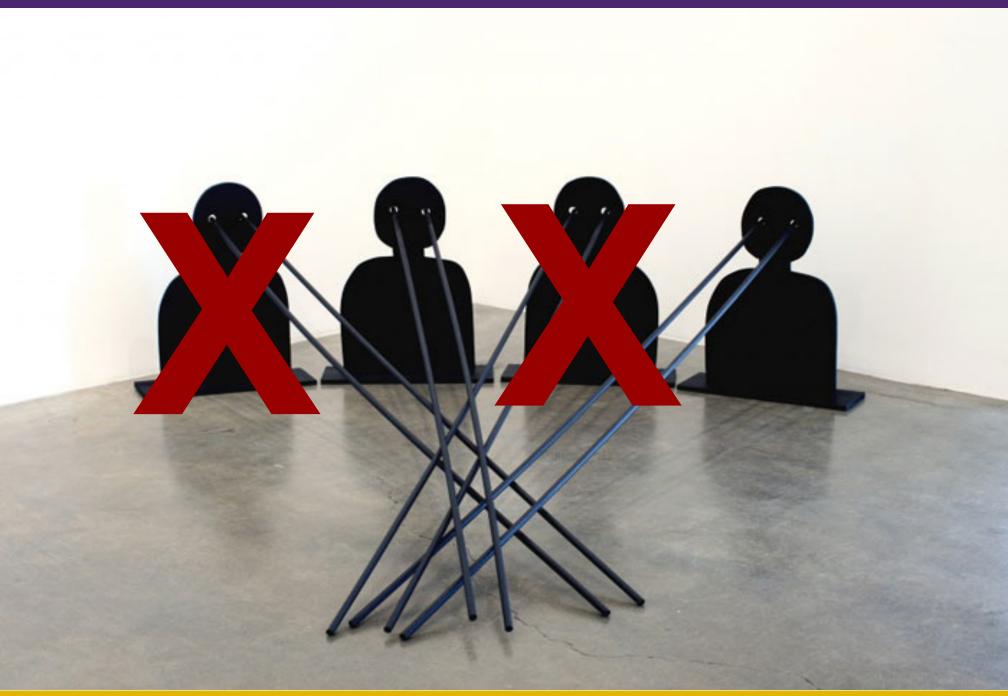
For reasons of greed!











"Every time we approach an engineering problem with a pale, male design team, we may not find the best solution. We may not understand the design options or know how to evaluate the constraints. We may not even understand the full dimension of the problem."

Bill Wulf The Bridge Winter 1998

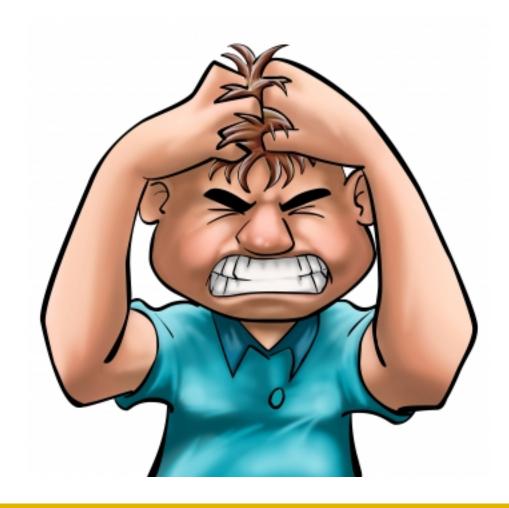
In other words: A more diverse team will yield a higher quality result

"We didn't realize how great baseball could be, until we allowed everybody to play."

Rev. Jesse Jackson December 2014

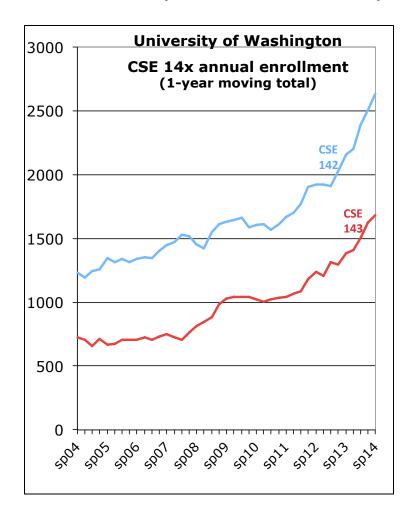


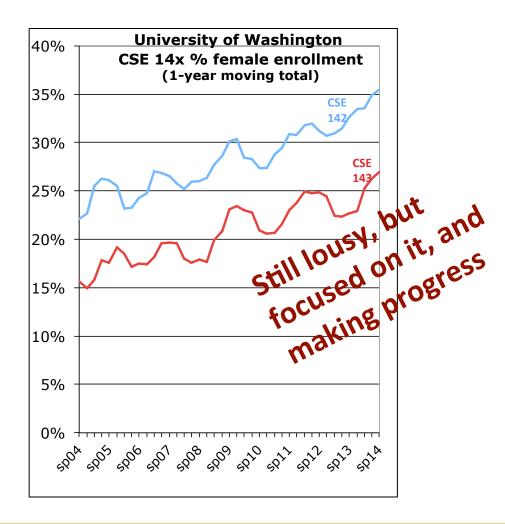
So let's admit that we have a problem – all of us – and explore whether and how we might be able to do something about it



