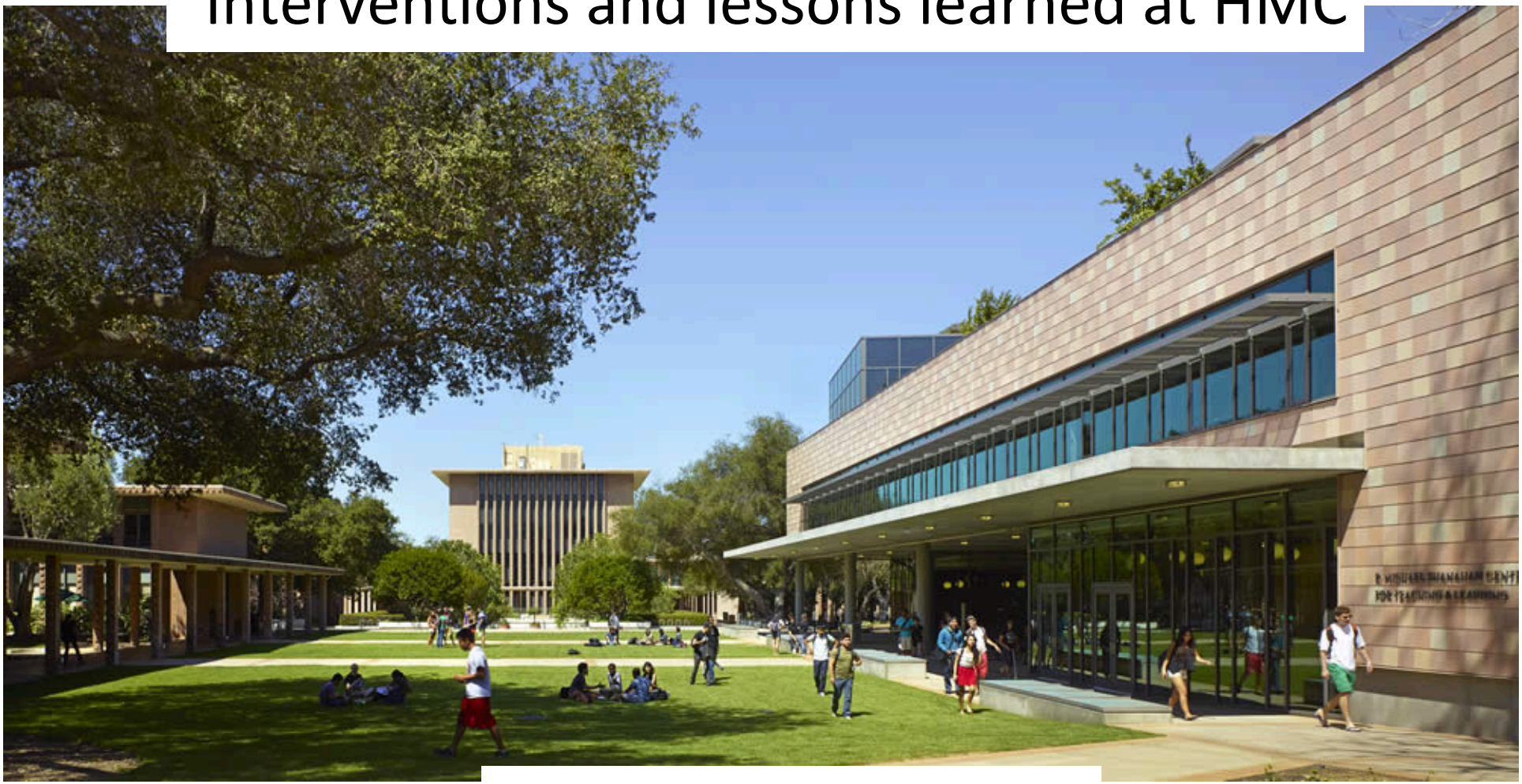
CS for All

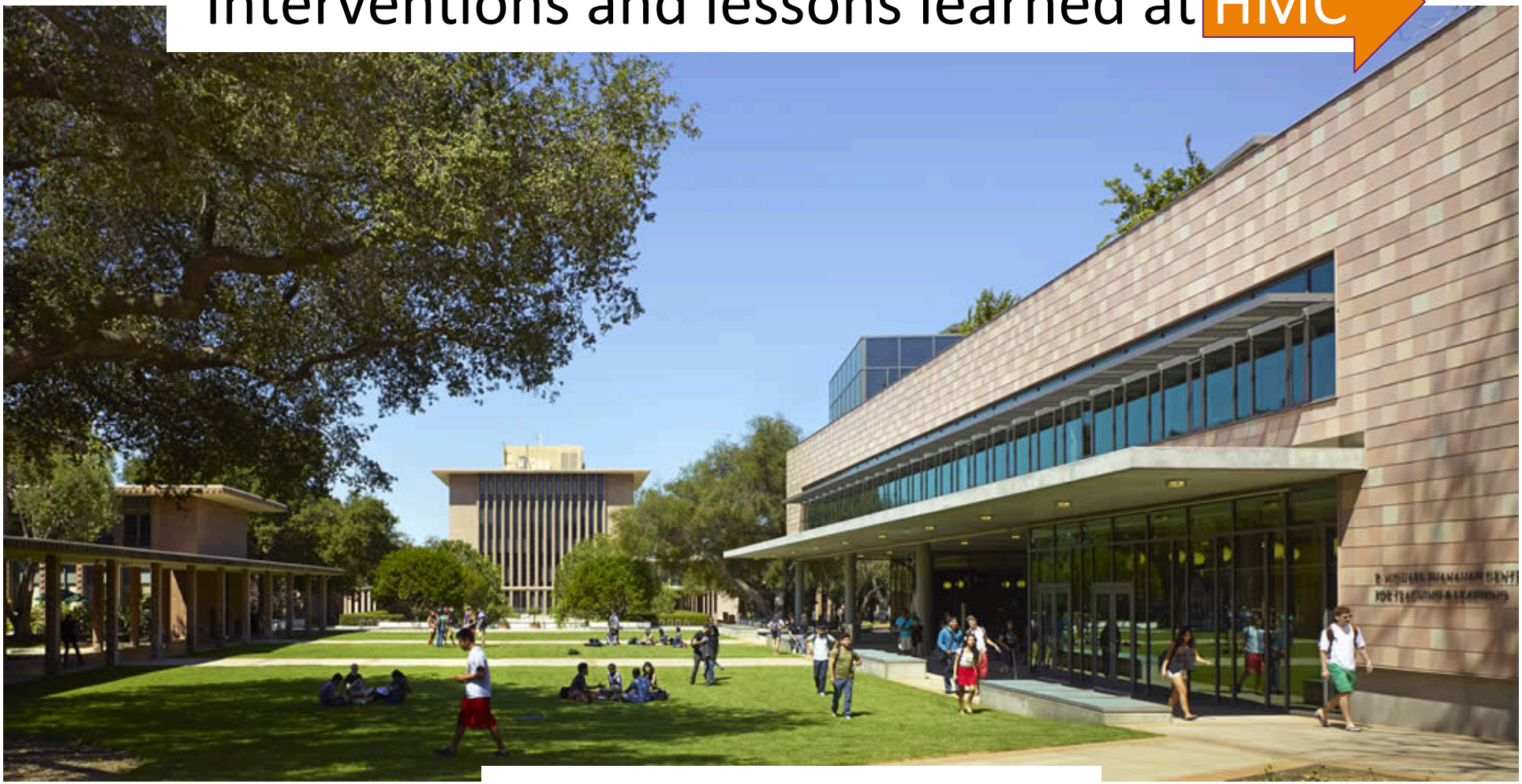
Interventions and lessons learned at HMC



