

Resources and opportunities...

<http://biblio.roboteducation.org/>

IPRE's extensive robot-in-education bibliography

AAAI 2008 Robot exhibition

email Paul Oh this week to join in!



AAAI 2008 AI Education Workshop

teaching AI? Robotics? Learning? **Submit!** (4/7)

AI in a breadth-first CS 1



Zachary Dodds

3/27/08 - AAAI Spring 2008 Stanford

Our Name is

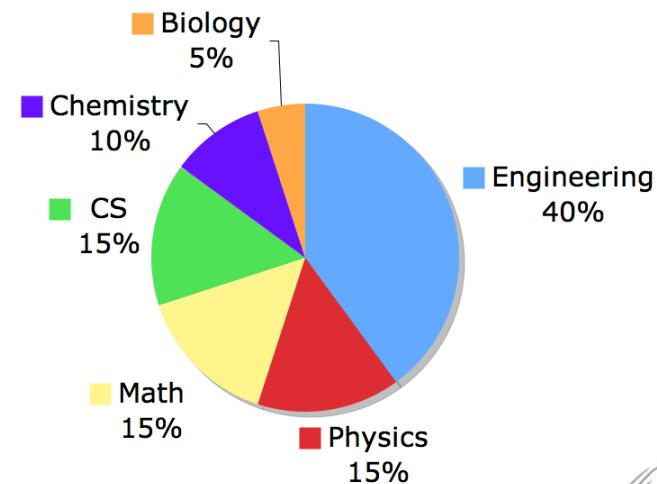
MUDD



Four undergraduate years

~ 190 students each

Every student must pass CS 1



Wanted from CS 1: more (women) CS majors

more enthusiasm

more CS



CS 1 for scientists



breadth-first (and -last)
150 lecture minutes, lab

CS breadth

Weeks	Paradigm
1-3	functional
4-6	machine-level
7-9	imperative
10-12	objects+classes
13-15	theory/projects

CS 1 for scientists



2-3 lectures per week, 1 lab

two experience-based sections

CS breadth



AI breadth

Weeks	Paradigm	AI-themed labs and assignments
1-3	functional	<i>turing(), Caesar decipher</i>
4-6	machine-level	<i>audio classification</i>
7-9	imperative	<i>Markov text generation</i>
10-12	objects+classes	<i>Connect Four</i>
13-15	theory/projects	<i>robotic navigation</i>

Small but recurring theme: 6 of the ~42 hw problems

Functions first

weeks 1-3

CS

conditionals & variables
functions & recursion

AI

language: meaning
vs. mechanics

computer conversationalist

programs can lie...

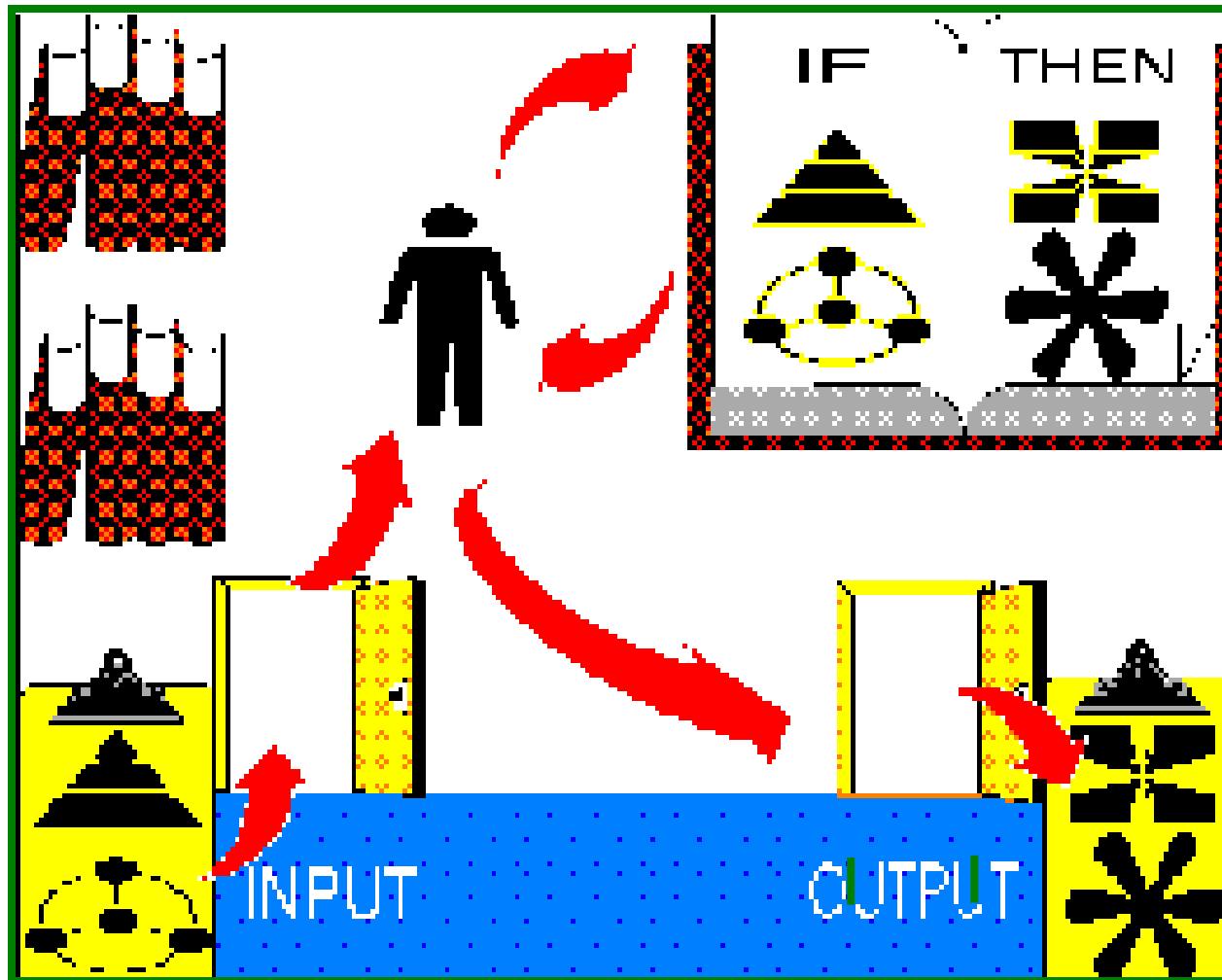
```
def turing():
    choice = raw_input("Rock, paper, or scissors? ")
    print "You chose scissors."
    print "I chose rock"
    print "You lose!"
```

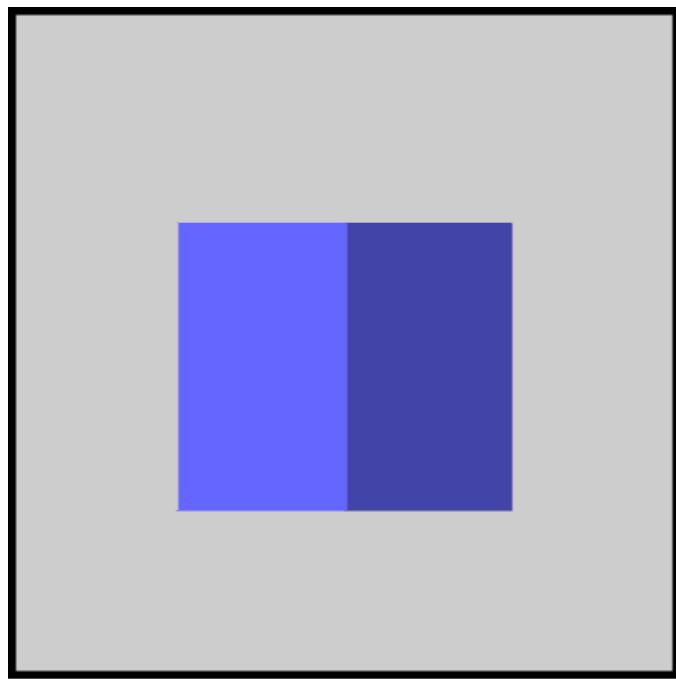
but can they act contrary to
their programming?

With acknowledgments to Tim...

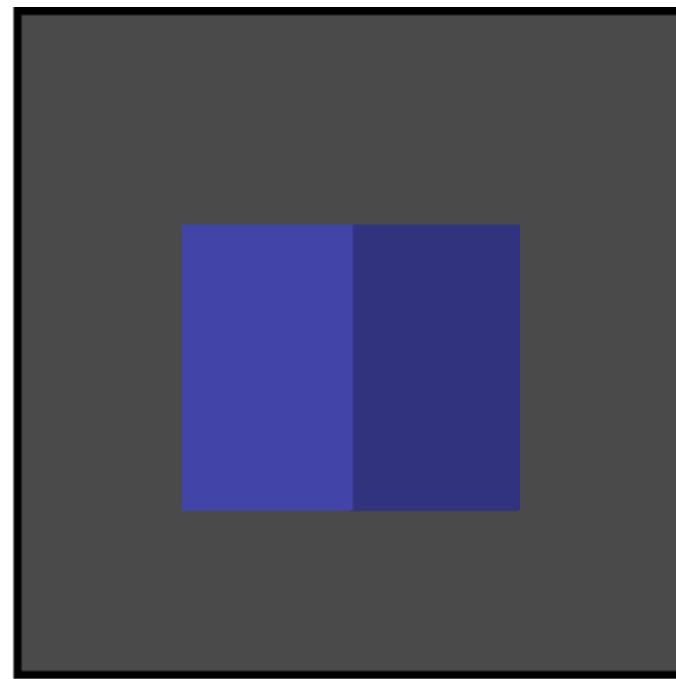
Our own *functioning*

machino-morphizing





A.



