Computing Across Domains

Leo Porter

Computer Science and Engineering

UC San Diego

Schedule (tentative)

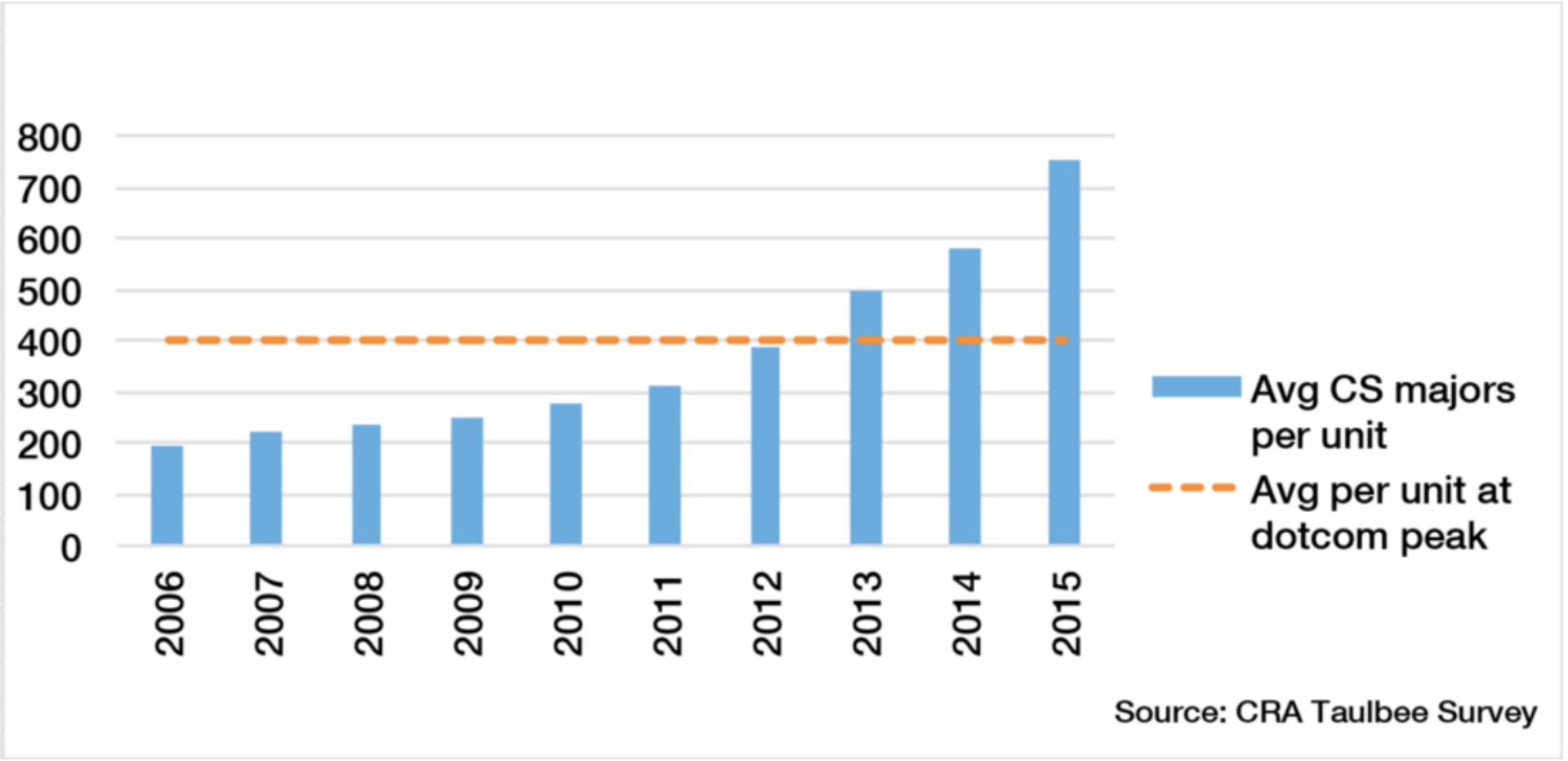
- State of computing / computer science
- ACTIVITY – Goal Design
- Best Practices in Computer Science
- ACTIVITY - Common Student Misconceptions
- Wrap-Up

STAND UP!

- Beach or mountain snow?
- Morning person or Night person?
- Java or Python?

- Name, Institution, Discipline, Goal for this workshop (1 sentence)