Zachary Dodds, Harvey Mudd College

CS for All

Interventions and lessons learned at HMC

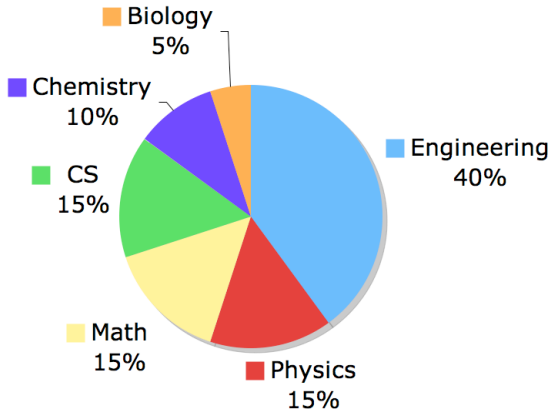


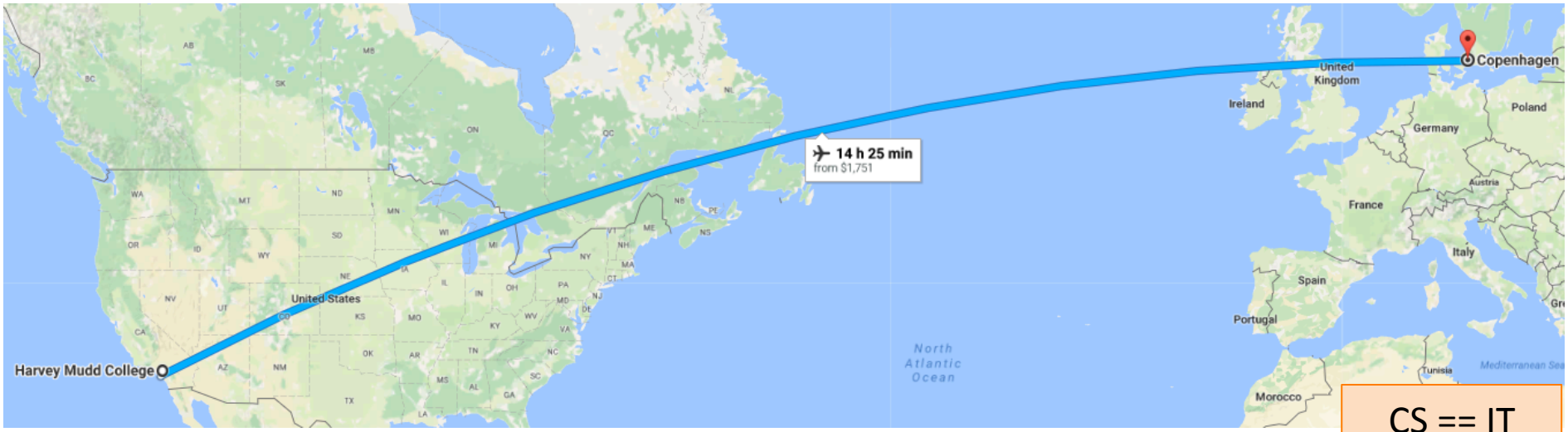
Zachary Dodds, Harvey Mudd College

HMC ~ Harvey Mudd College

southern california
engineering + technical
school of 850 students

ages 18-23, full-time
(mostly)