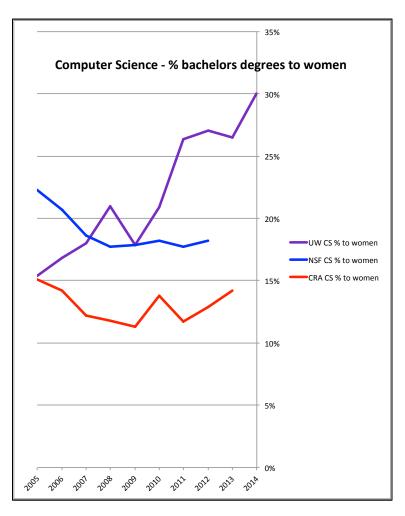
Whether we might be able to do something about it

Introductory course diversity



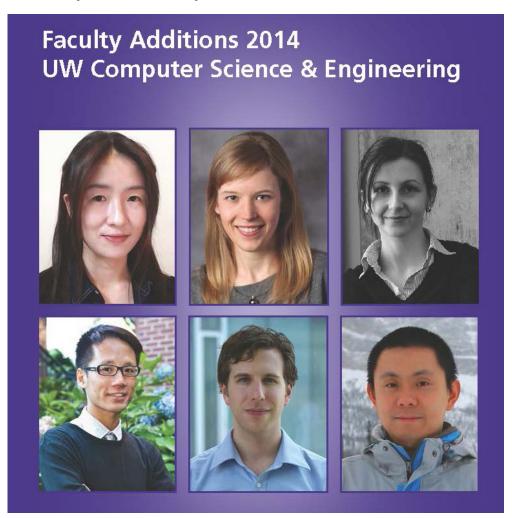


Undergraduate major diversity



Still lousy, but and focused on it, and making progress making progress

Faculty diversity



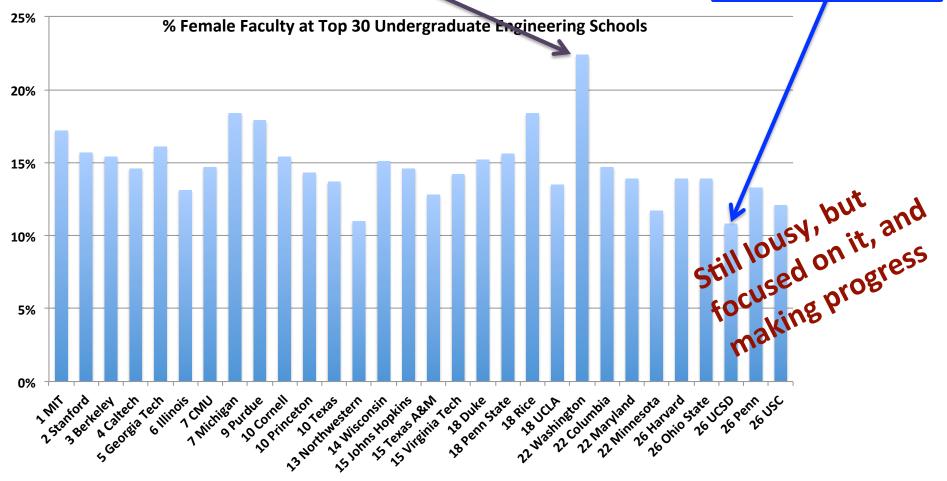
Still lousy, but and focused on it, and making progress making progress





Faculty diversity

C San Diego Jacobs School of Engineering



How we might be able to do something about it

There is no silver bullet!



- You need to commit to it and focus on it!
- There needs to be leadership, and constant attention
- There needs to be broad buy-in (although it will never be universal)
- You need to define metrics and track them carefully if it ain't measured, it ain't gonna happen

K-12 pipeline

For students

- Weeklong summer day camps for girls
- Programming competitions
- AP CS workshop and review day
- Saturday afternoon Computing Open House (kicking off CS Ed Week)
- NCWIT Awards for Aspirations in Computing
- Summer Academy for Advancing Deaf and Hard of Hearing in Computing
- Rainier Scholars
- Many school visits in both directions
- Code.org