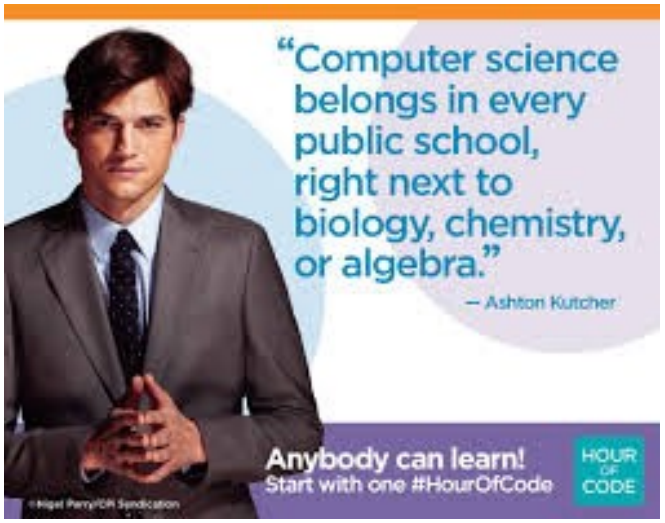
Computer Science – The Good



http://cra.org/data/generation-cs/phenomenal-growth-cs-majors-since-2006/

Computer Science – The Good

HOUR OF CODE



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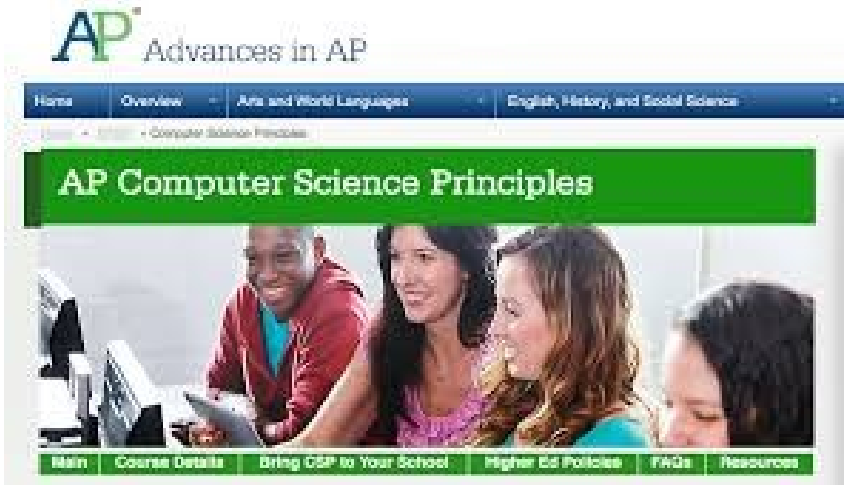


