Computer Science Teacher Professional Development: Towards a Research Agenda on Teacher Thinking and Learning

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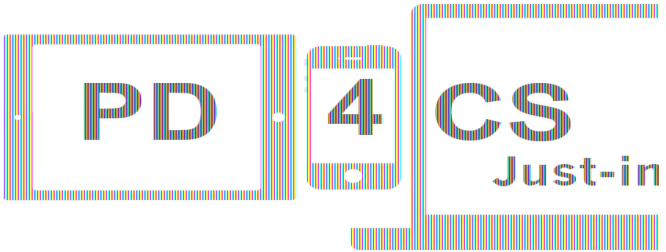
Guiding Questions

What kinds of experiences do students need to learn computer science, to be confident to pursue computing?

What kinds of knowledge do CS teachers need to have to facilitate these learning experiences?

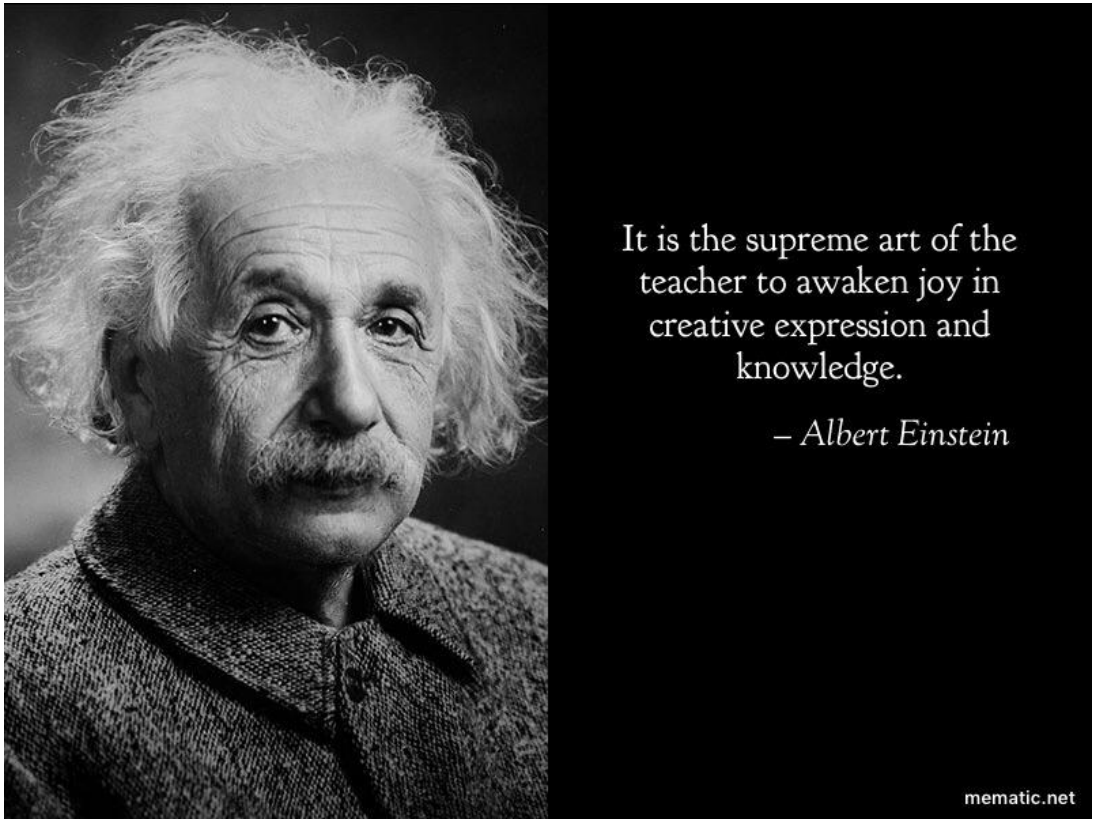
What kinds of experiences do teachers need to develop these kinds of knowledge?