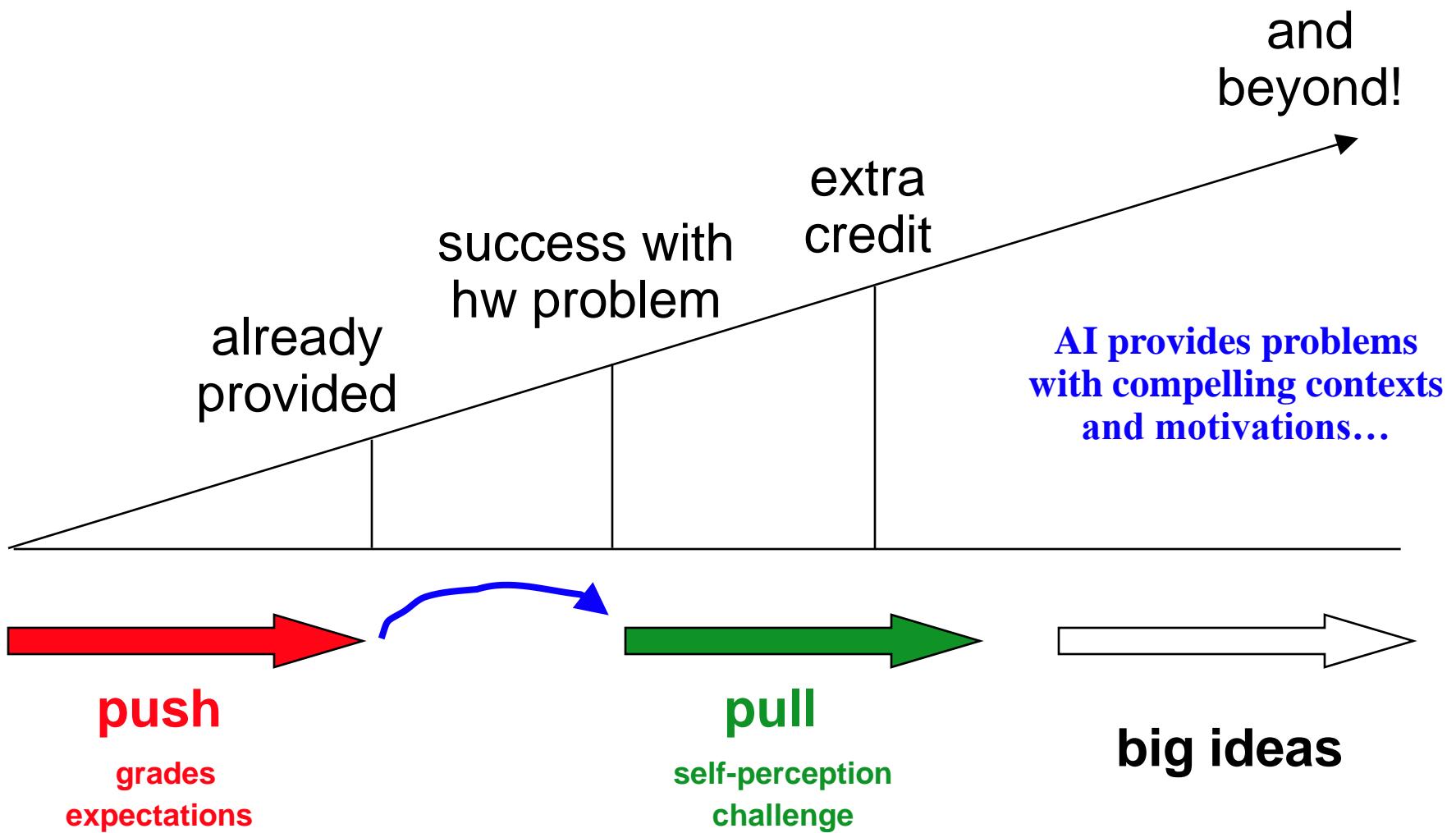
B.

Turing and Loebner

Judge 4 John Sundman					
Round 2		Carpenter			
	Score	Rank		Score	Rank
Milardo	92	2		8	7
					Program
Round 3		Wallace			
	Score	Rank		Score	Rank
Armour	90	3		10	6
					Program
Round 6		Watkins			
	Score	Rank		Score	Rank
Espinales	98	1		2	8
					Program
Round 7		Veselov			
	Score	Rank		Score	Rank
Salamensky	70	4		30	5
					Program

Scores for confederates and programs

The philosophy...



and beyond!

```
elif choice == 'case':  
    print 'Case is one of my favorite dorms. It\'s design is such  
    that\nthe only entrance is the only exit. This,  
    in\nconjunction with its thick walls, has\ngiven it the  
    nickname "The Dungeon,"\nbecause no one can hear the  
    screams.'  
print  
  
choice = raw_input('Would you like to visit Nate Jones?')  
print  
  
if choice[0] == 'y':  
    print 'Good choice. He is the head of a metal band named\n"The  
    Black Ravens of Immortal Death." He might get pissed if  
    you\npass him by.'  
print  
  
elif choice[0] == 'n':  
    print 'Well, fine then. Don\'t visit him.'  
print
```

and beyond!

task-driven discoveries...

```
elif choice[1:] == 'ase':
```

```
    print 'Case is one of my favorite dorms. It\'s design is such  
    that\nthe only entrance is the only exit. This,  
    in\nconjunction with its thick walls, has\ngiven it the  
    nickname "The Dungeon,"\nbecause no one can hear the  
    screams.'
```

```
print
```

```
choice = raw_input('Would you like to visit Nate Jones?')
```

```
print
```

```
if choice[0] == 'y':
```

```
    print 'Good choice. He is the head of a metal band named\n"The  
    Black Ravens of Immortal Death." He might get pissed if  
    you\npass him by.'
```

```
print
```

```
elif choice[0] == 'n':
```

```
    print 'Well, fine then. Don\'t visit him.'
```

```
print
```

and beyond!

I learn just as much!

```
elif choice == 'case':
```

```
    print 'Case is one of my favorite dorms. It\'s design is such  
        that\nthe only entrance is the only exit. This,  
        in\nconjunction with its thick walls, has\ngiven it the  
        nickname "The Dungeon,"\n        because no one can hear the  
        screams.'
```

```
print
```

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choice = raw_input('Would you like to visit Nate Jones?')
```

```
print
```

```
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```

```
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```

```
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```

```
print
```

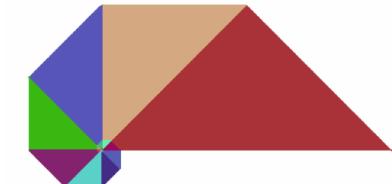
Other work

weeks 1-3

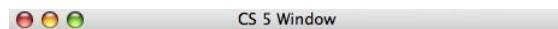
recursive thinking: `map`, `reduce`...

sorting, selection

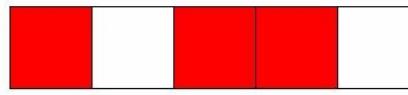
turtle graphics



random walks

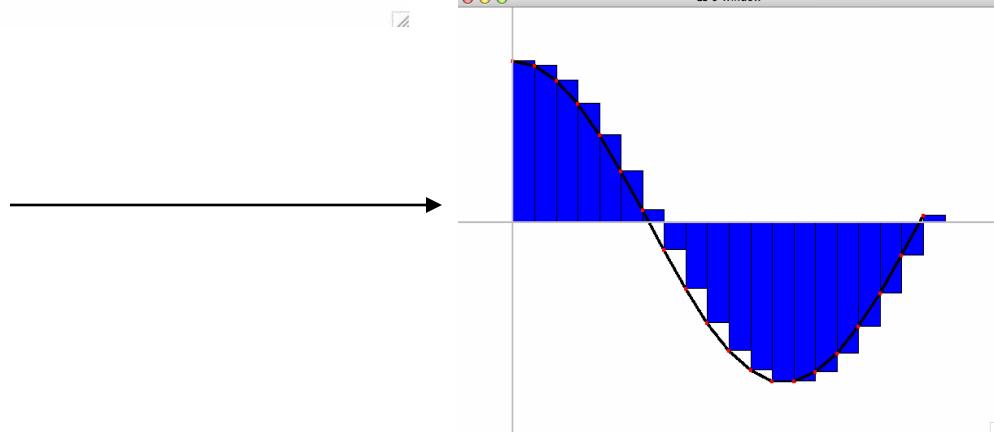


"lights out"



Pig Latin translator

dot products, integration



scrabble scoring

Functional Finale

Caesar *deciphering*

```
>>> encipher('Caesar cipher? I prefer Caesar salad.', 25)
'Bzdrzq bhogdq? H oqdədq Bzdrzq rzkzc.'

>>> decipher('Hu lkbjhapvu pz doha ylthpuz hmaly dl mvynla \
             'lclyfaopun dl ohcl slhyulk.')
'An education is what remains after we forget everything we
have learned.'

>>> decipher('gv vw dtwvg')
```

Functional Finale

Caesar deciphering

```
>>> decipher('Bzdrzq bhogdq? H oqdədq Bzdrzq rzkzc.')
'Caesar cipher? I prefer Caesar salad.'
```

```
>>> decipher('Hu lkbjhapvu pz doha ylthpuz hmaly dl mvynla \
             'lclyfaopun dl ohcl slhyulk.')
'An education is what remains after we forget everything we
have learned.'
```

```
>>> decipher('gv vw dtwvg')
```

consider all
encipherings

gv vw dtwvg
hw wx euxwh
ix xy fvyxi
jy yz gwzyj
kz za hxazk
la ab iybal
mb bc jzcbm
nc cd kadcn

od de lbedo
pe ef mcfep
qf fg ndgfq
rg gh oehgr
sh hi pfihs
ti ij qgjit
uj jk rhkju
vk kl silkv
wl lm tjmlw

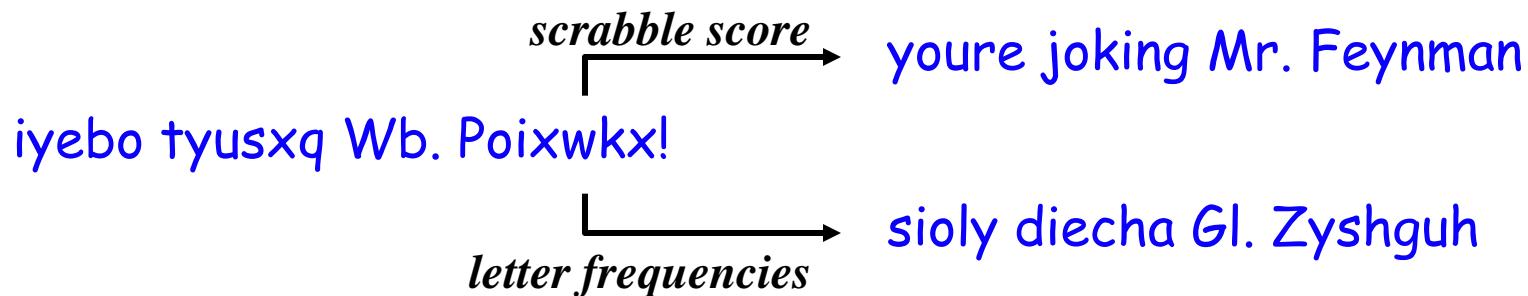
xm mn uknmx
yn no vlony
zo op wmpoz
ap pq xnqpa
bq qr yorqb
cr rs zpsrc
ds st aqtsd
et tu brute
fu uv csvuf

Quantifying *Englishness*

approach is open-ended

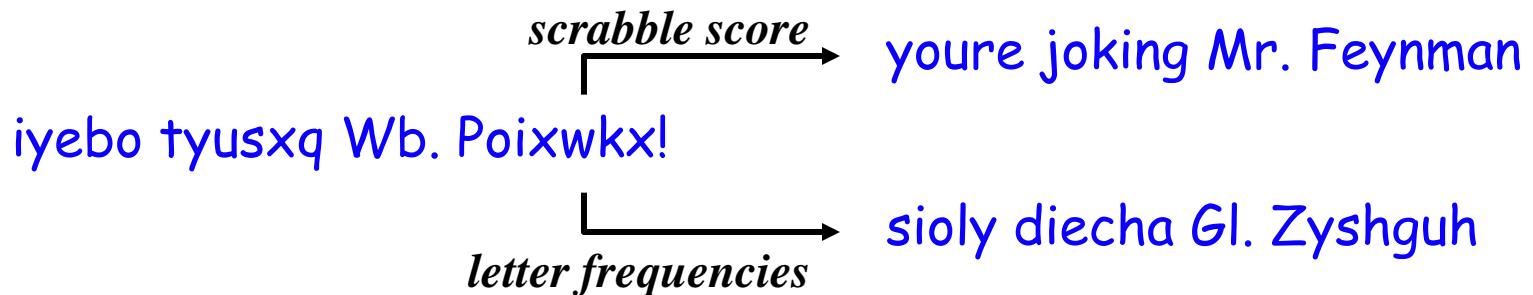
we provide letter-frequencies

the best solutions don't use them!