Computer Science – The Good

national center for women & INFORMATION TECHNOLOGY

ANITA BORG INSTITUTE
GRACE HOPPER
CELEBRATION OF WOMEN IN COMPUTING

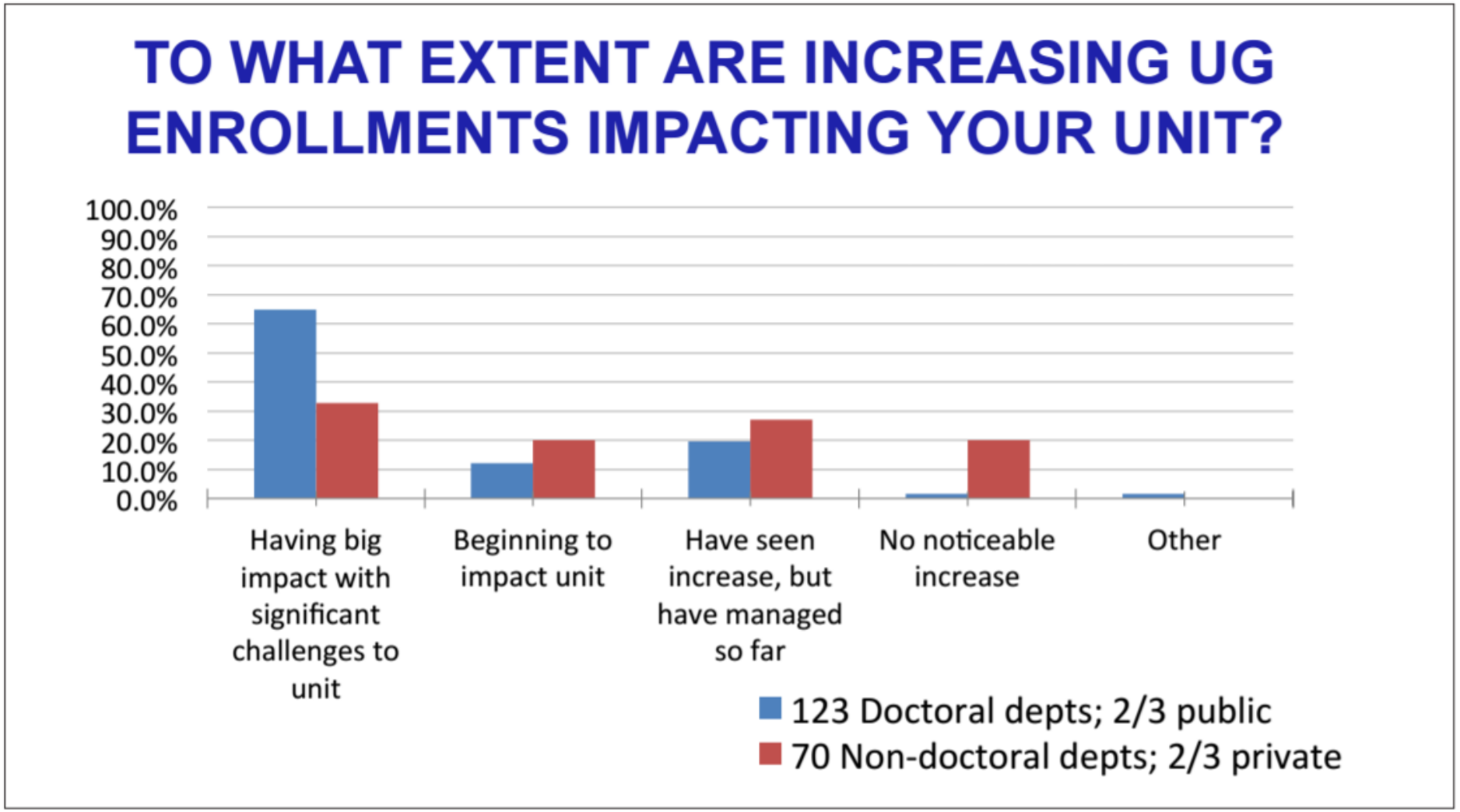
NSBE
NATIONAL SOCIETY OF BLACK ENGINEERS

NCWIT Engage CS Edu

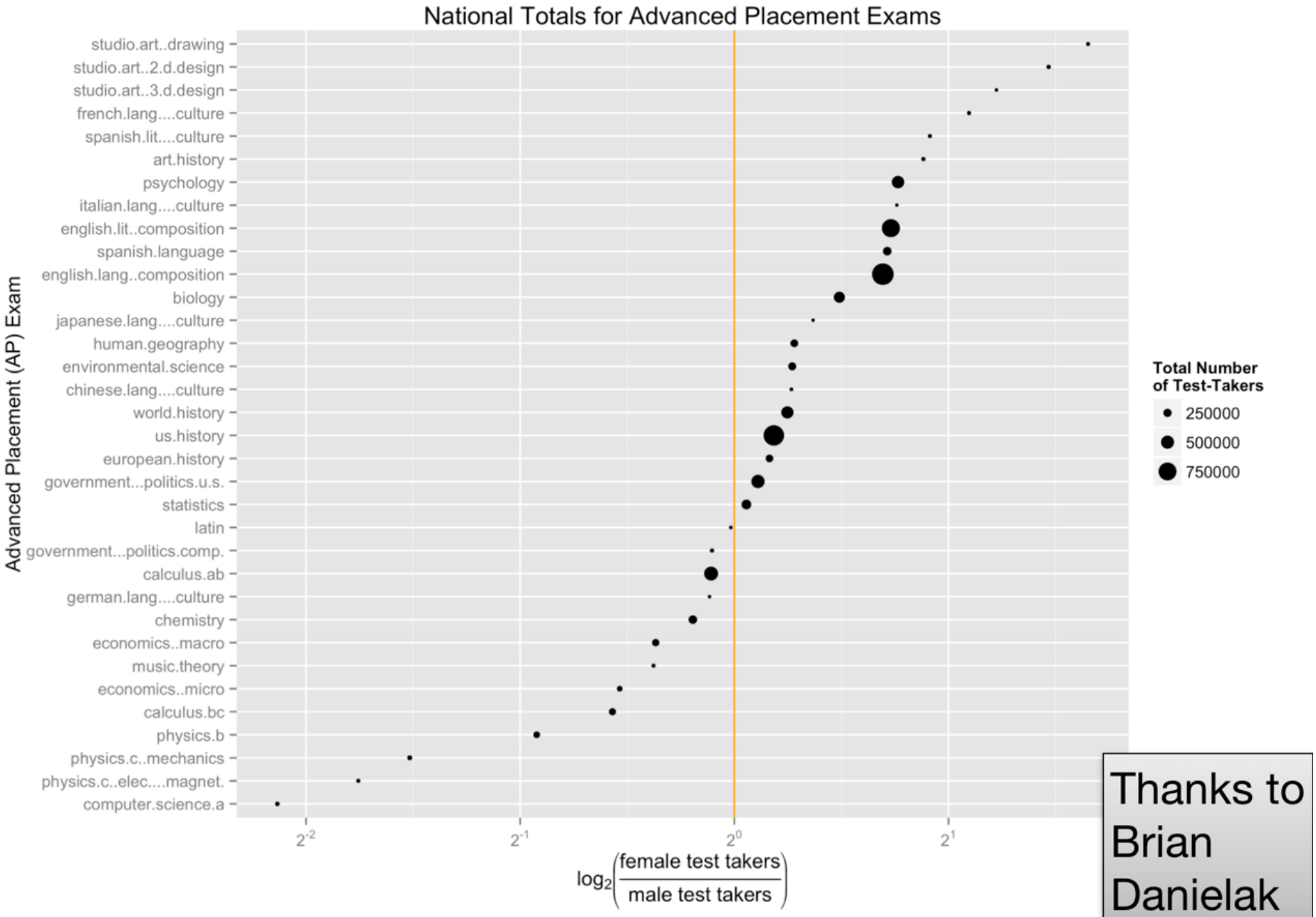
Society of Hispanic Professional Engineers
Changing Lives... Empowering Communities... Impacting the World...