CS Education work



CT4EDU

National Science Foundation Grants: CNS-0938999; 1502462; 1738677

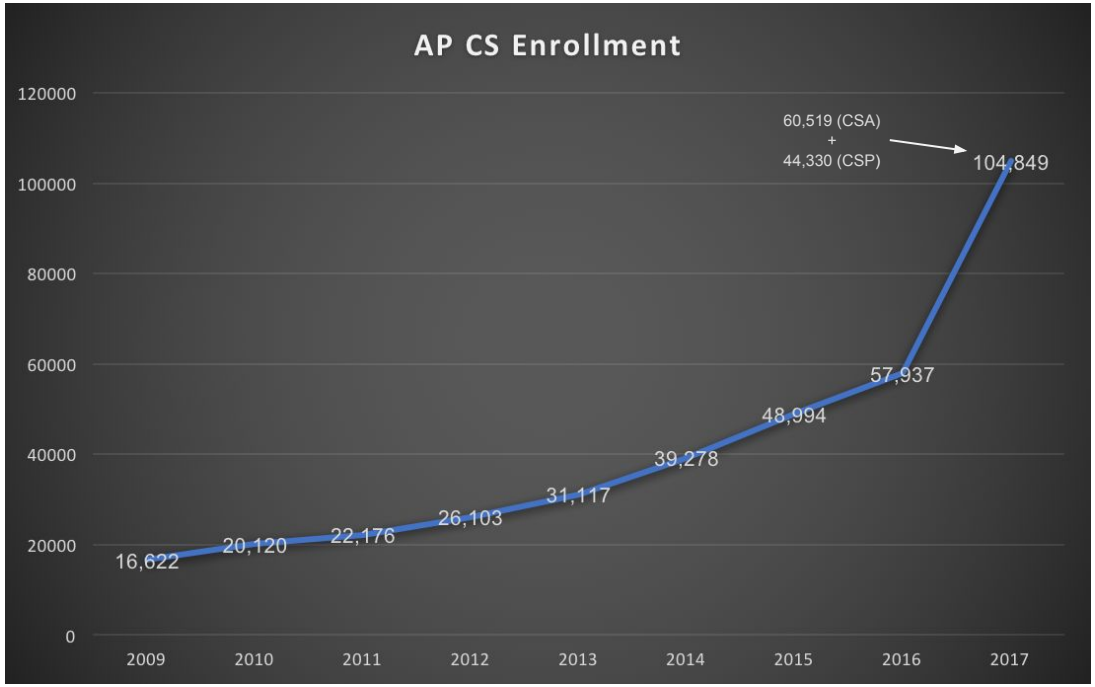

It is the supreme art of the teacher to awaken joy in creative expression and knowledge.
– Albert Einstein
mematic.net

Fostering Creativity through Computing

"Creativity and computing are prominent forces in innovation; the innovations enabled by computing have had and will continue to have far-reaching impact." (College Board, 2014)

Source: Yadav A., & Cooper, S. (2017). Fostering creativity through computing. *Communications of the ACM, 60* (2), 31-33.

AP CS Principles



CS10K to CSforALL

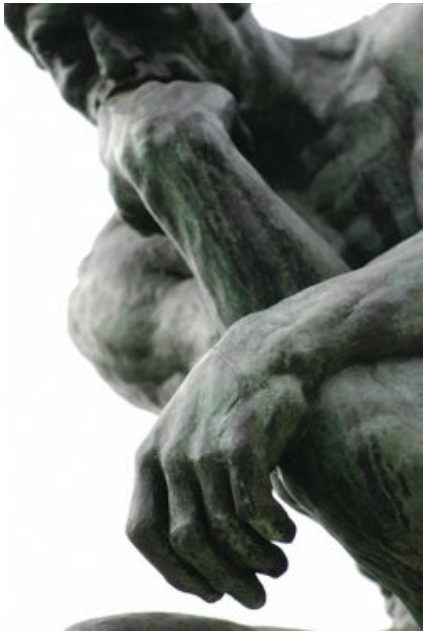
- To meet the growing demand/need for CS, we need:
  - Training new teachers in the teaching of computer science
  - Creating in-service opportunities for current teachers
  - Increasing education research in computer science.

The first take: CS4EDU

- Create new pathways for undergraduate education majors to become computationally educated secondary teachers
  - Computational Thinking Modules (Yadav, et al., 2014; Yadav, et al., 2011)
  - Contemporary Issues in Computing
  - Coursework in CS
  - Methods of Teaching Computer Science (Yadav & Korb, 2012)

Computational Thinking for Teacher Ed

- Introduction to Educational Technology
- Methods/Pedagogy Courses



Yadav, A., Stephenson, C., & Hong, H. (2017). Computational thinking for teacher education. *Communications of the ACM, 60* (4), 55-62. DOI:10.1145/2994591

Training New Teachers

- Bugs in the System
  - Roadblocks
- Teacher Professional Development

Source: http://blog.firebrandtalent.com/2014/11/the-new-skills-you-need-for-the-digital-age/

Challenges of Teaching Computer Science

"I think in general anything that's new to me that I don't have a lot of experience with is challenging to teach because now I'm not only trying to understand it myself but I'm trying to distill it in a way to help students understand it better."