Quantifying *Englishness*

approach is open-ended
we provide letter-frequencies
the best solutions don't use them!



Challenge Come up with a sentence for which native speakers would easily agree, but your system will fail.

I dont think qzxqxxz or zzzqzzqx are words at all

Not everyone succeeds

tradition of highlighting creativity

in all of its forms...

```
def encipher( phrase, shift ):
```

code for shifting forward through the alphabet

```
def decipher( phrase ):
```

```
""" This works sometimes! """
```

Not everyone succeeds

tradition of highlighting creativity

in all of its forms...

```
def encipher( phrase, shift ):
```

code for shifting forward through the alphabet

```
def decipher( phrase ):
```

""" This works sometimes! """

```
return encipher( phrase, 3 )
```

but it's OK...

Representation

weeks 4-6

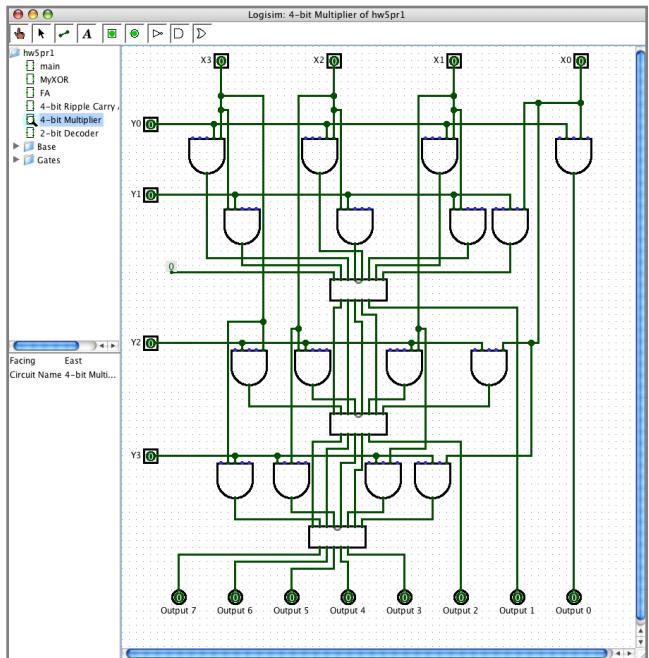
base-N representations

images and compression

CS logic gates: AND OR NOT

(non-AI) circuit composition →

assembly programming



Representation

weeks 4-6

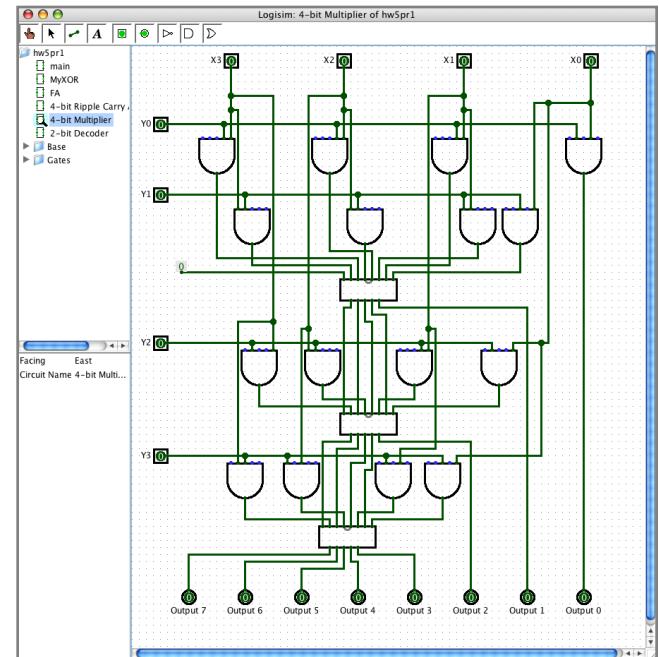
base-N representations

images and compression

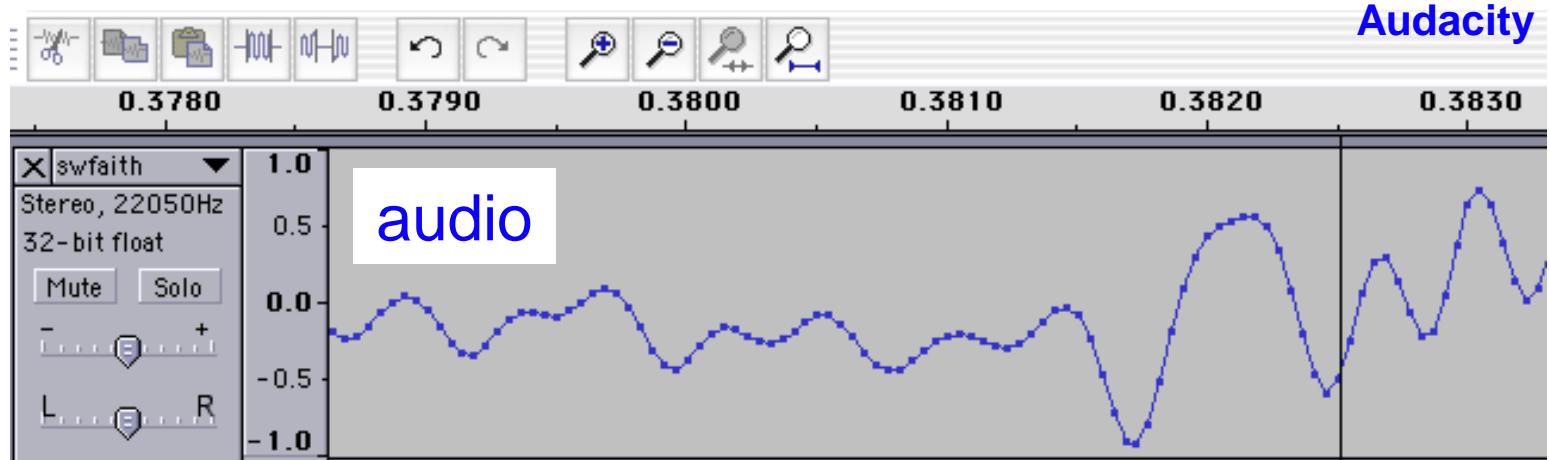
CS logic gates: AND OR NOT

(non-AI) circuit composition →

assembly programming



AI



Media computation: *both* sides

expressive creativity



analytic creativity



```
def reverse( sound ):
```



```
def oneFreq( freq ):
```



```
def myeffect( ... ):
```

creating audio data

Media computation: *both* sides

expressive creativity \longleftrightarrow **analytic creativity**

```
def dft( sound, freq ):  
    sinWave = oneFreq( freq ) ← week 4  
    power = dot( sound, sinWave ) ← week 2  
    return power
```

Media computation: *both* sides

synthetic creativity

analytic creativity

```
def dft( sound, freq ):  
    sinWave = oneFreq( freq )  
    power = dot( sound, sinWave )  
    return power
```



What mood
are you in?



and **breaking** it apart: chord classification *for any key*

Imperative

weeks 7-9

Who is the author ?

'Cause somethin' like he left knee and a harp," said he had to the whole school? The shouting and then some strange and Mrs. "Well, I know Hagrid; they spotted handkerchief and get him get rid of course, had a gigantic beet with her," he knew what to all he's

All the sky with the sun in the sun in the church where you're gone Lucy in my eyes. There beneath the girl with an hourglass And then the banker never wears a lot to hold your hand. Can't buy me tight, tight Owww! Love is love I can't hide,

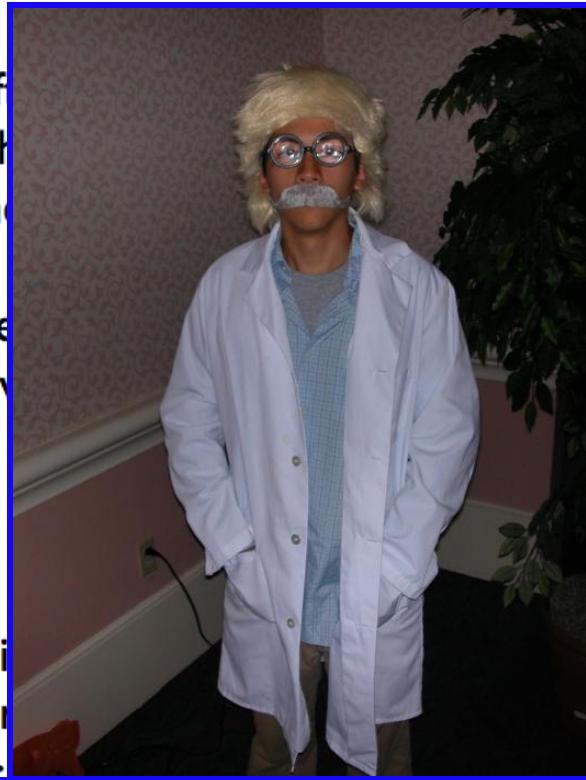
This is but ourselves. No, faith, My uncle!
O royal bed of confession Of your rue
for leave to nature; to this time I should
weep for thy life is rotten before he is.
have sworn 't. Or my blood. I have
closely sent for nine; and unprofitable,

Imperative

weeks 7-9

Who is the author ?