Computer Science – The Maybe

Computer Science – the Concerning

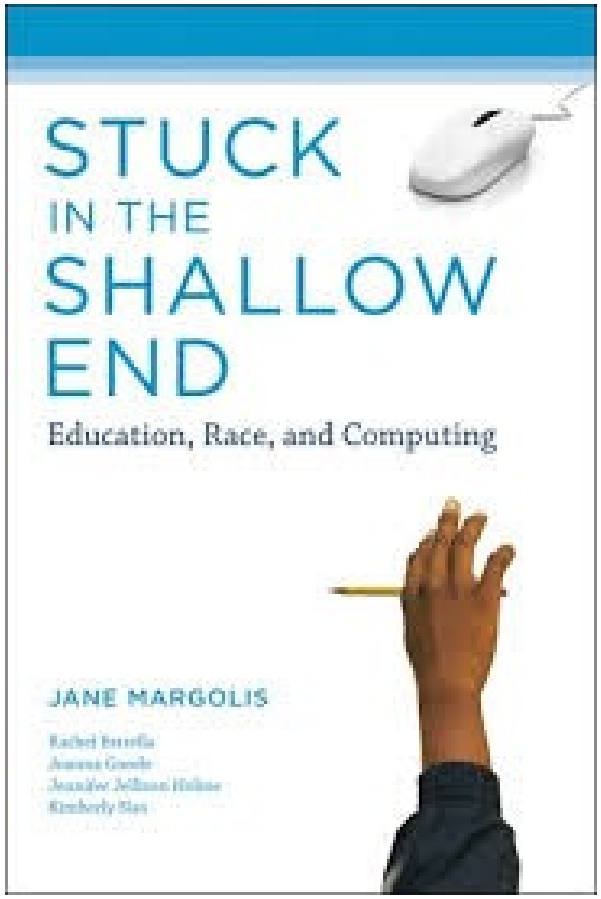


Lawrence M. Fisher. 2016. Booming enrollments. *Commun. ACM* 59, 7

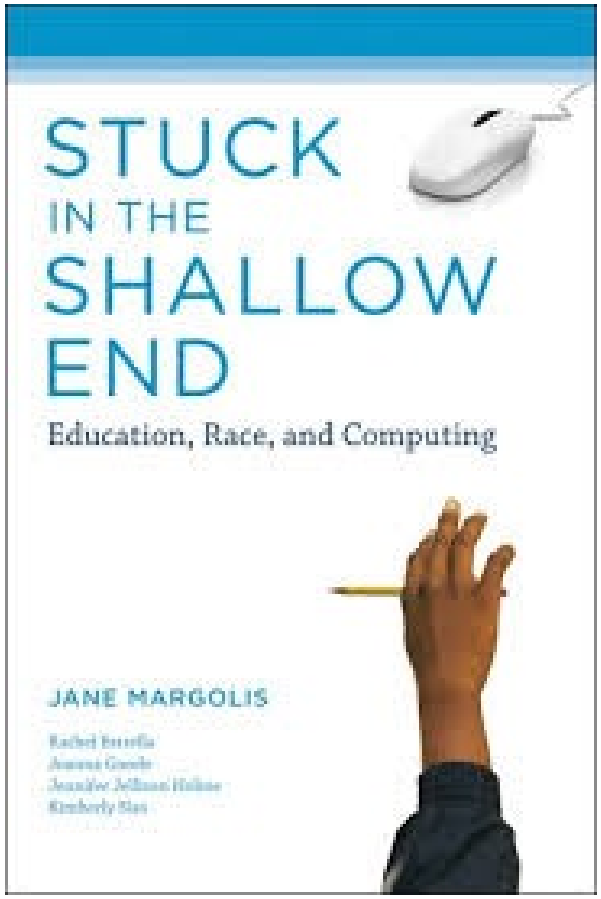


Thanks to Brian Danielak

Computer Science – the Concerning



Computer Science – the Concerning



"There is all of this inequity built up no matter what courses you have taken through your elementary years and by the time you get to high school, at least how things work now, you are trapped by what math classes you had and your prior success/failure."

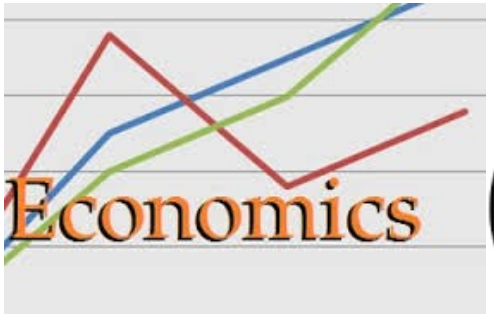
- Gail Chapman (Director ECS)

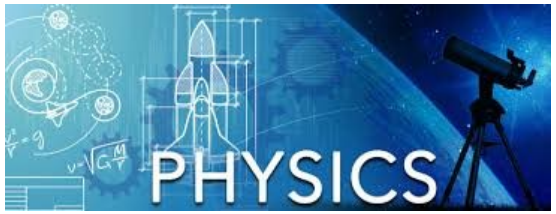
Computer Science – the Concerning

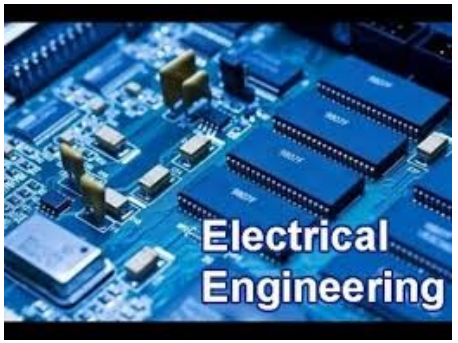
Talent?

Prior Experience…

Computing Distributed or Fractured?





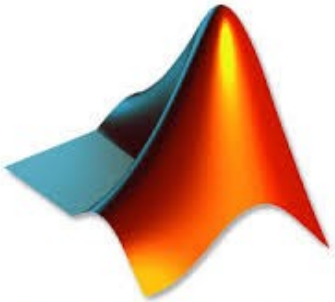


Are languages/tools getting in the way?

Java

C

C++



MATLAB
The Language of Technical Computing

IBM
SPSS

Computer Science Changing

- Traditional CS
  - Algorithms
  - Theory
  - Operating Systems
  - Architecture
  - Programming Languages
  - Compilers

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- New CS?
  - HCI
  - Software Engineering
  - Security
  - Robotics
  - AI/ ML
  - Vision / Graphics
  - CS Education

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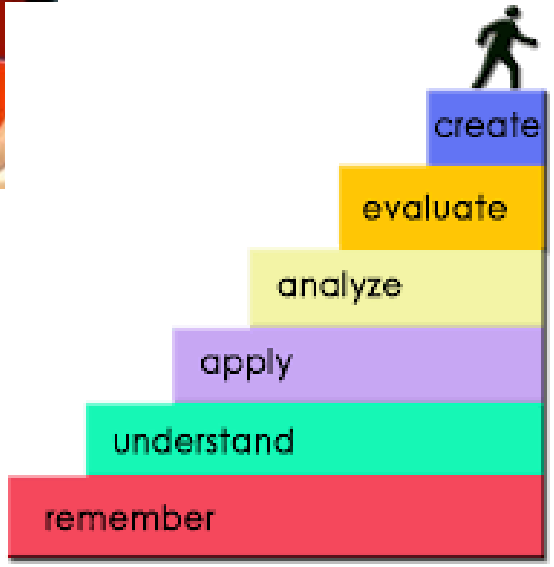
What do we all have in common?

- Shifting Tools

- Students

- Learning Objectives



Schedule (tentative)

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- Best Practices in Computer Science
- ACTIVITY - Common Student Misconceptions
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Learning Goal Activity

- Program Level Learning Goals

"After graduation, students will be able to assess the impact of computing on society."

- Course Level Learning Goals

"At the end of this course, students will be able to select the appropriate data structure API to solve a problem."