Source: http://hechingerreport.org/should-computer-assisted-teaching-expand-its-reach-to-more-states/

Yadav, A., Gretter, S., Hambrusch, S. & Sands, P. (2016). Expanding computer science education in schools: Understanding teacher experiences and challenges. *Computer Science Education, 26*, 235-254.

Challenges of Teaching Computer Science

"The big challenge that I face when I teach CS is that it's very ... because of its student-centered nature teaching the subject, there's a lot of one-on-one during class time and this year I have 32 students in one section, and there is one me and 32 of them."

Source: http://hechingerreport.org/should-computer-assisted-teaching-expand-its-reach-to-more-states/

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Challenges of Teaching Computer Science

"I mean textbooks, all that material. Now, I don't have the textbook. I have to build all my own content. There's only one of me where we have a bunch of English teachers, a bunch of math, they work together whereas I have to do all my content alone, I don't have anybody else. Well I have the business department, but I'm the only one that does programming."

Source: http://metro.co.uk/2016/01/28/this-is-what-a-day-in-the-life-of-a-teacher-actually-looks-like-5650540/

Yadav, A., Gretter, S., Hambrusch, S. & Sands, P. (2016). Expanding computer science education in schools: Understanding teacher experiences and challenges. *Computer Science Education, 26*, 235-254.

Teachers as Adaptive Experts

Teachers' capacity is not a fixed storehouse of facts, but as a "source and creator of knowledge and skills needed for instruction"

Bransford, Darling-Hammond, & LePage, 2007

Source: http://www.sweetsugarbelle.com/2013/08/cookie-cutters-by-sweet-sugar-belle/