'Cause somethin' like he left
the harp," said he had to the who
The shouting and then some
Mrs. "Well, I know Hagrid;
handkerchief and get him ge
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ky with the sun in the sun in the
where you're gone Lucy in my
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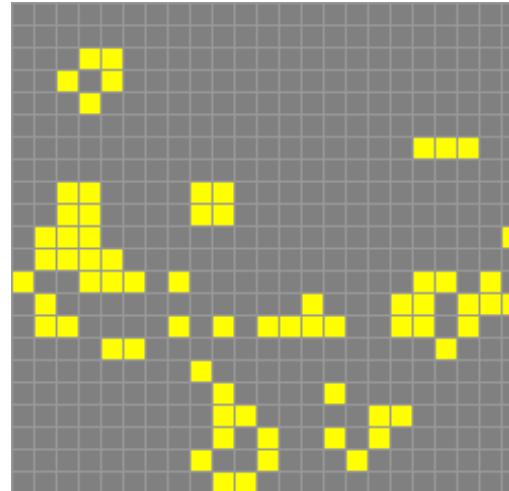
Rooter: A Methodology for the Typical Unification
of Access Points and Redundancy

Jeremy Stribling, Daniel Aguayo and Maxwell Krohn

Other work

weeks 7-9

Life →



Gaussian elimination

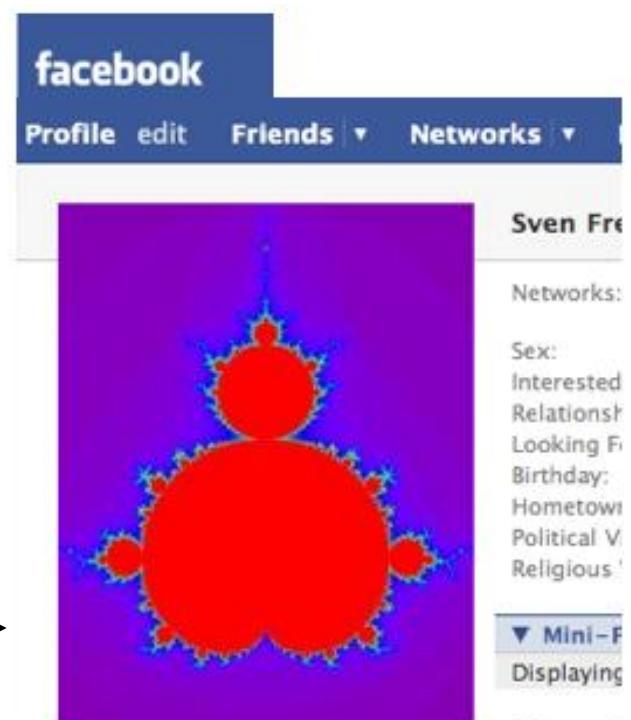
Physical time-step simulations

Monte Carlo simulations

Flesch readability

ASCII art

Mandelbrot Set →



Objects

weeks 10-11

emphasizing use over design

```
class Board: ...
```

```
b = Board(6,7)
b.hostGame()
```

O	O						
O	X		X	X			
X	X	X	O	O	O		

0	1	2	3	4	5	6	
X wins!							

```
class Player:...
```

```
b = Board(6,7)
px = Player('X',2)
po = Player('O',2)
b.playGame(px,po)
```

O	O	X	O	O	O	
X	X	O	X	X	X	
O	O	X	O	O	O	
X	X	O	X	X	X	
O	O	X	O	O	O	
X	X	X	O	X	X	

0	1	2	3	4	5	6
O wins!						

AI: Connect 4 ~ N-ply Minimax

Objects

weeks 10-11

emphasizing use over design

```
class Player:...  
class Board: ...  
b = Board(6,7)  
pX = Player('X',2)  
pO = Player('O',2)
```

**BWAHAHAHAHAHAHHAHAHAHAH - I AM THE
WINNER AND IT ALL WORKS!!!**

GWAHAHAHAHAHAHAHAHAH!!

**started at noon, I'm done at 11:11 (minus a brief
break to watch shawshank redemption and eat
dinner, I've been working solid ;)**) **I AM
TOTALLY THE WINNER!**

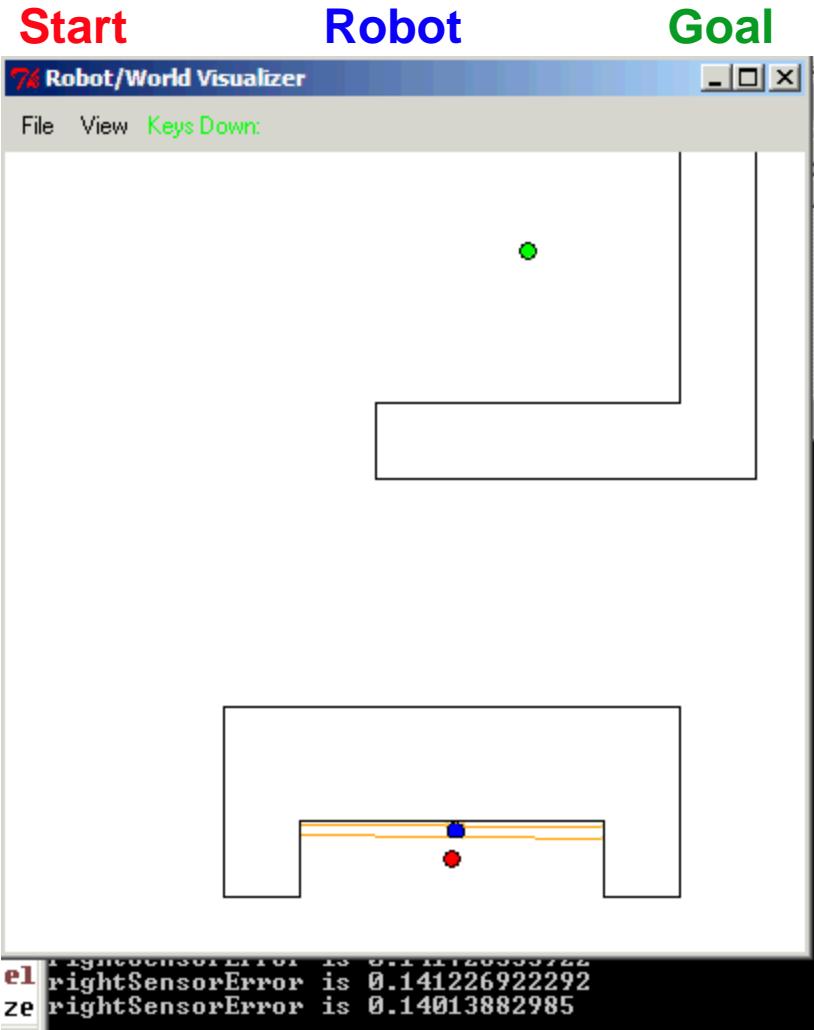
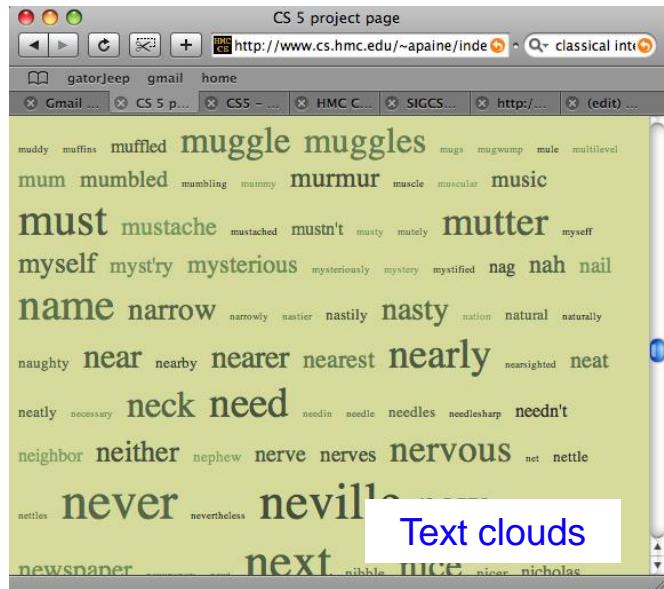
X wins!

O wins!

AI: Connect 4 ~ N-ply Minimax

Theory & Projects

weeks 12-14



implementing finite-state machines
for a robot-inspired navigation task

Theory & Projects

weeks 12-14



Take 1



Take 2

What do students get out
of this experience?

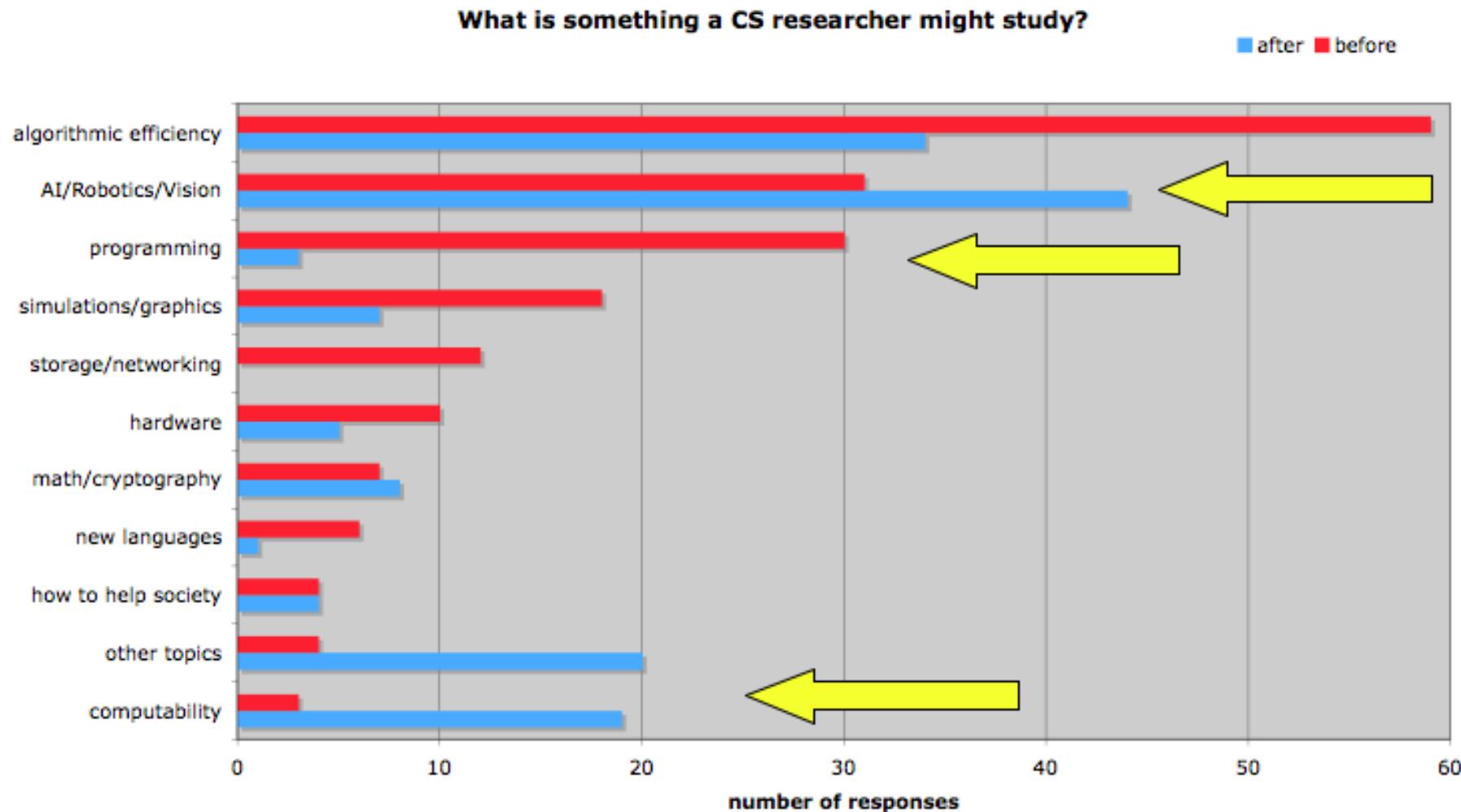
Breadth

Enthusiasm

Retention

Results

Breadth of CS



Results

Enthusiasm...