@11:40 we'll come together and talk as a group

Program Level Link: goo.gl/g51rrl
Course Level Link: goo.gl/Fhqsfv

Learning Goal Activity

1. Form a group of 2-4 people from your area (if possible) – 20 min.
   1a. Write your own
   1b. Swap and revise
2. Group by table (Program vs. Course) – 15 min.
   2a. Share your findings
   2b. Revise and find common themes
3. Report to entire group – 15 min

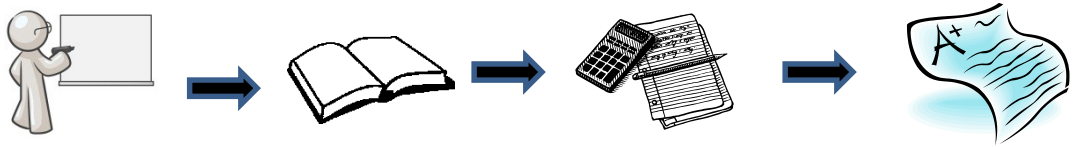
Program Level Link: goo.gl/g51rrI
Course Level Link: goo.gl/Fhqsfv

Schedule (tentative)

- State of computing / computer science
- ACTIVITY – Goal Design
- **Best Practices in Computer Science**
  - Peer Instruction
  - Computing in Context
  - Pair Programming
- ACTIVITY - Common Student Misconceptions
- Wrap-Up

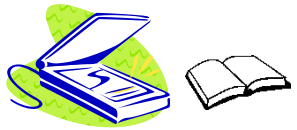
What is it?
Flipped Classroom with Peer Instruction

Lecture → Textbook → Homework → Exam



First Exposure → Read Hard Stuff → See if You Know Hard Stuff → Show Knowledge Mastery

Textbook/ Online mini-lecture → QUIZ → Lecture → Homework → Exam

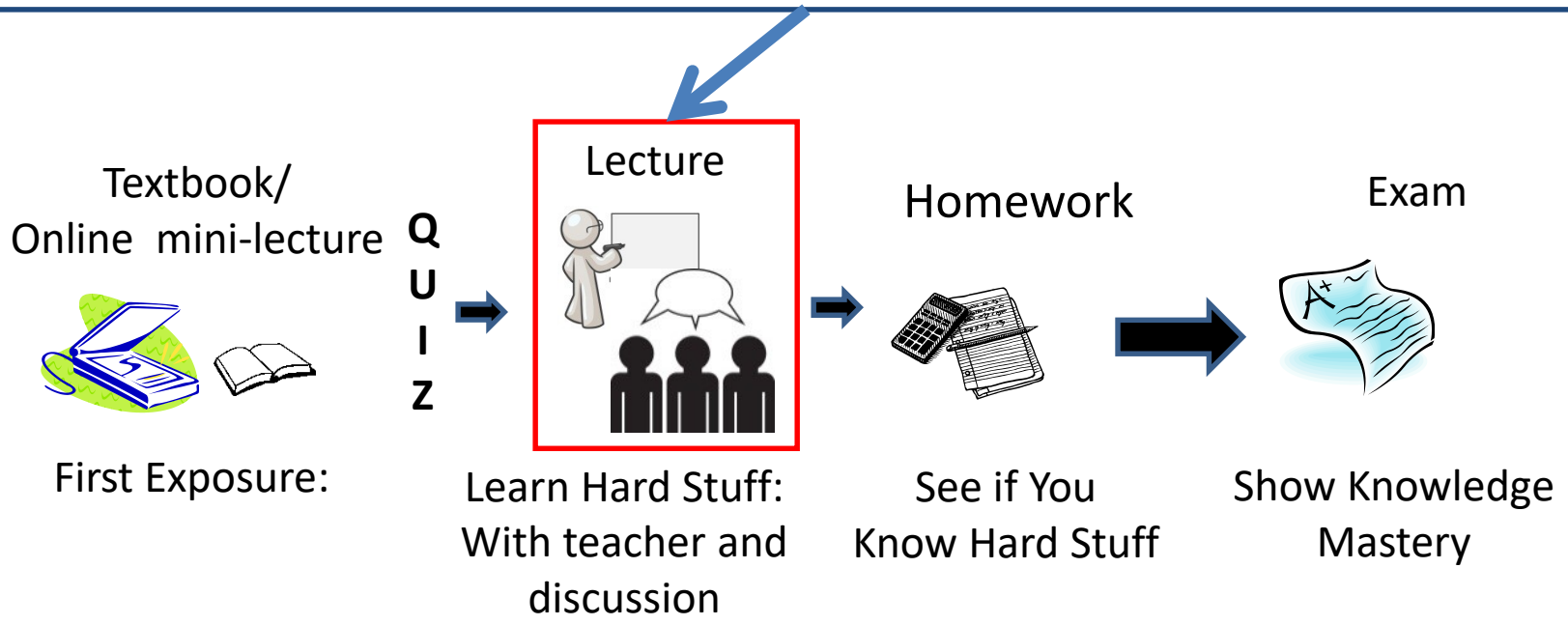


First Exposure: | Learn Hard Stuff: With teacher and discussion | See if You Know Hard Stuff | Show Knowledge Mastery

What is it?

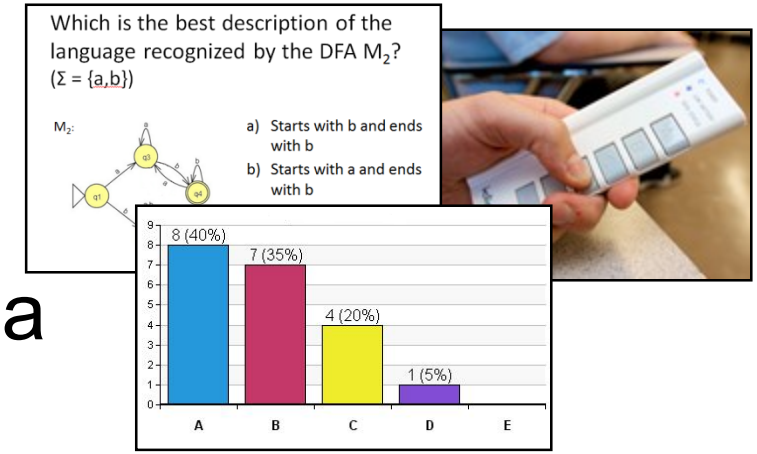
Multiple approaches here:

1. Think-Pair-Share (TPS)
2. Problem Based Learning (PBL)
3. Process Oriented Guided Inquiry Learning (POGIL)
4. Peer Instruction (PI)
5. Others