For teachers

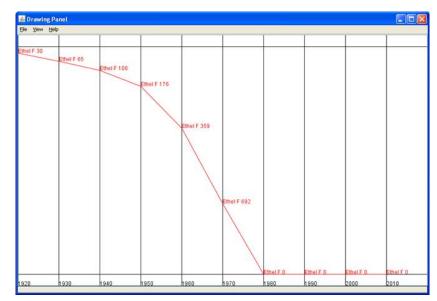
- Puget Sound CSTA
- CS4HS summer CS workshop for teachers of science and math
- "Inspirational Teachers" dinner
- Summer CSE 142 (and use of materials)



Check out our DawgBytes ("a taste of UW CSE") web page

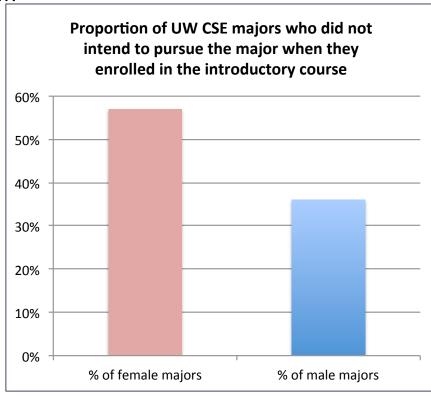
Pre-major pipeline

- A hugely welcoming "one size fits all" introductory course
 - Designed to encourage everyone to succeed
 - Assignments illustrate a broad range of applications, and are nifty enough to share with family and friends (baby names over time, anagram solver, etc.)
 - Weekly supplementary <u>"Exploration</u>
 <u>Sessions"</u> featuring faculty research disproportionately attended by women
 - 100% undergraduate TAs –
 disproportionately women with a phenomenal sense of community





- Associated women-focused events (women's tea, company tours, alumni panels)
- Associated honors section
- Active encouragement of women and members of other underrepresented groups by the teaching staff
- The "attraction waters" of a great introductory course are especially important to members of underrepresented groups!
 - If introductory courses go "weedout" to control the size of the major in the face of skyrocketing demand, it is absolutely clear who will be weeded out!



Undergraduate majors

- A highly committed, highly supportive, adequately sized undergraduate advising staff
- Constant attentiveness making it clear that creating a welcoming environment and a level playing field is a top priority for us
 - Lunch with the Chair
 - Gatherings before (with female alums) and after (department-wide)
 the Grace Hopper Conference
 - Staying in touch with the "vibe" of the undergraduate student body
- Heavy focus on building a strong culture and sense of community
 - In recent weeks, our student Facebook page was on fire following news reports of Satya Nadella at GHC, the Barbie book, and Zillow's Irvine CA office – with men speaking up as much as women

- ACM-W
- Grace Hopper Conference
- Many prep events for internship and job interviews, to build confidence
 - Resume workshops
 - Resume reviews
 - Mock interviews
 - Annual "What I learned on the job that I wish I had learned in school" seminar course
- Tremendous support from Amazon, Facebook, Google, Microsoft
- Outreach and encouragement by faculty
- Celebration of successes

Grad students, postdocs, and faculty

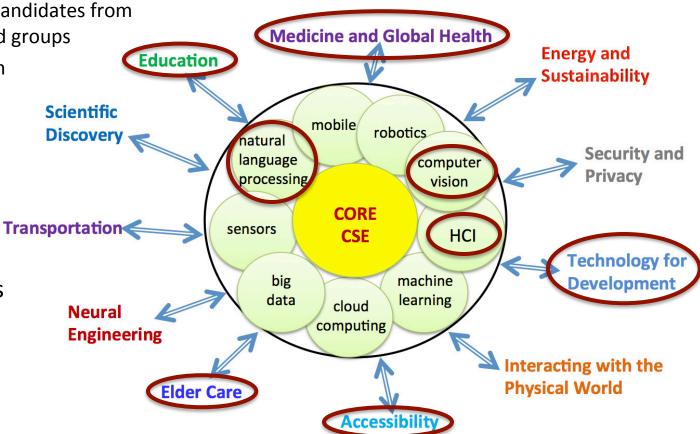
- Broadening our view of the field
- Keen attentiveness in recruiting
 - A single faculty search committee

 Active search for candidates from under-represented groups

 A heavy hand from the department chair

Practically every hire involves a spousal accommodation

 Constant emphasis that "excellence" has many dimensions



Some readings/resources

- <u>Unlocking the Clubhouse: Women in Computing</u>, Jane Margolis and Allan Fisher (2003)
- "Barriers to Equality in Academia: Women in Computer Science at MIT" (1983)
- "A Study on the Status of Women Faculty in Science at MIT" (1999)
- "Broadening Participation: The Why and the How" (Computer, March 2013)
- Various NCWIT resources
- NSF CISE/EHR STEM-C program (for activities directed at K-12)
- NSF ADVANCE program (for activities directed at faculty)

Thank you!

http://lazowska.cs.washington.edu/UCSD.pdf,pptx