Core curriculum students' hours per week (and anticipated grades), Fall '06

	Physics	CS 1	Math	Writing	Bio	Engin.
Women	5.2 (C+)	7.2 (B)	6.4 (B-)	5.3 (B-)	2.8 (B-)	7.0 (B-)
Men	5.9 (B-)	7.3 (B+)	6.6 (B)	5.7 (B-)	2.3 (B)	6.2 (B)



And felt that the work would pay off.

Students reported working more in CS 1 than other intro courses...

Results

Enthusiasm & breadth

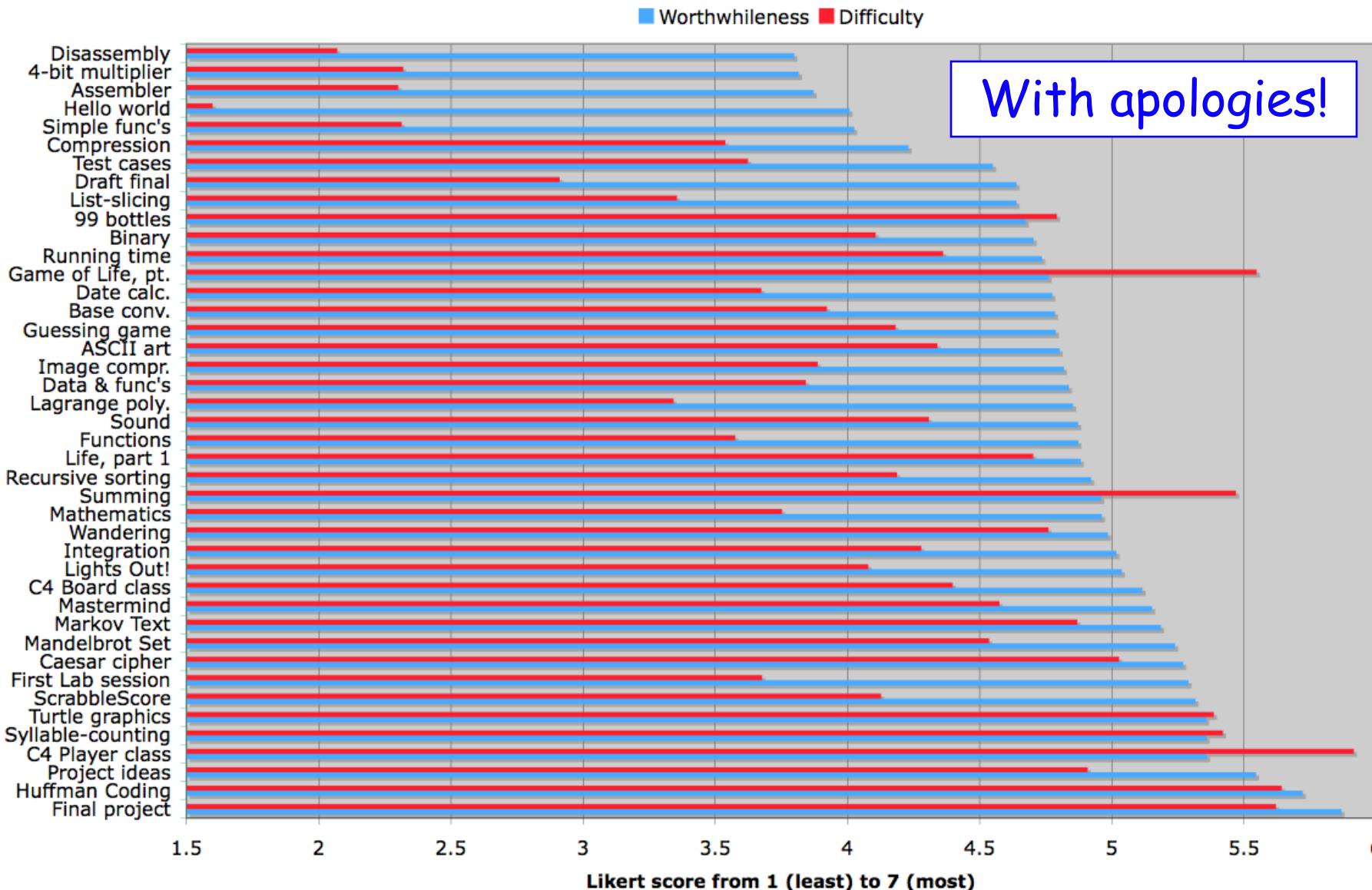
- A) The course stimulated my interest in the subject matter.
- B) I learned a great deal in this course.

Students Considered	Agreement with (A), from 1-7	Agreement with (B), from 1-7
Fall 2005: all courses	5.65	5.71
Fall 2005: traditional CS1	5.14	5.81
Fall 2006: <i>CS for Scientists</i>	5.89	6.11
Fall 2006: all courses	5.70	5.80