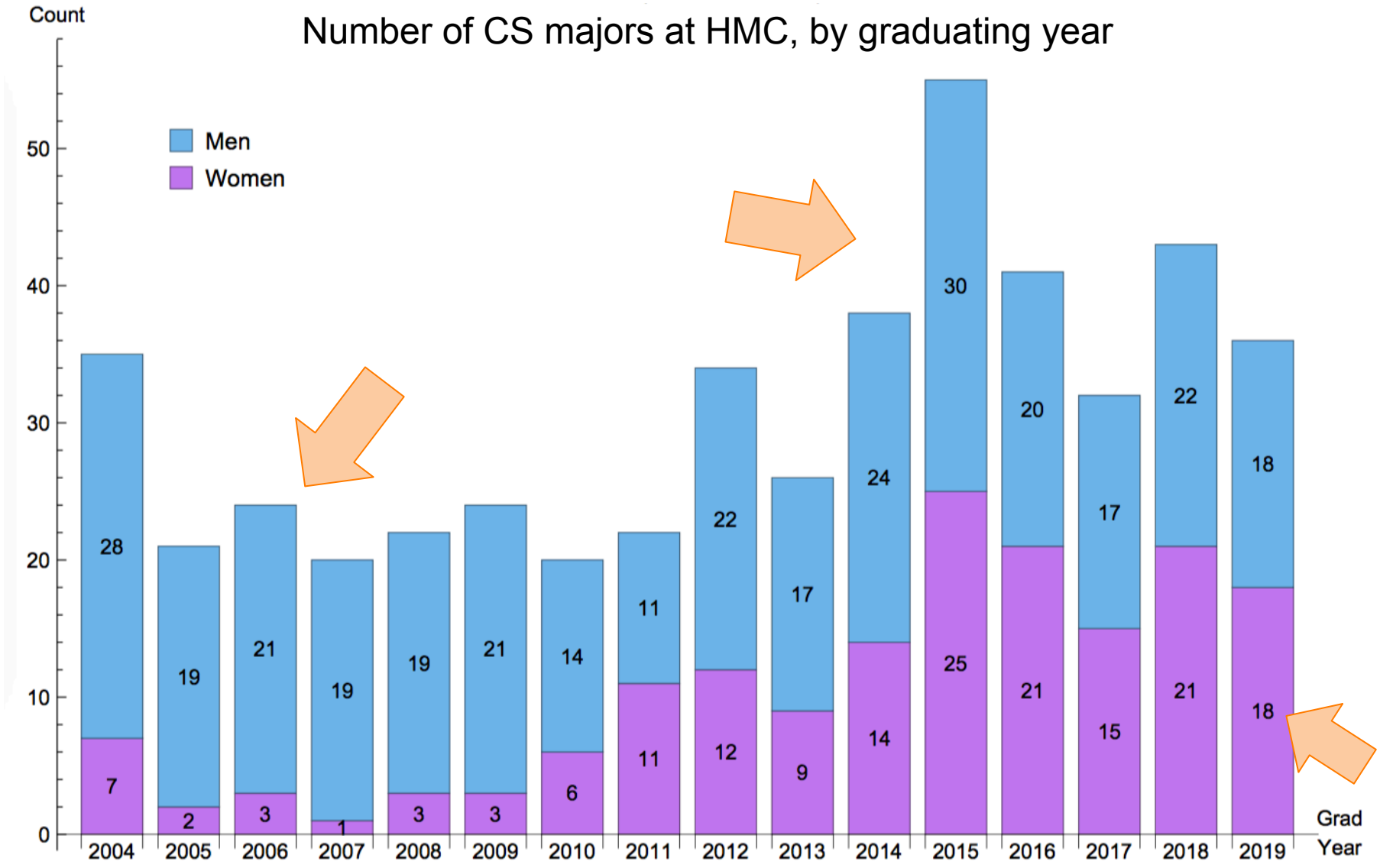




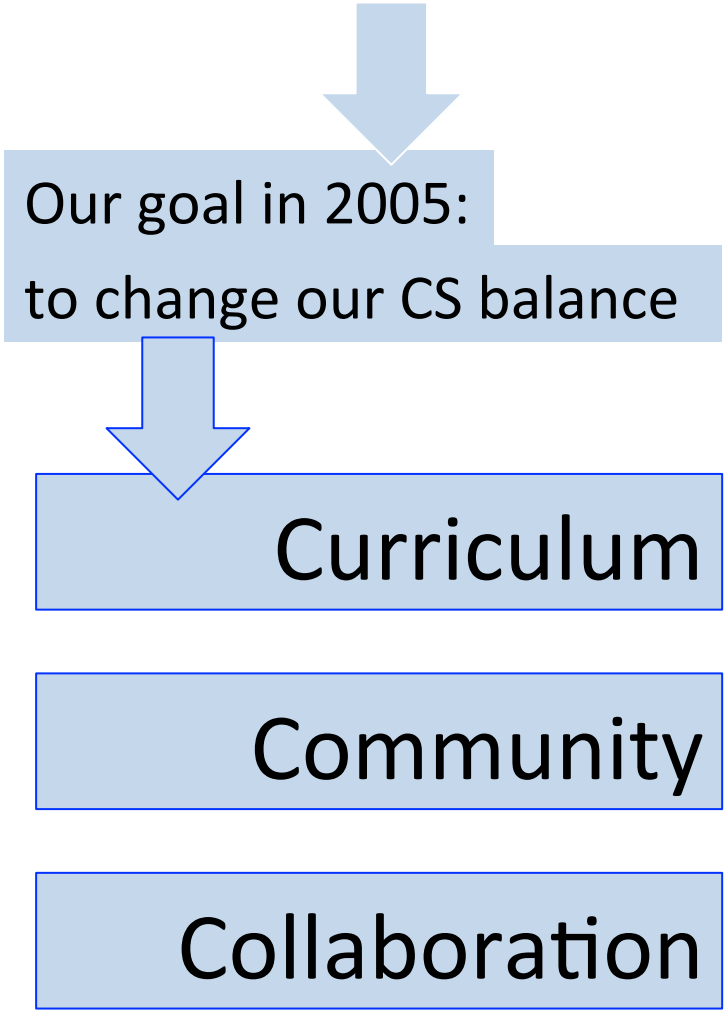
CS == IT

IT University of Copenhagen May 29, 2017 Gender Diversity in IT

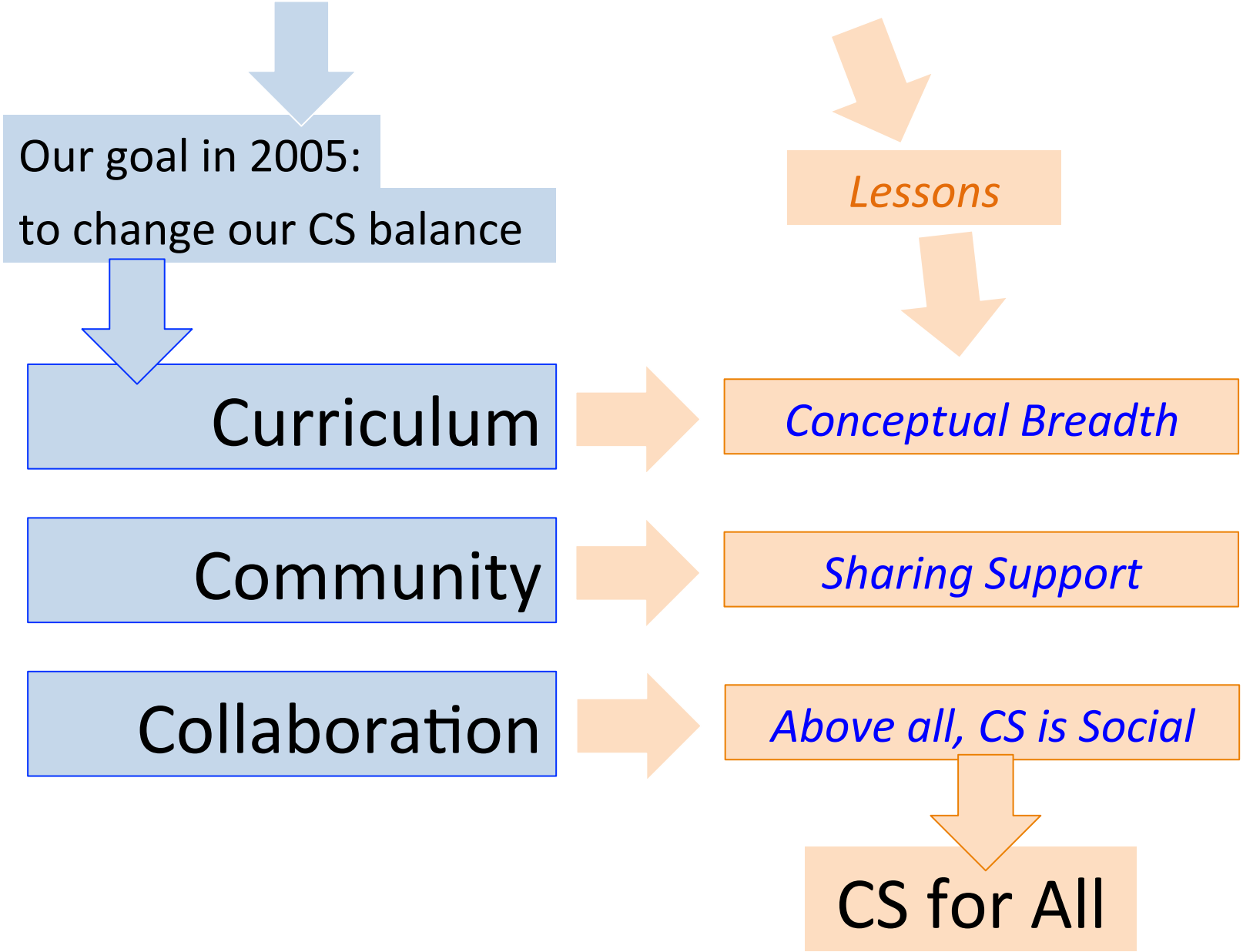
Mudd's story


Count
Number of CS majors at HMC, by graduating year
Men
Women
50
40
30
20
10
0
28
7
19
2
21
3
19
1
19
3
21
3
14
6
11
11
22
12
17
9
24
14
30
25
20
21
17
15
22
21
18
18
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
Grad Year

Several deliberate accidents…



Several deliberate accidents…



Curriculum

We deliberately changed one course: CS1

what is learned = $\sqrt{\text{what is taught}}$

Java course

Programming as a professional skill

Meant to bring students one semester closer to creating software for other people to use

but use *for what*?

2005

Python course

with detours into *all* corners of CS

Means to show students that CS amplifies the paths and projects they choose

Whatever you are, be a good one. CS can help!

2006

Every student takes CS1 in their first semester

Curriculum

what is learned = $\sqrt{\text{what is taught}}$

Java course

Programming as a professional skill

Meant to
one seme
creating s
other pec

lots of facts

but use *for what*?