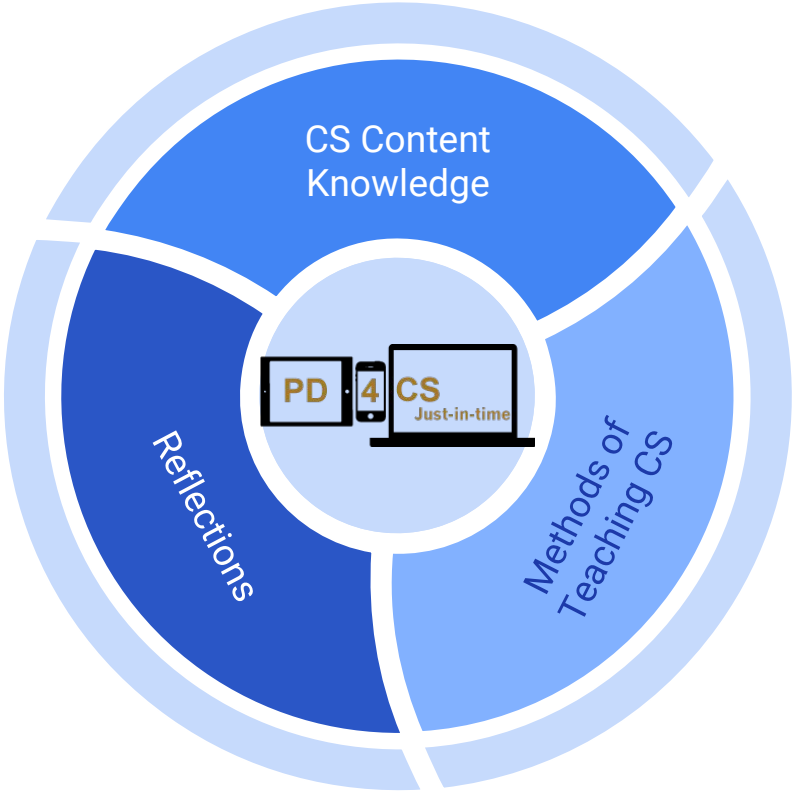
Teachers as Adaptive Experts

Think effectively and use knowledge flexibly

Online Professional Development

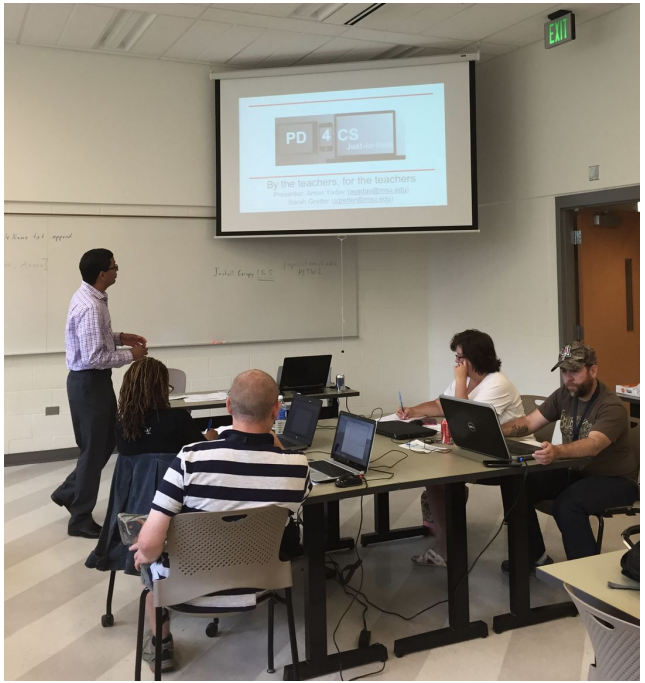
- Anytime, Anywhere (Macià & García, 2016)
- Similar learning outcomes as f-2-f (Fishman et al., 2013)
- Self-directed learning based on teachers' curricular and pedagogical needs (Ericson, et al., 2016)

Source: http://gocoderz.com/blog/online-professional-development/

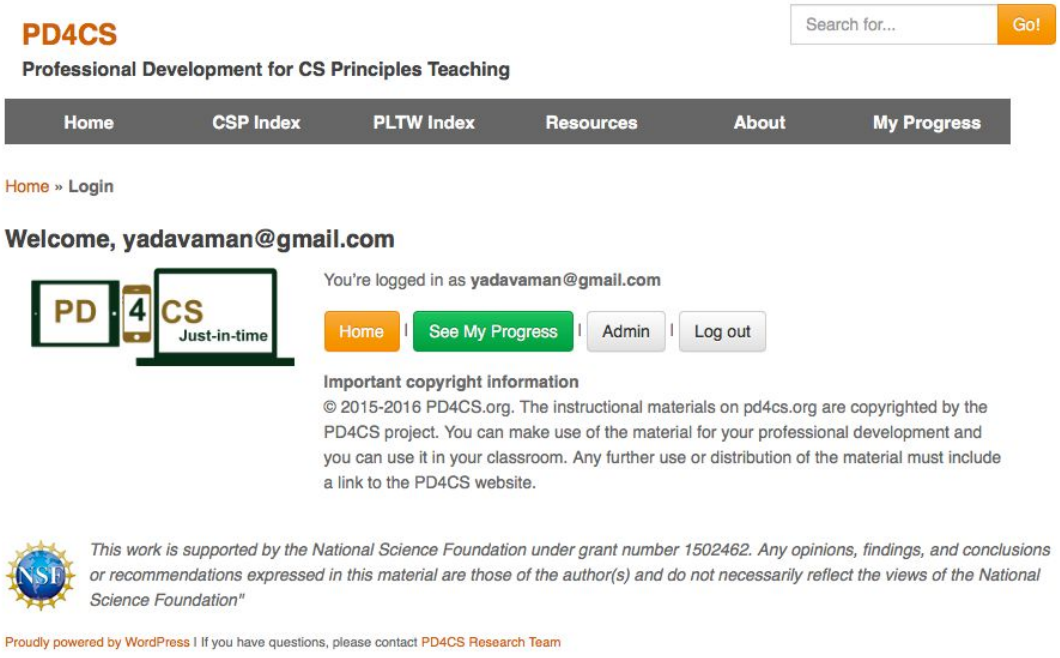

CS Content Knowledge
Methods of Teaching CS
Reflections
PD 4 CS
Just-in-time

PD4CS

- Traditional PD
  - Phase 1: Readiness Training
  - Phase 2: Core Training
- Just-in-time online PD



PD4CS: Organization



PD4CS: Organization

Basic Programming	Advanced Programming	Other CSP Topics
Variables Conditionals Data Structures Loops Functions	Debugging Classes & Objects Packages Algorithms Recursion	Internet Git & GitHub Information Security Simulation & Modeling Big Data Assessment Computing Degrees

Course Index

Unit 1: Algorithms, Graphics, and Graphical User Interfaces

CSP Index

BIG IDEA 1: CREATIVITY	
LO 1.1.1 Apply a creative development process when creating computational artifacts.	- Loops – Scratch - Loops – Nested Loops - Functions – A Class Project - Algorithms – Solving Problems
LO 1.2.1 Create a computational artifact for creative expression.	- Loops – Scratch - Loops – Nested Loops - Functions – A Class Project - Algorithms – Solving Problems - Recursion – Algorithms

How does teacher background influence their use of online professional development materials?