on a seven-point scale

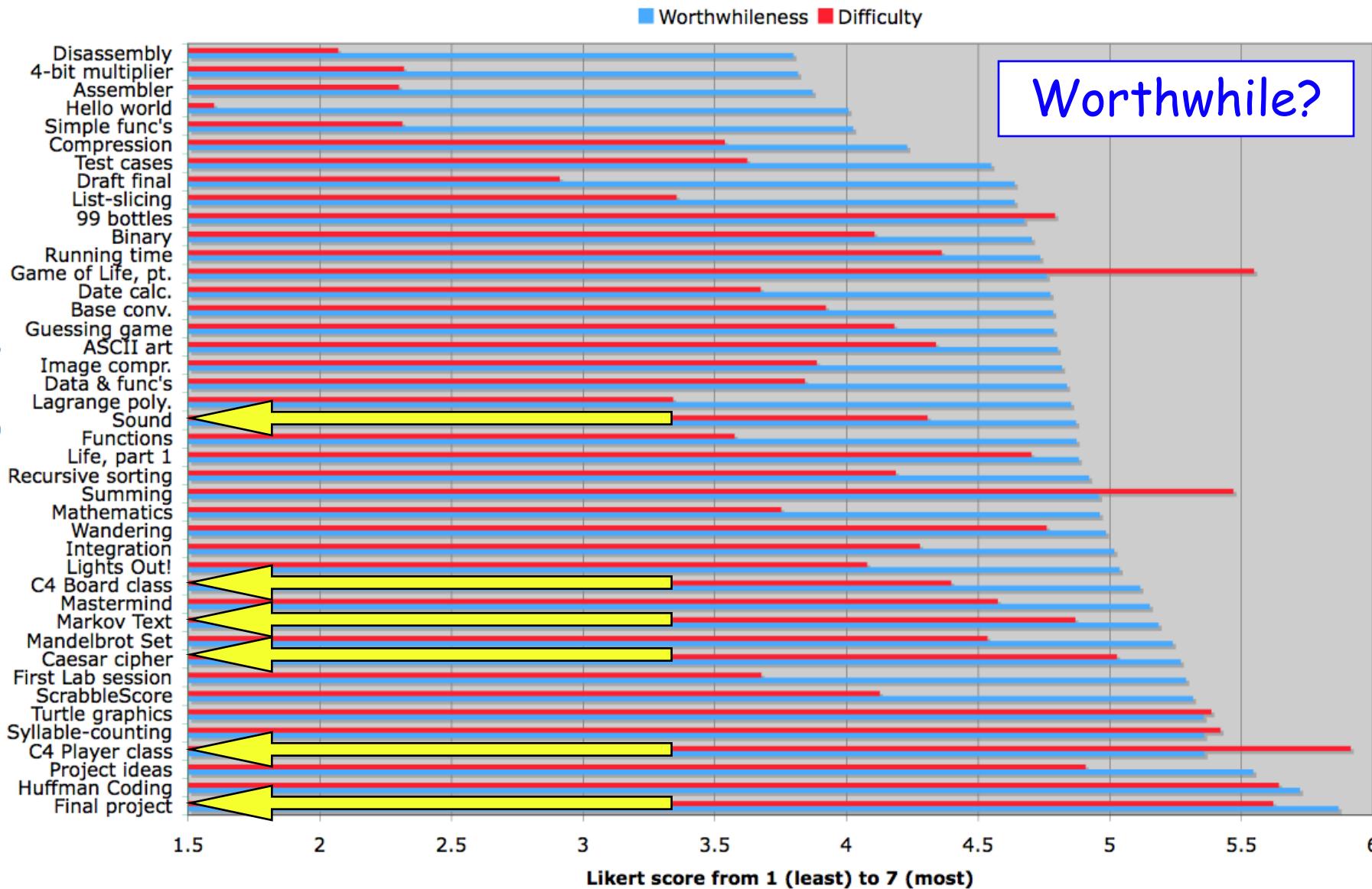
Results

Student-reported worthwhileness and difficulty



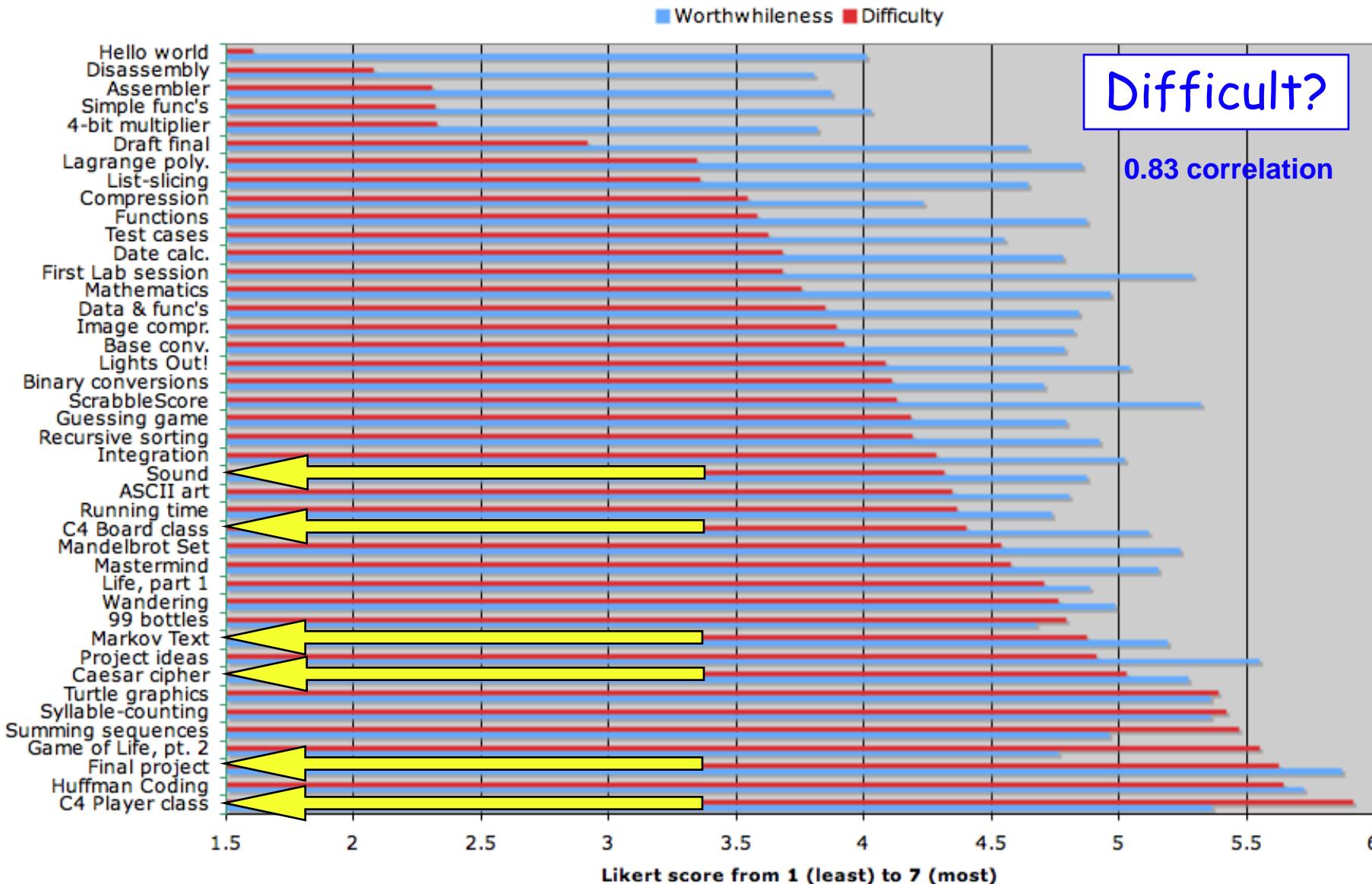
Results

Student-reported worthwhileness and difficulty



Results

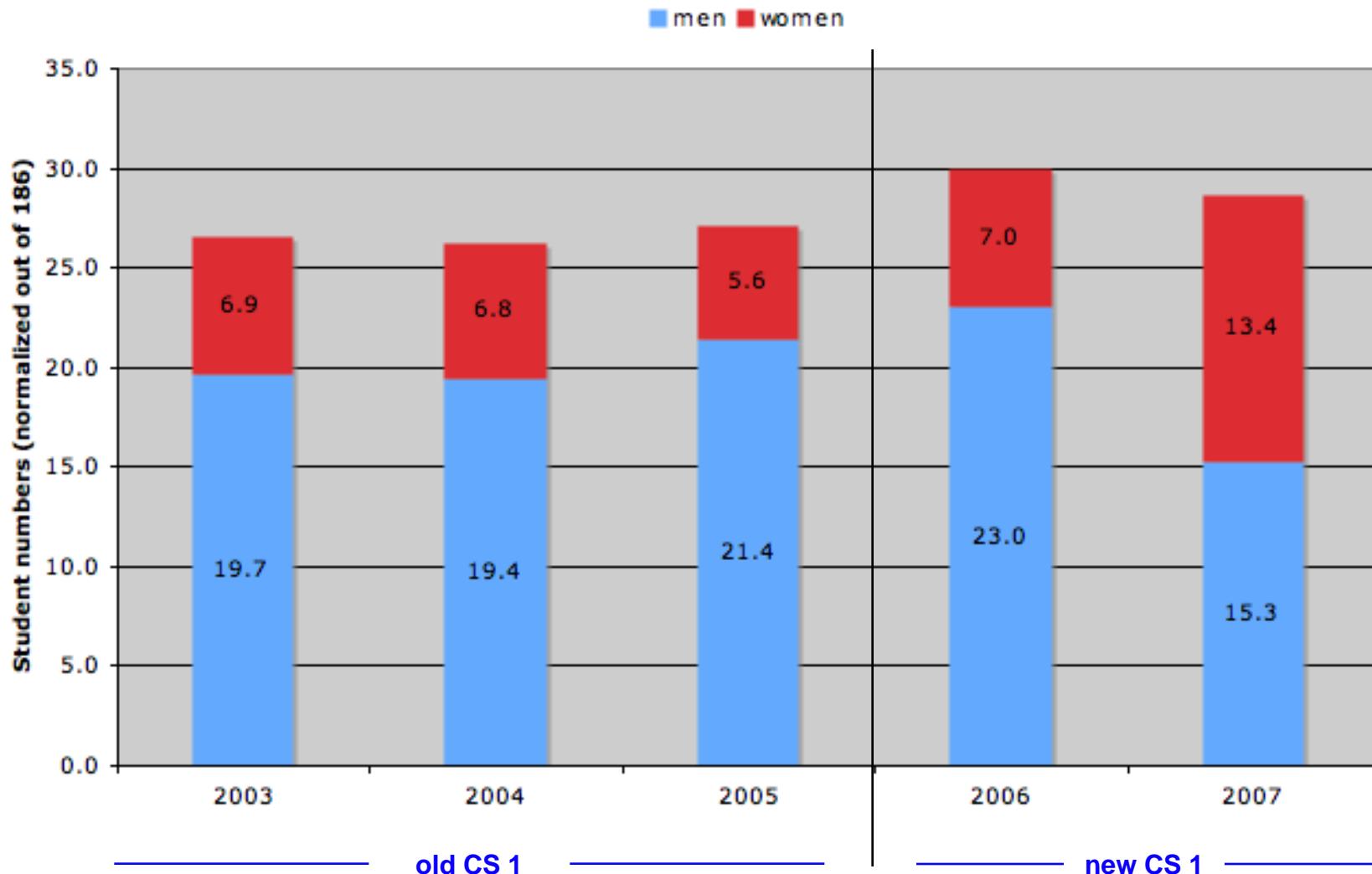
Student-reported worthwhileness and difficulty



Results

Retention flat...
but more women!

Students choosing to take CS 2 in the spring

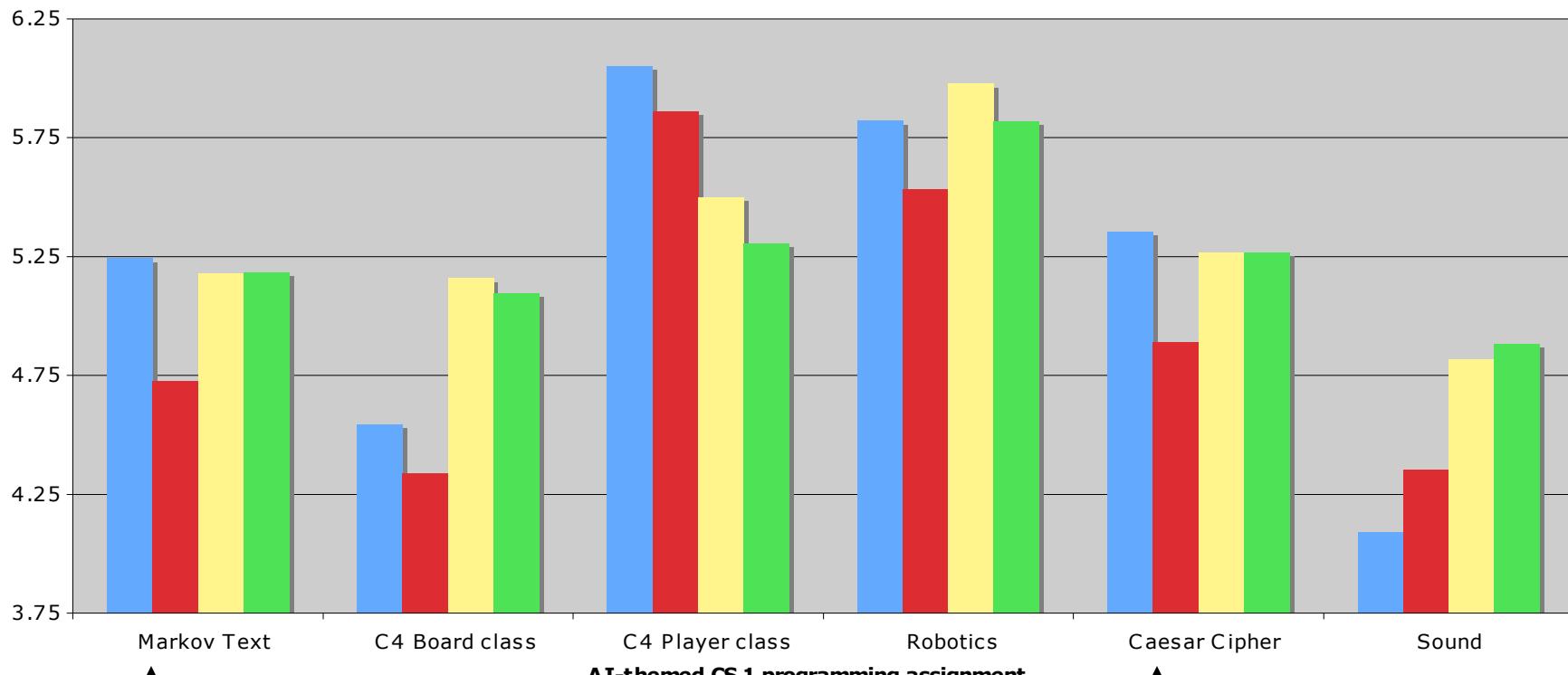


Results

but not because of AI ?

Comparison between women's and men's responses to AI-themed CS 1 assignments

■ Difficulty, reported by women ■ Difficulty, reported by men ■ Worthwhileness, reported by women ■ Worthwhileness, reported by men



only significant differences: women reporting the hw more difficult
 $t = 0.05$

Beyond the numbers

AI as springboard...

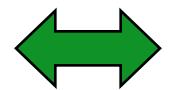


Six-week summer project
for three first-year women

Verdict

Breadth 

Enthusiasm 

Retention 

AI ~ motivating without dominating.

politically flexible !