2005

Python course

with detours into *all* corners of CS

Means
that CS a
and proj

Whateve
good one

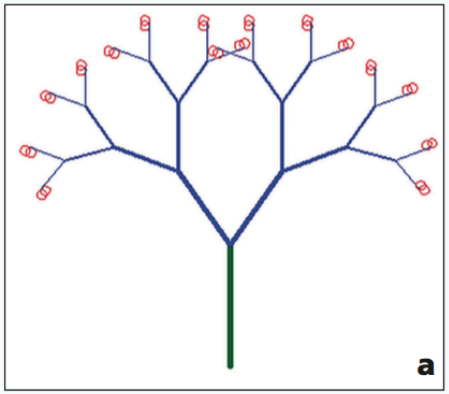
a small fraction of a *much* larger world

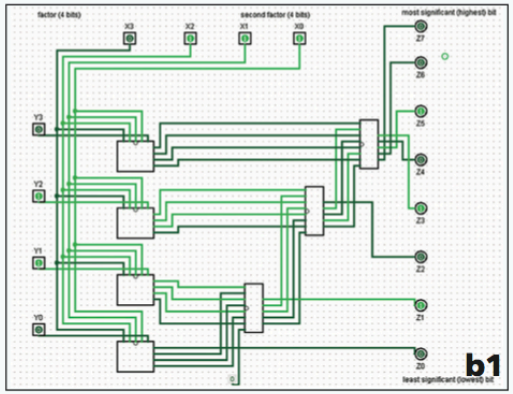
2006

Every student takes CS1 in their first semester

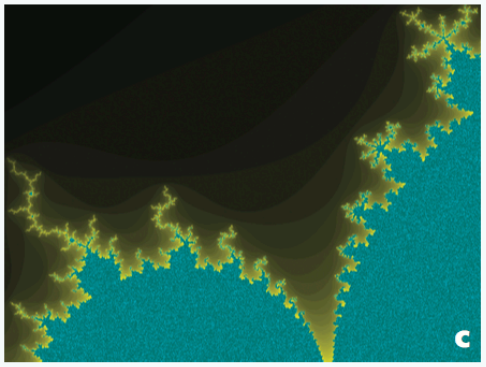
Curriculum *content*

Lesson:
Conceptual breadth over trendiness






```
Fibonacci = """
00 read r1          # input n
01 loadn r2 1       # first fibonacci #
02 loadn r3 1       # second fibonacci #
03 write r2         # print first
04 addn r1 -1       # decrease n by 1
05 write r3         # print second (larger)
06 addn r1 -1       # decrease n by 1
07 add r4 r2 r3     # next fibonacci in r4
08 mov r2 r3        # move r3 to r2
09 mov r3 r4        # move r4 to r3
10 jnez r1 05       # repeat until n = 0
11 halt
"""
```
b2




```
>>> b = Board()
>>> px = Player('X','RANDOM',2)
>>> po = Player('O','RANDOM',2)

>>> b.playGame(px,po)

(... 34 positions omitted ...)

| | |X| |O| | |
|O| |O|X|X| |X|
|O|X|X|O|X|O|O|
|X|O|O|O|X|X|O|
|X|X|X|O|O|O|X|
|X|X|O|X|O|O|X|
---------------
 0 1 2 3 4 5 6

X wins! Congratulations!
```
d

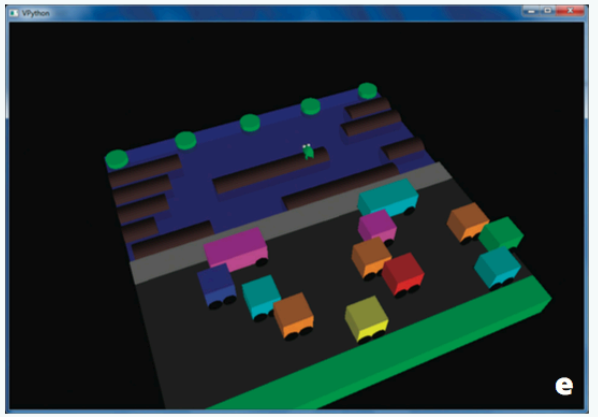
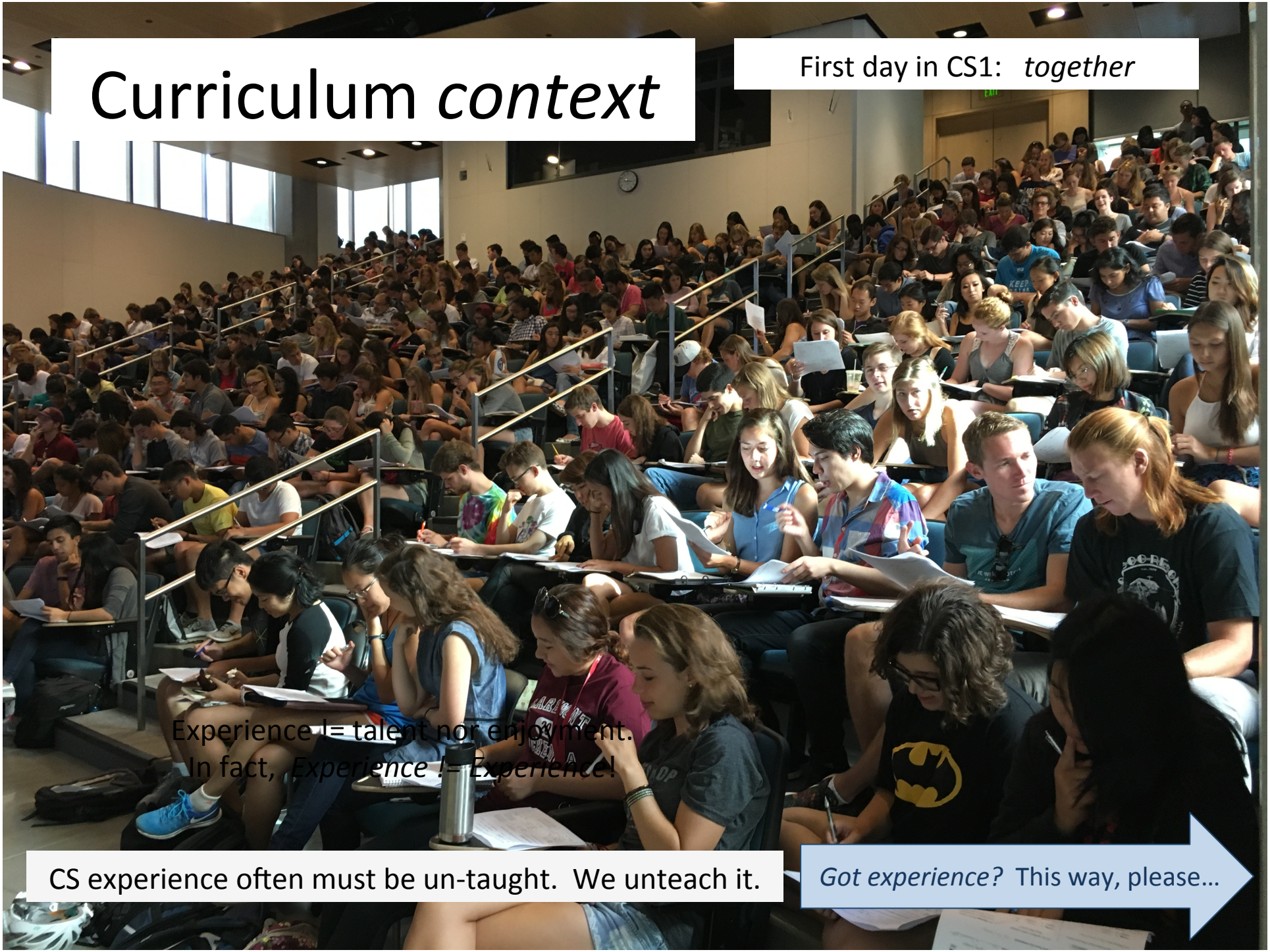


Figure 1: A gallery of student work showing the different modules in CS 1. (a) Functional Programming: Recursively generated trees using the turtle package. (b) Machine Organization: (1) A four-bit multiplier created and simulated in Logisim. (2) An assembly-language homework problem that computes the Fibonacci sequence. (c) Imperative Programming: A visualization of the Mandelbrot set, (d) Object Oriented Programming: A Connect 4 game with an AI player, (e) Final Projects: 3D games, in this case Frogger, are a popular final project option.