Peer Instruction

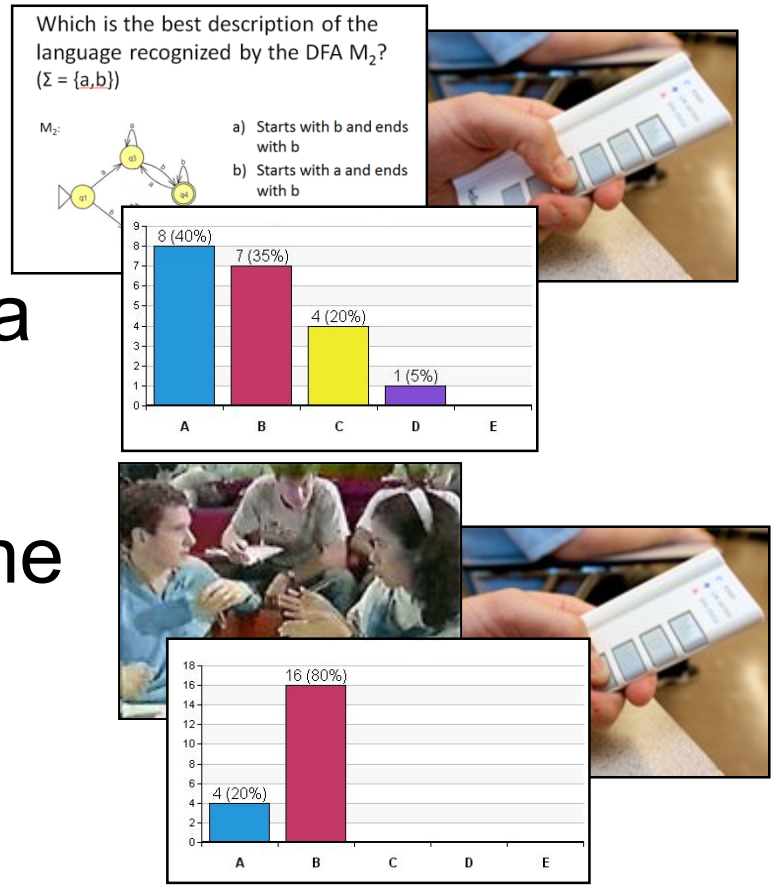
1. Students individually consider and respond to a multiple choice question



Mazur, E. *Peer Instruction: A User's Manual.* Prentice Hall, 1997.

Peer Instruction

1. Students individually consider and respond to a multiple choice question
2. Students discuss the same question in groups, then submit another response



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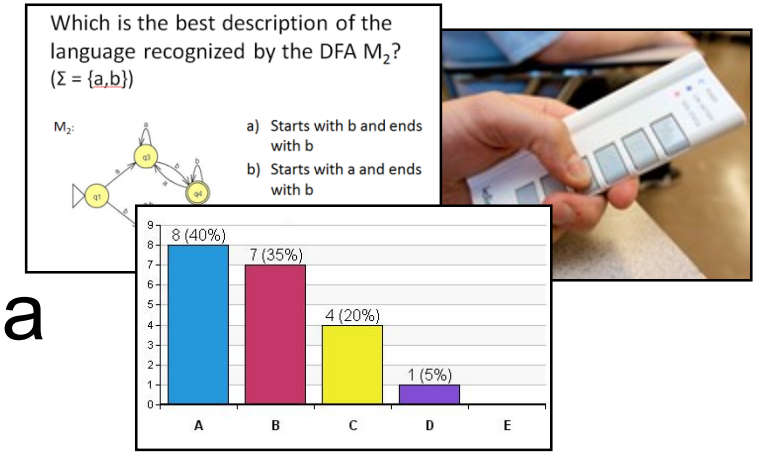
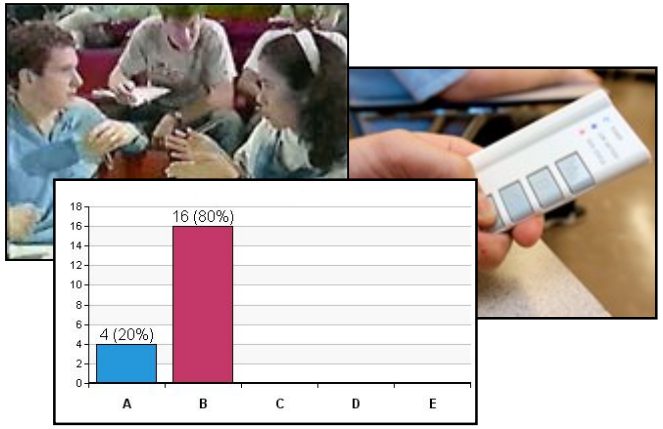
Peer Instruction

1. Students individually consider and respond to a multiple choice question
2. Students discuss the same question in groups, then submit another response
3. Instructor guides students in a class-wide discussion





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Peer Instruction in Computer Science

- Improved final exam performance [Simon et al. SIGCSE`13; Zingaro et al. SIGCSE`16]
- Reduced Failure Rates by 67% [Porter et al. SIGCSE`13]
- Students Learn from Discussion [Porter et al. ICER`11]
- Peer Discussion and Instructor Explanations are complementary and Hard Questions offer best opportunity for Learning [Zingaro and Porter, C&E`14]
- Students overwhelmingly value Peer Instruction and desire more faculty use it [Porter et al., ITiCSE`13; Porter et al., SIGCSE`16]
- Can provide valuable data for predicting student outcomes [Porter et al., ICER`14; Liao et al., ICER'16]

Contextualized Computing Education

- Teaching computing in relation to an application domain or a community of practice.

- Teach similar concepts as in equivalent non-contextualized classes, but can also teach concepts relevant to the domain.