CS 1 is where we *faculty*
are now most passionate.

disproportionate impact: *Cultivating the Long Tail*



In CS 2

Comparing old vs. new CS 1 students,
in terms of performance in CS 2

(cohort numbers)

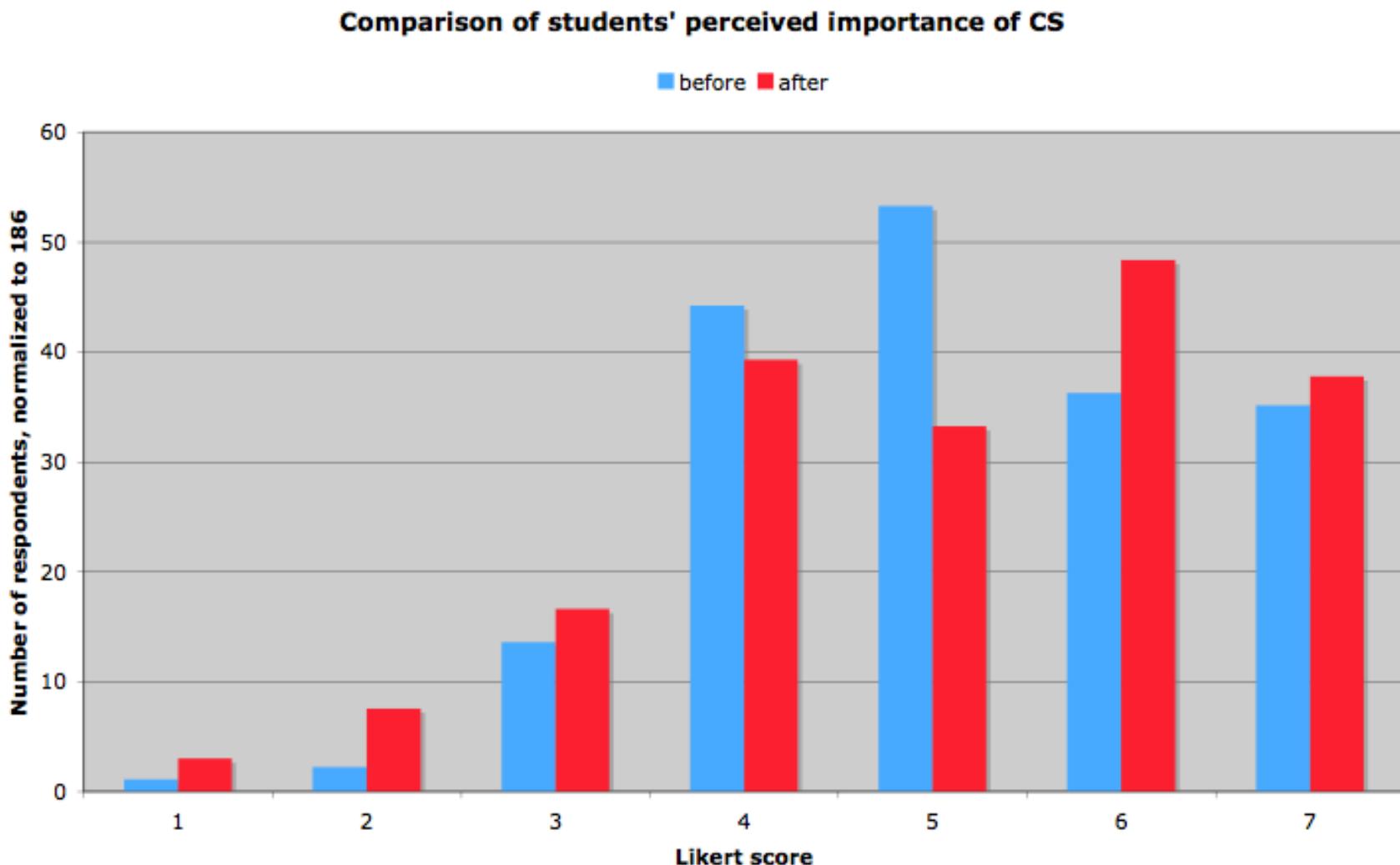
CS 2, Spring '07	Midterm exam scores, %			Final exam scores, %		
	women	men	overall	women	men	overall
Java CS 1	84.0 (1)	79.5 (12)	79.8 (13)	92.0 (1)	78.4 (9)	79.8 (10)
Python CS 1	80.7 (7)	84.7 (25)	83.8 (32)	88.1 (7)	84.3 (24)	85.1 (31)



Starting with Python was no disadvantage,
even without changing later courses.

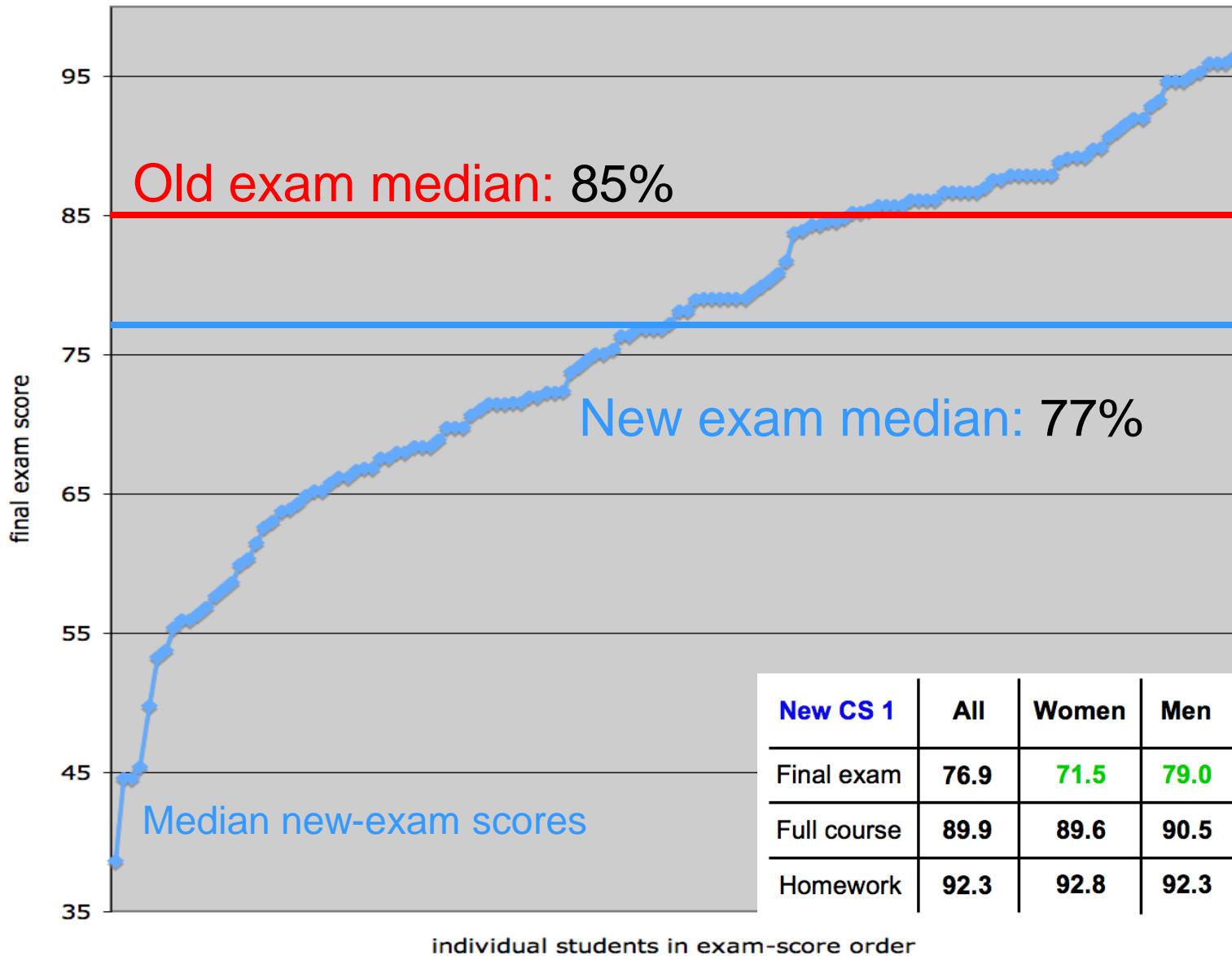
Results

Taking sides!



Final exam

week 15



Final exam

week 15

Old and new exam questions

1. Create and compose three small functions to spec.
2. Demonstrate correct use of references vs. raw data
3. Manipulate a 1d data structure, e.g., `mode`
4. Write a program searching a 2d array along both dims.
5. Design/write a `Time` class with data, methods to spec.

Additional new exam questions

6. Design/sketch a novel digital circuit from its I/O spec.
7. Compose an assembly-language routine to spec.
8. Prove a (previously unseen) function uncomputable

AAAI '08 Opportunities



The 17th Annual AAAI Robot Workshop and Exhibition

Chicago, IL, USA, July 13-17, 2008



Tracks:

1. Robotics and Creativity
2. Mobility and Manipulation

Email Paul Oh this week!



AAAI 2008

AI Education Colloquium

Theme: **Teaching AI per se**

Submissions of 2-6 pages by April 7, 2008.

AAAI '08 Opportunities

CS 1 options!

Precedence

imperative-first

objects-first

functional-first

breadth-first

algorithms-first

hardware-first

rigor-first

Thematic Structure



games

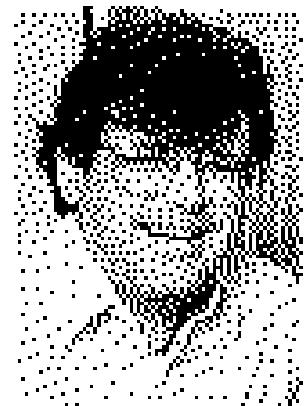


robots

math & science



media



CS 1 options!

Precedence

imperative-first

objects-first

functional-first

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hardware-first

rigor-first

Thematic Structure



games

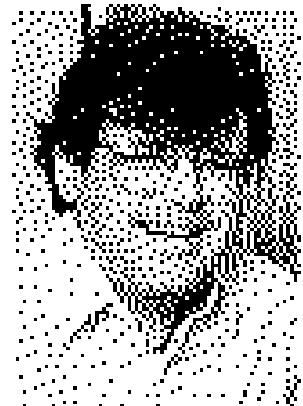


robots

media



math & science



Functional Finale

Caesar deciphering

An education is what remains when we forget everything we have learned.

Et tu, Brute?

CS

composition, design, map, and
reduce (or list comprehensions)

solution

wonderfully AI-ish!

run forward and optimize

Verdict

AI can be motivating without dominating.

offers challenge - requires creativity

disproportionate impact: *cultivating the long tail*

A dozen first-year women are working with our
CS department this coming summer

politically flexible !

CS 1 is where *we* are
now most passionate.

What is learned is the square
root of what is taught.



Results

Motivation?

Core curriculum students' hours per week (and anticipated grades), Fall '06

	Physics	CS 1	Math	Writing	Bio	Engin.
Women	5.2 (C+)	7.2 (B)	6.4 (B-)	5.3 (B-)	2.8 (B-)	7.0 (B-)
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And felt that the work would pay off.

Students reported working more in CS 1 than other intro courses...

Verdict

Skills ↑

Retention ←→

Breadth ↑

Primum non nocere.



CS 1 is where *we* are
now most passionate.

Imperative

weeks 7-9

Guest Editor
Peter Neumann

The Complexity of Songs

DONALD E. KNUTH



Keys: design, loops, multidimensional lists

A screenshot of a Python Shell window. The title bar says "Python Shell". The menu bar includes "File", "Edit", "Shell", "Debug", "Options", and "Windows". The main window displays the lyrics of the "99 Bottles of Beer" song, starting from 97 down to 91. The lyrics are printed in blue. At the bottom, there is a red error message:

```
You take one down, pass it around,  
97 bottles of beer on the wall!  
97 bottles of beer on the wall  
97 bottles of beer!  
You take one down, pass it around,  
96 bottles of beer on the wall!  
96 bottles of beer on the wall  
96 bottles of beer!  
You take one down, pass it around,  
95 bottles of beer on the wall!  
95 bottles of beer on the wall  
95 bottles of beer!  
You take one down, pass it around,  
94 bottles of beer on the wall!  
94 bottles of beer on the wall  
94 bottles of beer!  
You take one down, pass it around,  
93 bottles of beer on the wall!  
93 bottles of beer on the wall  
93 bottles of beer!  
You take one down, pass it around,  
92 bottles of beer on the wall!  
92 bottles of beer on the wall  
92 bottles of beer!  
You take one down, pass it around,  
91 bottles of beer on the wall!  
  
Traceback (most recent call last):  
  File "<pyshell#3>", line 1, in -toplevel-  
    bottlesFallSong()  
  File "/private/var/automount/mnt/courses/wwwader/ce5"
```

THEOREM 1.