Fashion turns heads. Substance grows roots.

Curriculum *context*

First day in CS1: *together*



CS experience often must be un-taught. We unteach it.

Got experience? This way, please…

Curriculum *context*

Second day in CS1 *?!*

Lesson: 8:10am is ***early*** whether you're 19 or 49

Community

every Thursday evening

Are large introductory classes a problem? *Or an opportunity…*

evenings ~ grading

for students to help grade / tutor their peers

afternoons ~ tutoring

Community

Friday afternoons' open hours to work on assignments…

Lesson: define CS community contributions through self-support

Lesson: offer lots of *internal* opportunities for *outreach + shared experience*

Community

every Saturday afternoon	every Monday evening
every Sunday afternoon	every Tuesday evening
every Sunday evening	every Wednesday evening

Friday afternoons' open hours to work on assignments…

Lesson: define CS community contributions through self-support

Lesson: offer lots of *internal* opportunities for *outreach + shared experience*

Community

our CS community is only a small fraction of a *much* larger world

student trips to Grace Hopper Celebration of Women in Computing, 2006-2017

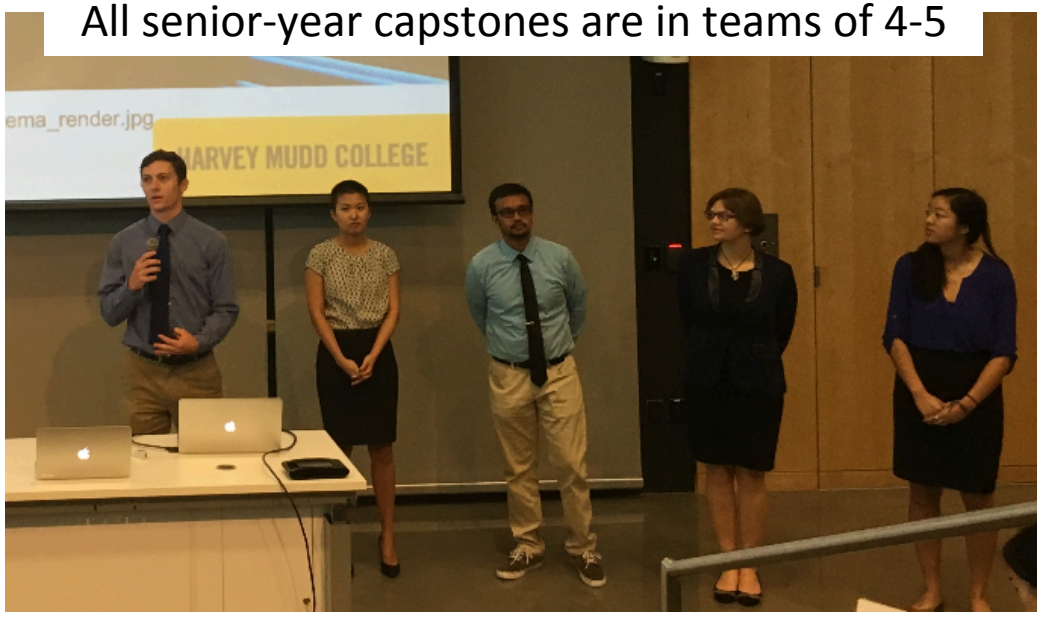
Collaborations

Pairing/teaming encouraged for all work (except some exams)

At several points, teaming is *<u>required</u>* -- and forcefully framed

Not working well in a team is *by definition* not successful

All senior-year capstones are in teams of 4-5



Lesson: CS is social.

Collaborations ~ *Summer*

Ten week research/independent-study opportunities

Approach: design, develop, prepare, travel, present *together*

Funding ~ up to 10 first-year women students, *in teams*

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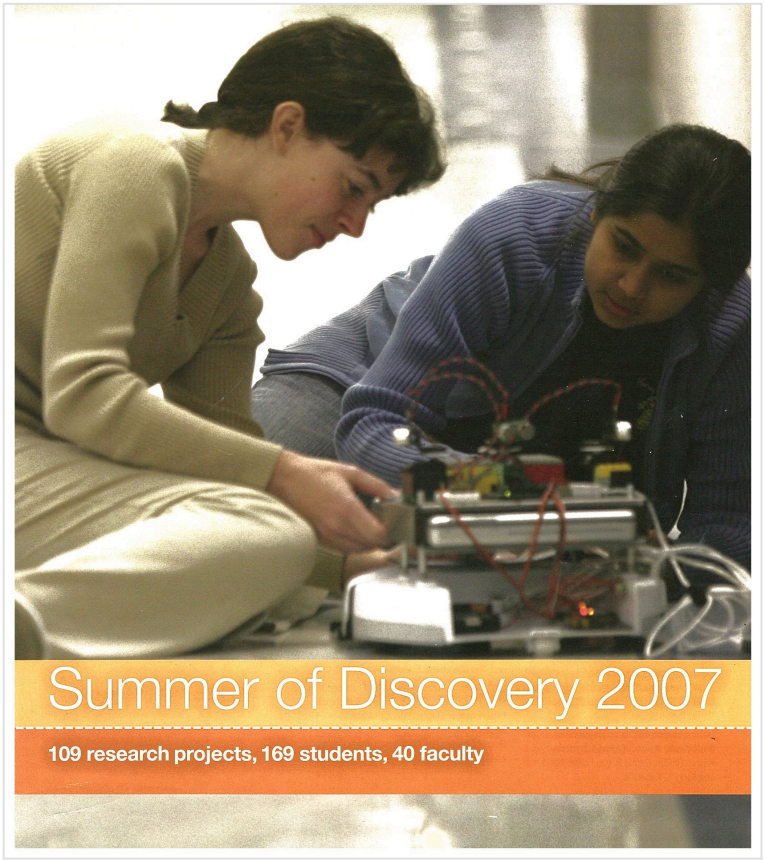
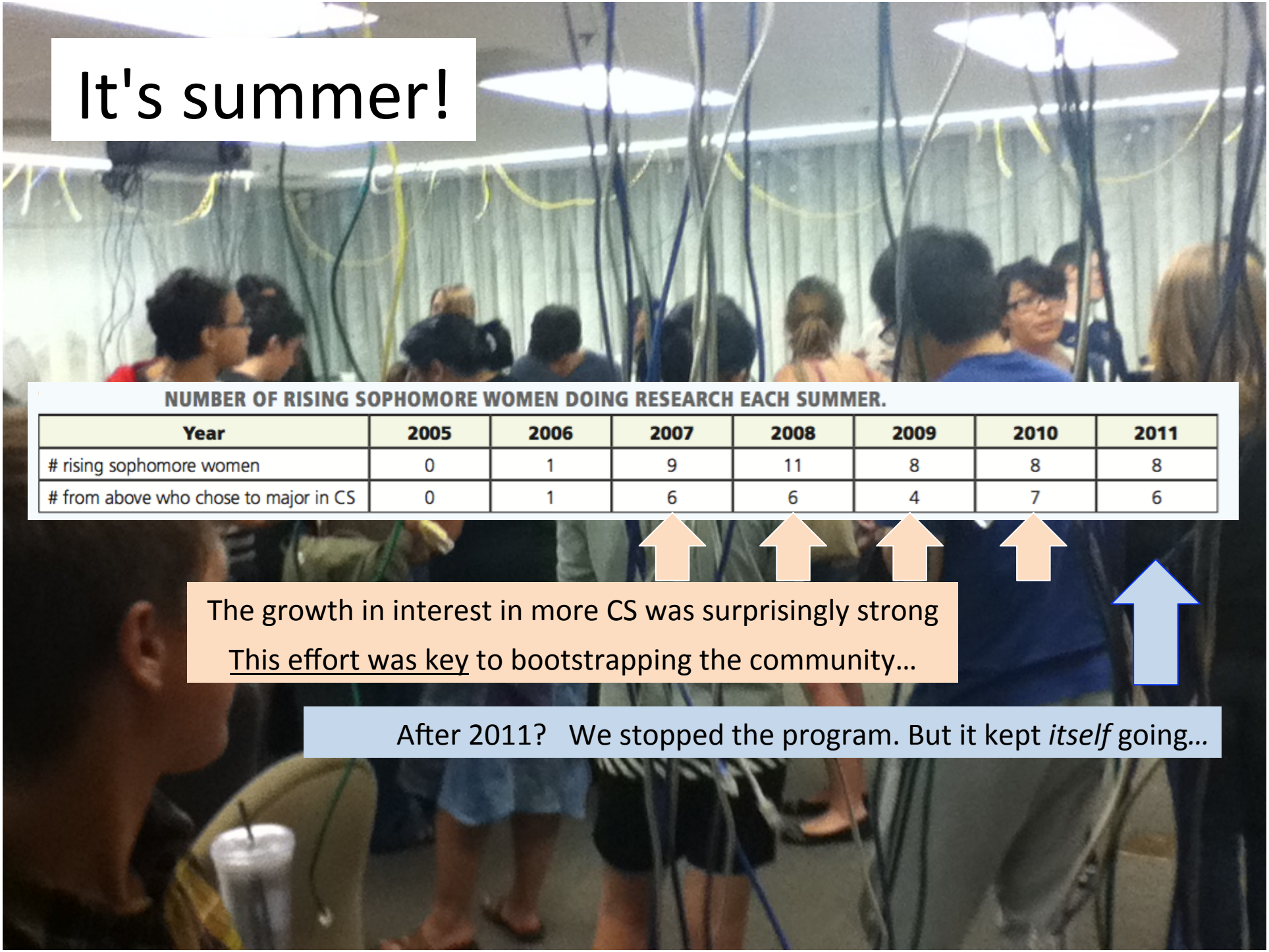