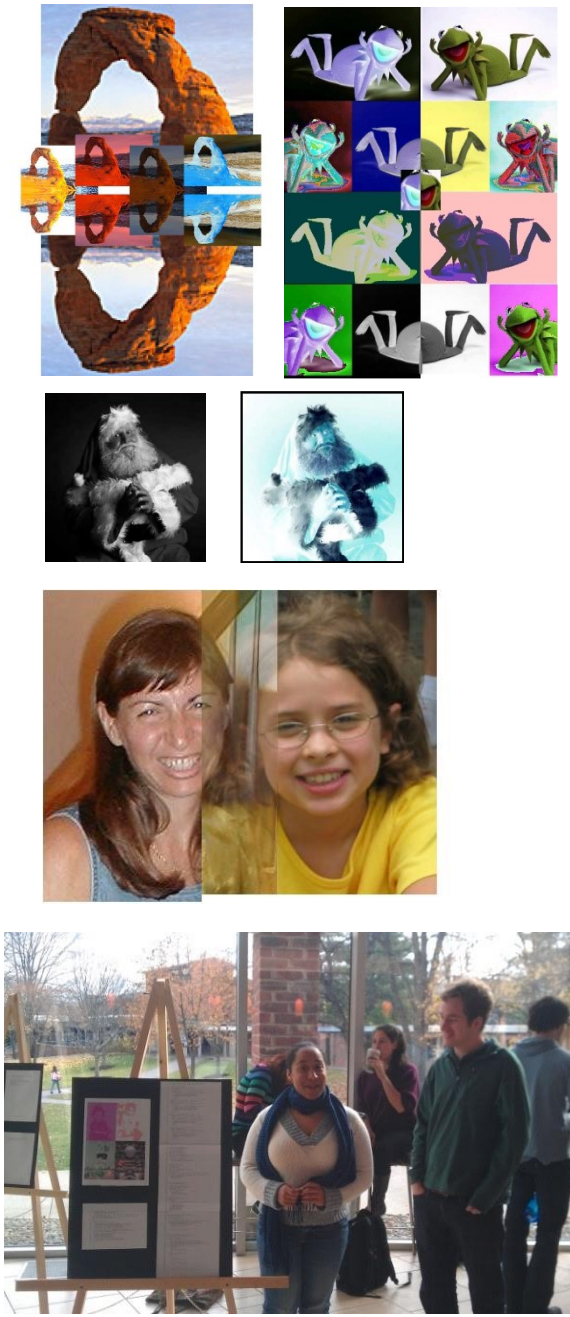
Thank you to Mark Guzdial for the base slides for Computing in Context.

Media Computation: Teaching in a Relevant Context

- Computing for Liberal Arts, Architecture, and Business/Management students at Georgia Tech.

- Programming across data abstractions
  - Iteration for creating negative and grayscale images
  - Indexing in a range for removing redeye
  - Algorithms for blending both images and sounds
  - Visualization of sounds

- **Opportunity for creative computing.**



Media Computation: Results at GT

Change in Success rates in CS1 (2002-2004)		
	Pre-MediaComp	Post-MediaComp
Architecture	*46.7%*	85.7%
Biology	*64.4%*	90.4%
Economics	*54.5%*	92.0%
History	*46.5%*	67.6%
Management	*48.5%*	87.8%
Public Policy	*47.9%*	85.4%

Other Examples

- Video game development and testing (e.g., diSalvo's *Glitch*)
- Robotics
- Community service learning, e.g., "Computing for Good."

Pair Programming

- Pair or group collaboration on closed lab work
- Pair or group collaboration on homework assignments
- Enables certain forms and scope of projects that would not be possible without group work, …
- but can also be a policy change on existing assignments unchanged

Thank you to Cynthia Lee for the slides on Pair Programming.

Pair Programming

- Two students program together
  - Driver – at keyboard
  - Navigator – advising

Thank you to Cynthia Lee for the basis of these slides on Pair Programming.

Best practices/research findings

(summary from [Rodriguez et al. SIGCSE 2017])

- Encourage robust and continuous discussion
- Navigator should speak the most, but encourage interaction with driver by asking an open-ended question (rather than a yes/no question)
- Foster culture of valuing expressions of uncertainty and confusion
- When both partners are confused or too much uncertainty exists, recognize need for outside help

Research findings

(summary from [Braught et al. TOCE 2011])

- Greater **mastery** of programming skills
- Greater likelihood of **successful course completion**
- **Improved attitudes** toward programming and IT in general
  - Myth-busting the "loner coder"
- Increased **confidence** in programming abilities
- Closer to **real world** work than traditional homework experiences [Williams et al. SIGCSE 2007]
- Increased **retention** into subsequent computer science courses, and improved performance in those courses
- A best practice for **inclusion**
  - Benefits seen specifically for **African American millennials** [Williams]

Putting it all together: Retention in CS1

- Modified CS1 to contain a "Trio" of Best Practices
  - Context: Media Computation
  - Community: Paired Programming
  - Pedagogy: Peer Instruction

- Post-hoc analysis of the past 10 years of CS1

Porter, L. and Simon, B. Retaining Nearly One-Third more Majors with a Trio of Instructional Best Practices in CS1. SIGCSE, March 2013.

Dataset Characteristics

	CS1-Before Previous Version	CS1-BP New Version
Timeframe	FA01-SP08	FA08-WI11
Course Instances	18	9
Instructors	5	4
Overall Enrollment Week 1	2067	1371
Percentage CS/E Majors	46%	52%
Non-Majors (Male/Female)	66% / 34%	60% / 40%
Majors (Male/Female)	81% / 19%	76% / 24%