There exist songs of complexity $O(\log n)$.

PROOF.

Consider the schema

$$V_k = T_k B W^*, '$$

$$T_k B^*; '$$

If one of those bottles should (12)
happen to fall, '

$$T_{k-1} B W^*.'$$

where

$$B = ' \text{bottles of beer}' , \quad (13)$$

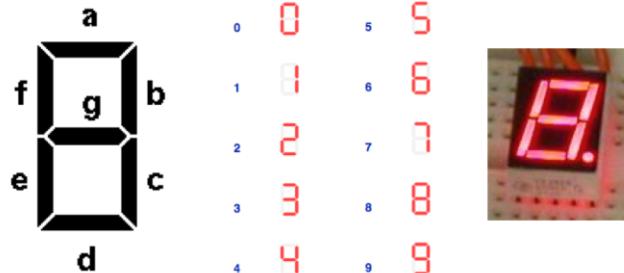
$$W = ' \text{on the wall}' ,$$

and where T_k is a translation of the integer k into Eng-

² Again Kennedy ([8], p. 631) claims priority for the English, in this case because of the song "I'll drink m if you'll drink $m + 1$." However, the English start at $m = 1$ and get no higher than $m = 9$, possibly because they actually drink the beer instead of allowing the bottles to fall.

Final exam

2) Create a circuit for segment 'g'



5) Floating-point division in (integer-only) assembly

6) Count words in a 2d array

```
>>> wordCount( 'spam', [ 'asmic', 'spams', 'papaj', 'amsoy' ] )  
3
```

asmic
spams
papaj
amsoy

8) Show that **contrary** is uncomputable

```
def contrary( prog ):  
    """ contrary takes in a python function, prog  
        prog will always be a python function of zero inputs  
  
        contrary returns True if prog() returns False and  
        contrary returns False otherwise  
    """
```

Perspective

Keep

breadth-first

closed labs and
final project

homework choices

Change

imperative *with* functional

8 am class time

Audio vs. 3d

breadth-first



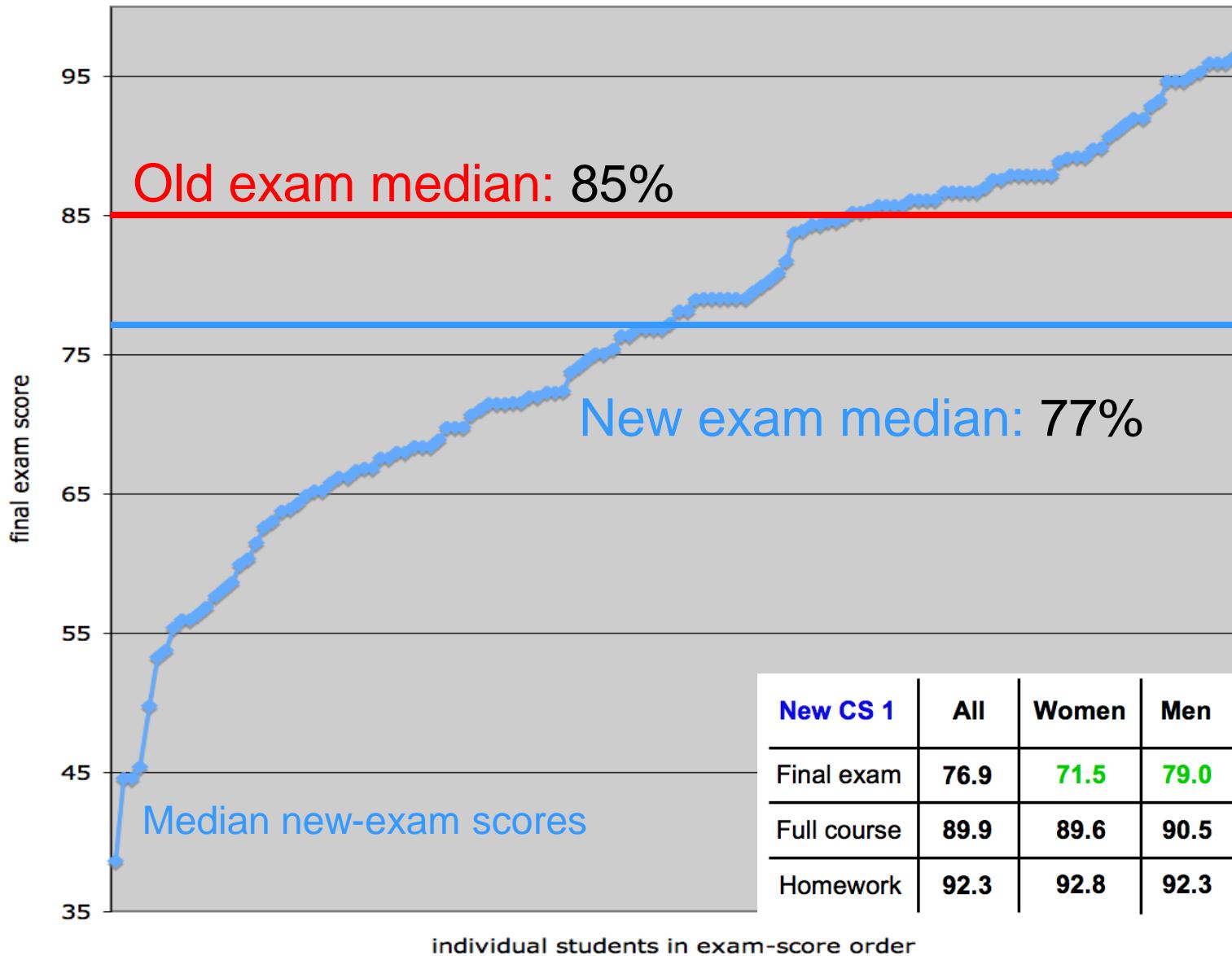
breadth-last

the breadth-first model has not enjoyed the success that its proponents had envisioned... most breadth-first courses that exist today seem to be lead-ins to a more traditional programming sequence

- CC 2001

Final exam

week 15



Objects

weeks 10-11

emphasizing use over design

Date

hw11

```
def dow(self):
    dayOfWeekList = ["Thu",
                      "Fri", "Sat", "Sun",
                      "Mon", "Tue", "Wed"]
    now = Date(3,27,2008)
    b = self.diff(now)
    return dayOfWeekList[b%7]
```

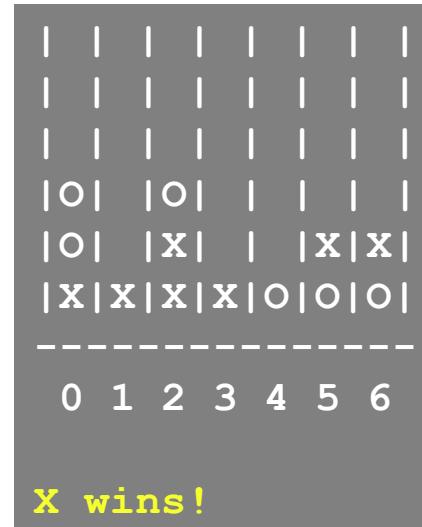
at the command line:

```
(30)% python -i hw11pr1.py
>>> d = Date(3,4,2009)
>>> d.dow()
Wed
```

an object-based Date calculator

ASCII Connect 4

```
p1 = Player('X',2)
p2 = Player('O',0)
b = Board(6,7)
b.playGame(p1,p2)
```



Connect Four with lookahead

CS 1 at HMC

traditional, mostly imperative, Java

wk 1-2: variables
wk 3-4: control
wk 5-6: functions
wk 8-9: arrays
wk 10-: objects

```
|   | ****|   | ****|   |   |   |
|   | ****|   | ****|   |   |   |
|   | ****|   | ****|   |   |   |
|   | ****|   | ****|   |   |   |
0   1   2   3   4   5   6

Choose a light: 2

|   |   | ****|   |   |   |
|   |   | ****|   |   |   |
|   |   | ****|   |   |   |
|   |   | ****|   |   |   |
0   1   2   3   4   5   6

Choose a light: 1

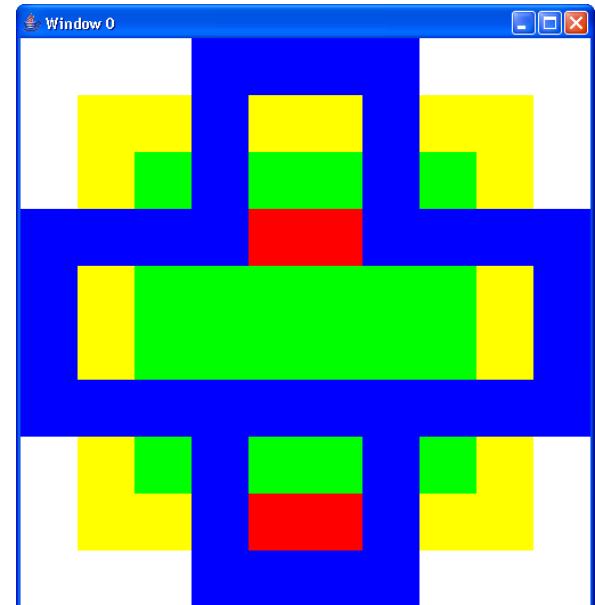
|****|****|   |   |   |   |
|****|****|   |   |   |   |
|****|****|   |   |   |   |
|****|****|   |   |   |   |
0   1   2   3   4   5   6

Choose a light: 0
You win!
```

lights out

'mystery' function

```
f("onyx","balk") == 13.0
f("adds","beet") == 1.0
f("zach","bach") == 0.5
```



abstract(ion) art

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- CC 2001

breadth-first



breadth-last

the breadth-first model has not enjoyed the success that its proponents had envisioned... most breadth-first courses that exist today seem to be lead-ins to a more traditional programming sequence

- CC 2001

Goals:

- develop computational skills sufficient for CS 2 and useful for any scientific field of study
- draw more students, especially women, to CS
- build a context for CS: an important field of study

CS 1 for scientists



2-3 lectures per week, 1 lab
two experience-based sections

CS breadth



AI breadth

Weeks	Paradigm	AI-themed labs and assignments
1-3	functional	integration, random walks, ciphers
4-6	machine-level	recursion in assembly, 4-bit multiplier
7-9	imperative	Markov text generation, Conway's life
10-12	objects+classes	Connect Four player, Date calculator
13-15	theory/projects	uncomputability, finite-state machines