It's summer!

It's summer!



NUMBER OF RISING SOPHOMORE WOMEN DOING RESEARCH EACH SUMMER.

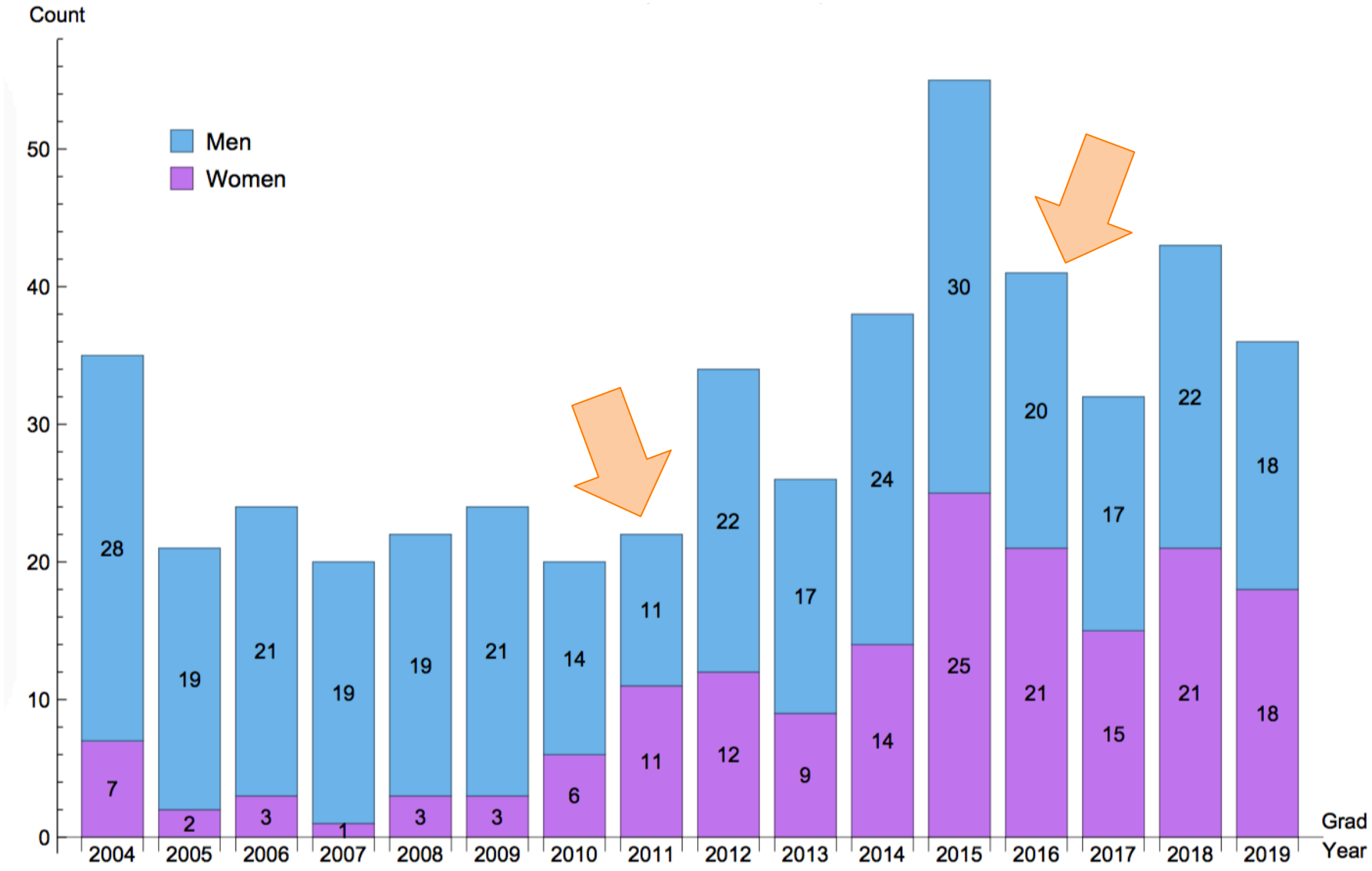
Year	2005	2006	2007	2008	2009	2010	2011
# rising sophomore women	0	1	9	11	8	8	8
# from above who chose to major in CS	0	1	6	6	4	7	6