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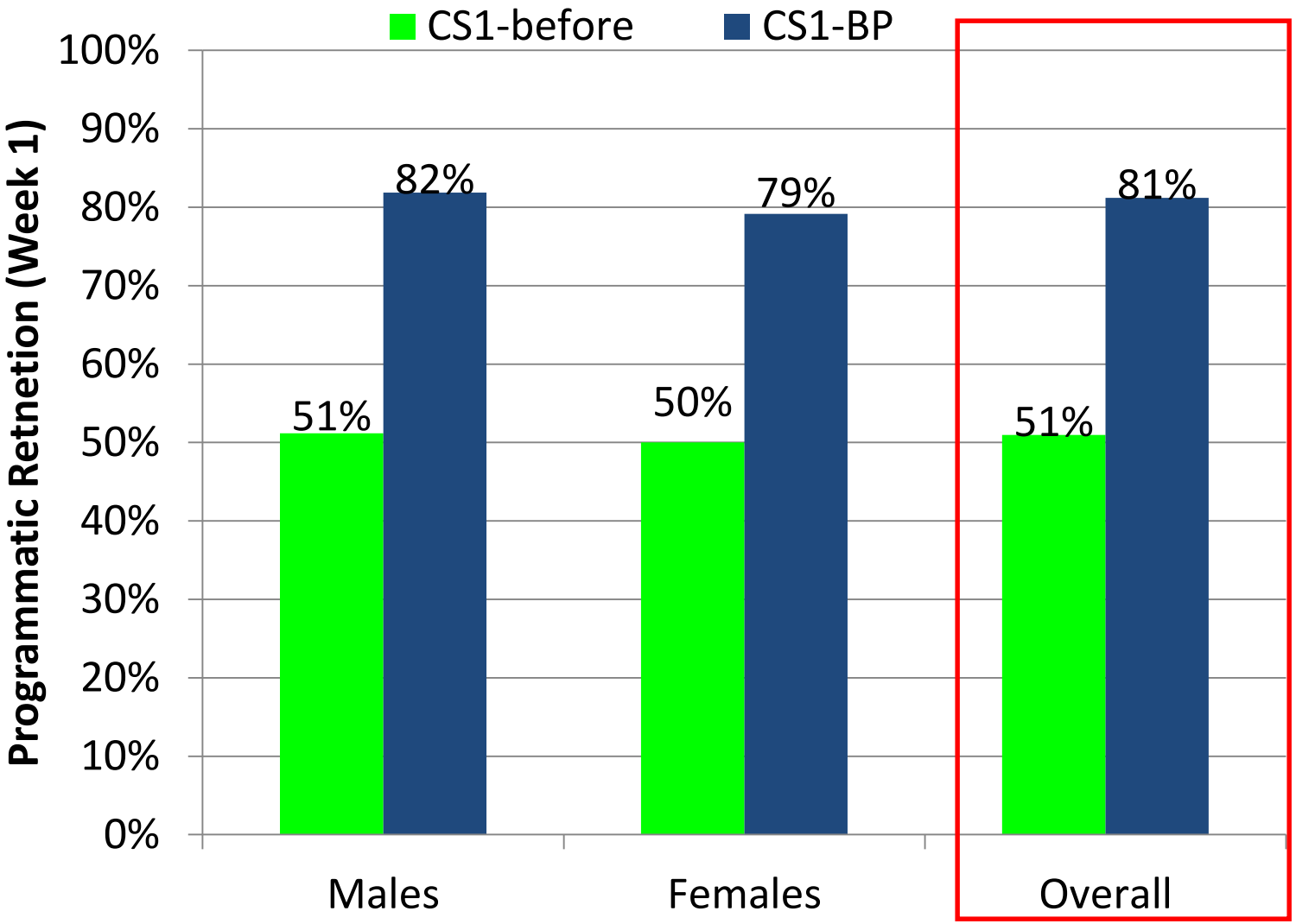
1-yr Major Retention



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python

```
>>> x = 7
>>> y = x
>>> x = 3
>>> print(x,", ",y)
```

What is printed?

A. 7, 3
B. 3, 7
C. 3, 3
D. 7, 7

Explain in plain English, what does this code do?

```
// array arr is initialized before this
boolean bValid = true;
for (int i = 0; i < arr.length-1; i++) {
    if (arr[i] > arr[i+1]) {
        bValid = false;
    }
}
```

Jacqueline L. Whalley, Raymond Lister, Errol Thompson, Tony Clear, Phil Robbins, P. K. Ajith Kumar, and Christine Prasad. 2006. An Australasian study of reading and comprehension skills in novice programmers, using the bloom and SOLO taxonomies. In Proceedings of the 8th Australasian Conference on Computing Education - Volume 52 (ACE '06), Denise Tolhurst and Samuel Mann (Eds.), Vol. 52.

python

```
>>> x = [10,20,30]
>>> y = x
>>> x[1] = 42
>>> print(y)
```

What is printed?

A. **[10, 20, 30]**
B. **[10, 42, 30]**
C. **Error**

```
def swap(val1, val2):
      tmp = val1
      val1 = val2
      val2 = tmp


x = 6
y = 3
swap(x, y)
print(x,", ",y)
```

What is printed?

A. 6, 3
B. 3, 6
C. 3, 3
D. 6, 6

Function 1

```
def my_abs(val):
        if val < 0:
                return 0-val
        return val
```

Function 2

```
def my_abs(val):
        if val < 0:
                print 0-val
        else:
                print val
```

Which function returns the absolute value of "val"?

A. Function 1
B. Function 2
C. Both
D. Neither

How many times is each set of code executed?

```
Pixel[] pixelArray = this.getPixels();
int value = 0;
Pixel p  = null;
int index = 0;
while (index < pixelArray.length)
{
  value = pixelArray[index].getRed();
  value = (int) (value * 0.5);
  pixelArray[index].setRed(value);
  index = index + 1;
}
```

Sect A

Sect B

Sect C

Sect D

	Sect A	Sect B	Sect C	Sect D
A	Many	Many	1	1
B	Many	Many	Many	1
C	1	1	Many	Many
D	1	1	1	Many

Rainfall Problem (variant)

Write a method that will be given an array of integers and will calculate and return (as a double) the mean (average) of all the integers in the array.

64% is the average student performance at multiple institutions at the end of CS1

Simon, Judy Sheard, Daryl D'Souza, Peter Klemperer, Leo Porter, Juha Sorva, Martijn Stegeman, and Daniel Zingaro. 2016. Benchmarking Introductory Programming Exams: Some Preliminary Results. In Proceedings of the 2016 ACM Conference on International Computing Education Research (ICER '16).

Wrap Up - Questions

- Resources for Peer Instruction:

peerinstruction4cs.org

- Resources for Media Computation

http://coweb.cc.gatech.edu/mediaComp-teach

- Resources for Pair Programming

http://dl.acm.org/citation.cfm?id=563353