The growth in interest in more CS was surprisingly strong

<u>This effort was key</u> to bootstrapping the community…

After 2011? We stopped the program. But it kept *itself* going…

Celebrate when you can…



Celebrate when you can…

Most computer science majors in the U.S. are men. Not so at Harvey Mudd

Education

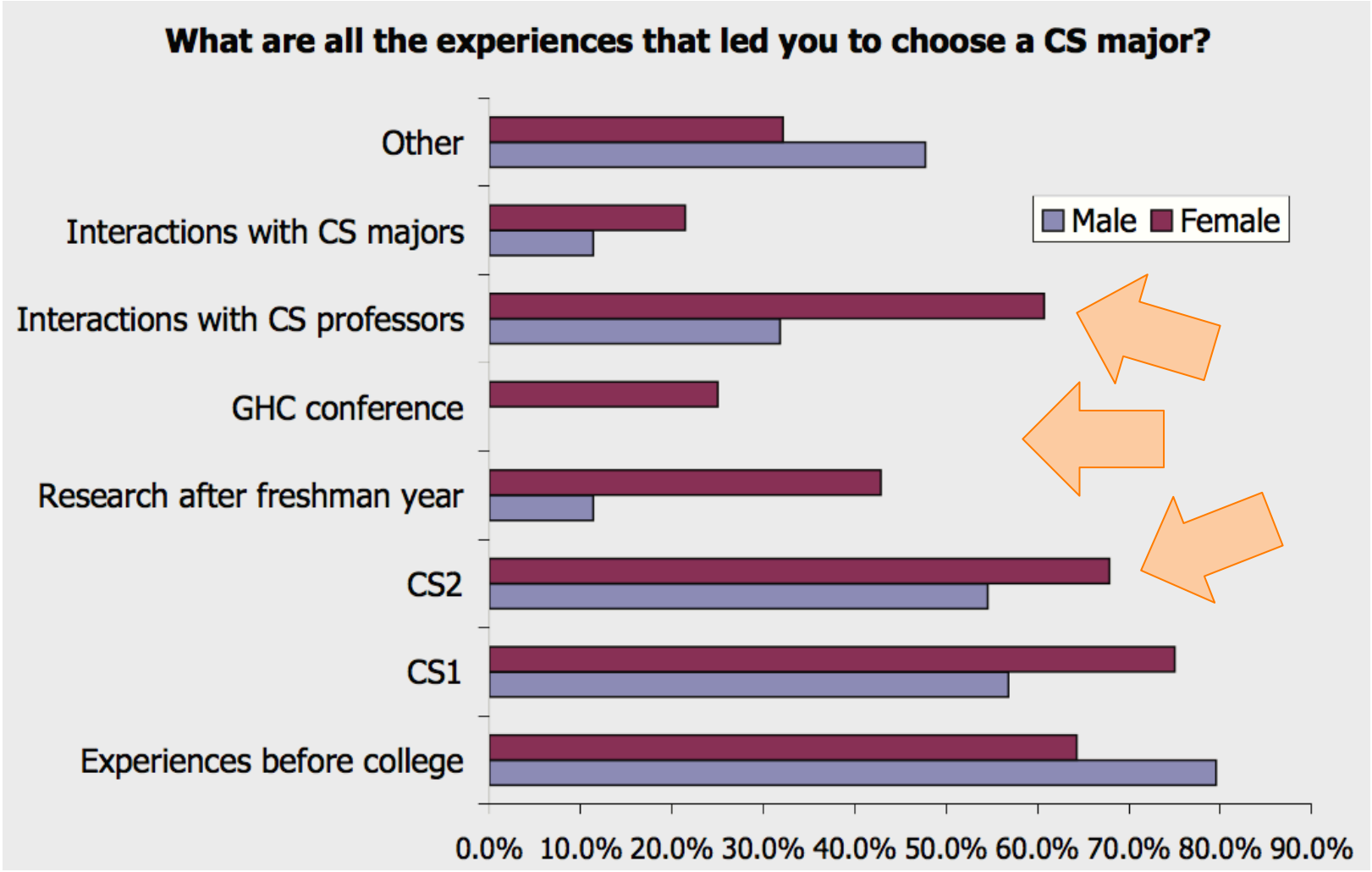
Women break barriers in engineering and computer science at some top colleges

By Nick Anderson September 16, 2016

LOCAL / L.A. Now

At Harvey Mudd more than half of of computer science graduates are women

Influences in choosing CS



n = 449 alums

What's next?

students of other fields embracing CS…

What's next?

students of other fields embracing CS…

HMC CS	Major
8	3-2 Engineering
0	Africana Studies
2	American Studies
3	Anthropology
5	Art
1	Art Conservation
4	Art History
2	Art-Studio
0	Asian Studies
5	Biochemistry
34	Biology
8	Biophysics
17	Chemistry
0	Chicana/o-Latona/o Studies
1	Classics
1	Computational Biology
31	Computer Science
0	Dance
106	Economics
16	Economics - Accounting
4	Economics & Engineering
5	English
2	Env-Analysis: Science
9	Environ, Econ & Politics
14	Environmental Analysis
1	Fem Gndr Sex Studies
1	Film Studies
1	Foreign Languages
1	French
2	French Studies
4	Geology
11	Government
1	Hispanic Studies
7	History
2	Human Biology
21	International Relations
1	Int'l Political Economy
1	Japanese
2	Latin American Studies
1	Legal Studies
2	Linguistics
7	Linguistics & Cog. Sci.
4	Literature
4	Management - Engineering
1	Mathematical Economics
29	Mathematics
12	Media Studies
0	Middle Eastern Studies
11	Molecular Biology
4	Music
32	Neuroscience
2	Organismal Biology
4	Organizational Studies
1	Phil. & Public Affairs
11	Phil., Politics, Econ.
10	Philosophy
22	Physics
1	Political Studies
3	Politics
7	Politics+Int'l Relations
21	Psychology
7	Public Policy-Various
1	Religious Studies
0	Romance Languages/Literatures
0	Russian + Eastern European Studies
3	Sci, Technology & Soc.
25	Science & Management
2	Science Tech & Society
3	Sociology
1	Spanish
0	Theater
143	Undecided/Undeclared
708	total # of majors
for 676	total # of students

Computing is much larger than CS or IT.

We are the advocates, the coaches, the guides…

… which is an ideal role to have!

Our Biology 1 course

In Biology 1, all HMC students use computing to gain insight into the processes that direct and define life.

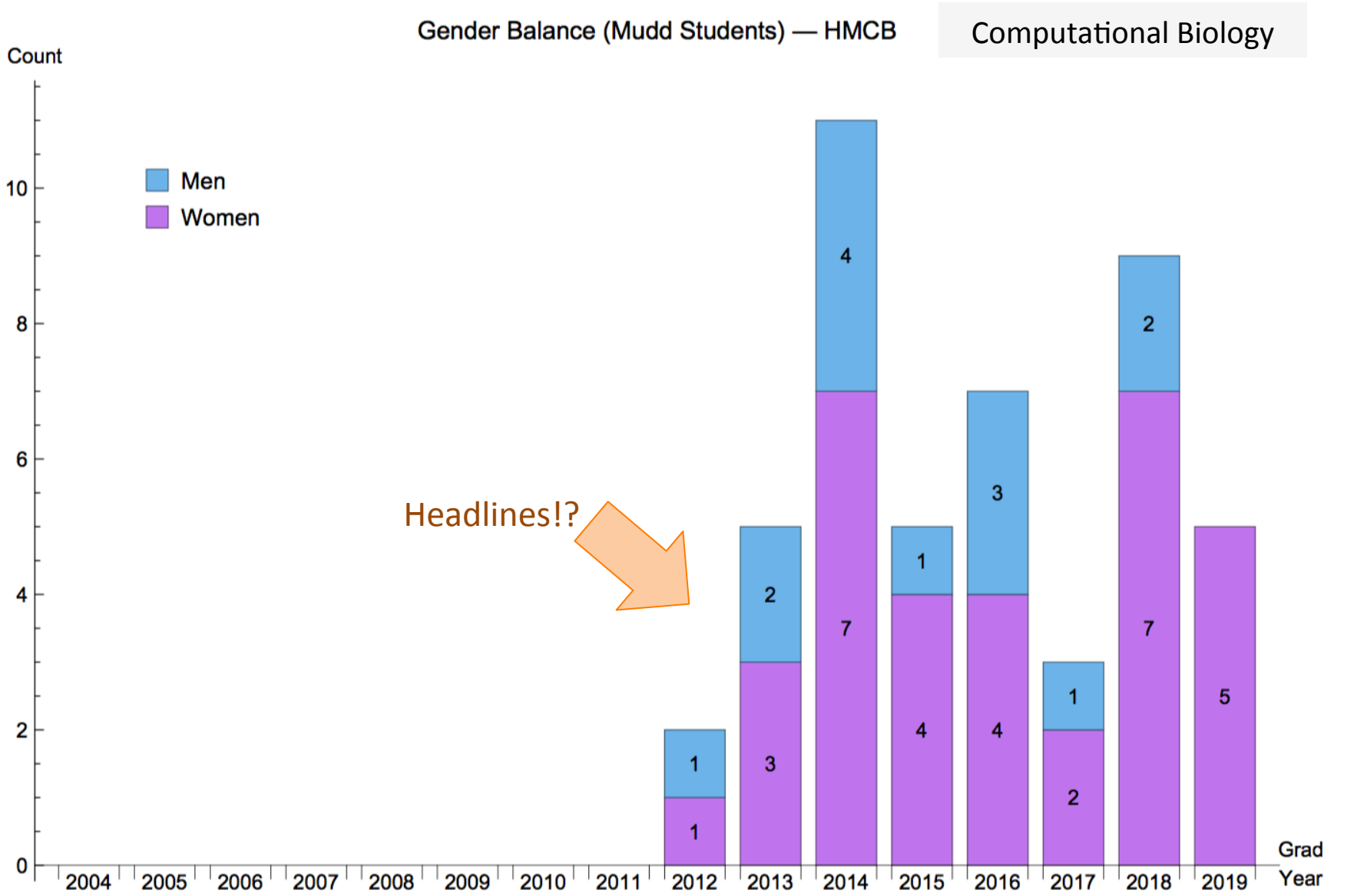
Each week, students submit programs **they write** from scratch:

wk2	Here **you will create a simple evolutionary simulator** with drift, natural selection and mutation.
wk4	In this problem you will **implement** the neighbor-joining algorithm for phylogenetic reconstruction and **use it to reconstruct the relationships** between a set of HIV/SIV sequences.
wk6	To find genes in a novel genome sequence, we must find all the open reading frames, and then determine which of these are really genes. In this assignment, **you will write** a series of short Python functions **to find open reading frames in a bacterial genome sequence**.
wk8	Some bacteria cause disease, and others don't. In fact, closely related strains often differ greatly in this respect. What separates a pathogenic bacterium from a harmless one? Often it is just a handful of protein coding genes. In this assignment **you will identify how proteins differ** in closely related **pathogenic** (N16961) and **non-pathogenic** (PS15, 2740_80) strains of Vibrio cholerae.

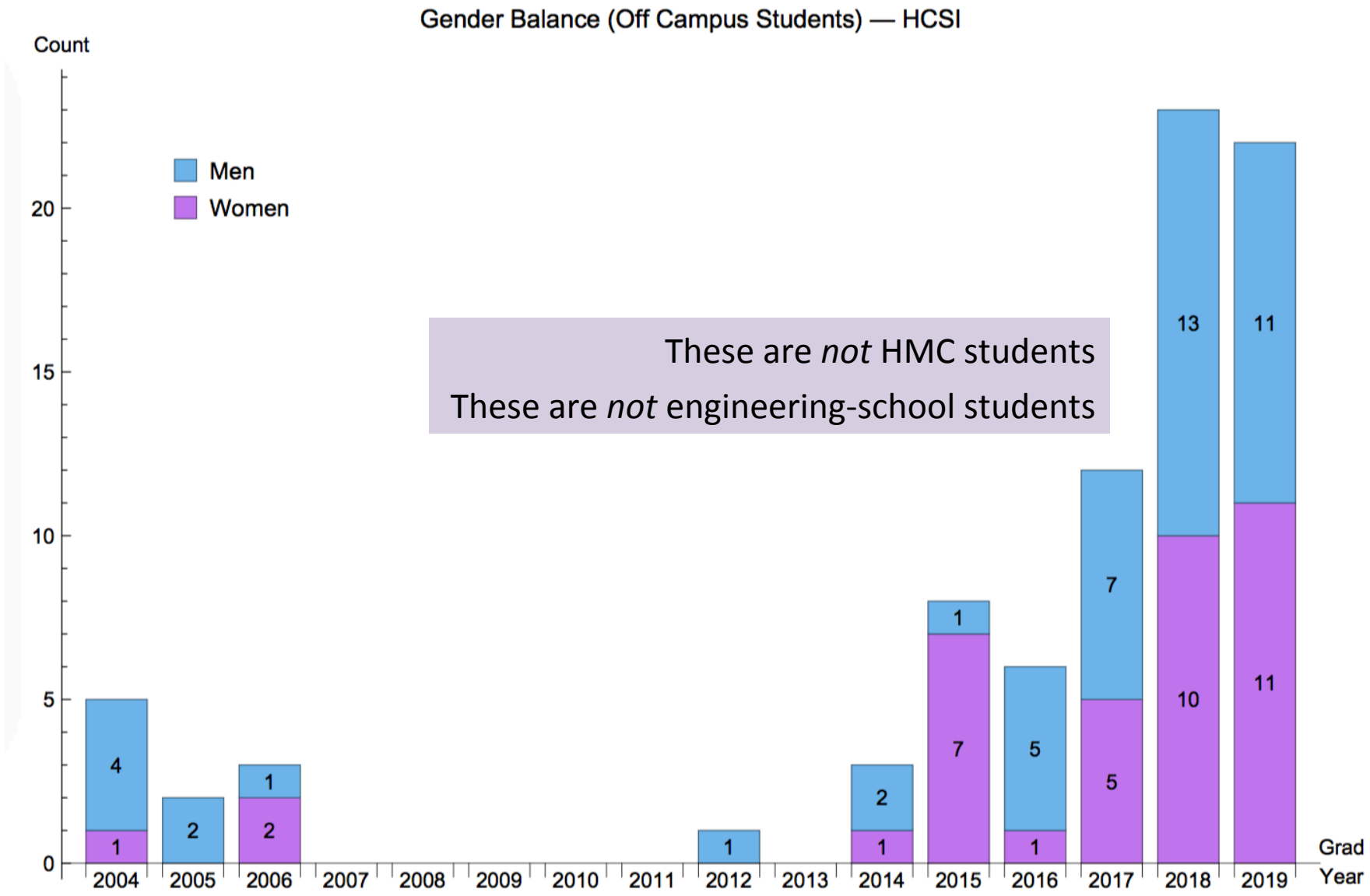
https://sites.google.com/a/g.hmc.edu/bio52/

Note that Bio1 does **not** teach computing, just as Physics1 does not teach math.

Biology ⊃ CS


Gender Balance (Mudd Students) — HMCB
Computational Biology
Count
Men
Women
Headlines!?
Grad Year
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
0
2
4
6
8
10
1
1
2
3
4
7
1
4
3
4
1
2
2
7
5

True *everywhere*…



Community >> Content

Computing is not owned by CS + IT

- But CS + IT *should be* its strongest supporters
- And CS + IT *benefit from* being a pathway to computing for everyone

Lesson learned

- We don't strive to bring *any individual* into CS for CS's sake.
- Rather, we bring CS out to the problems and projects that women - and men - care about. Women (and men) are already there!

Only 1 thing?

Like writing, require CS1 of all students.

They won't all love it, but many will.
… and they'll all share it, either way!