Source: http://cerps.info/159-2/

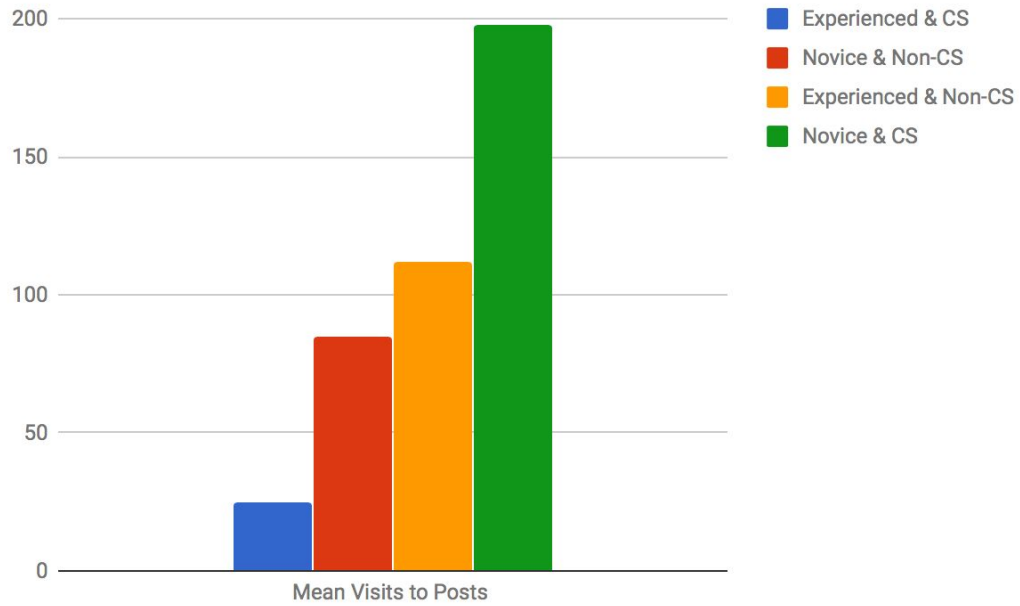
Data Sources

- Background Questionnaire
  - General Teaching Experience (Novice versus Experienced)
  - CS Experience (CS versus Non-CS).
- Website log files
- Interviews

PD4CS Usage

		Active Users	% Active
Novice & CS	6	5	83%
Novice & Non-CS	11	6	55%
Experienced & CS	17	8	47%
Experienced & Non-CS	43	28	65%
Total	77	47	61%

PD4CS Usage

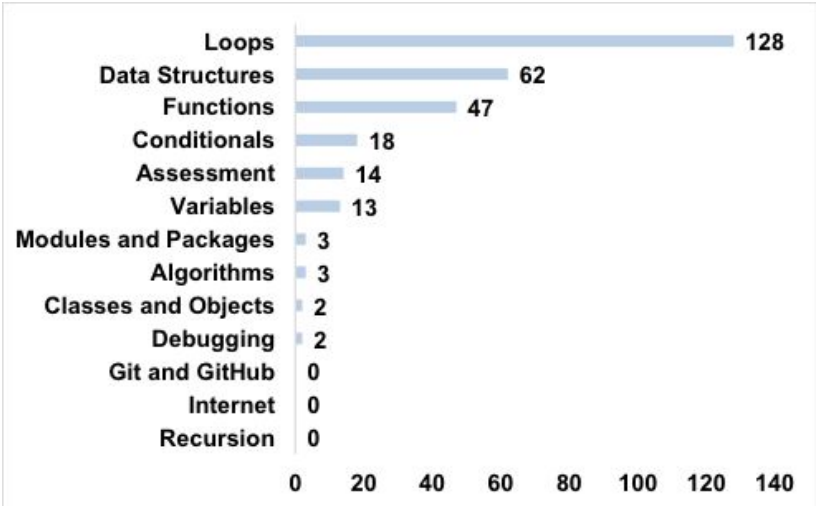

200
150
100
50
0
Mean Visits to Posts
Experienced & CS
Novice & Non-CS
Experienced & Non-CS
Novice & CS

"*I would have needed the website 10 years ago, but now my CS background is strong. I like the delivery and it would be useful for novices." (*Experienced & CS*)*

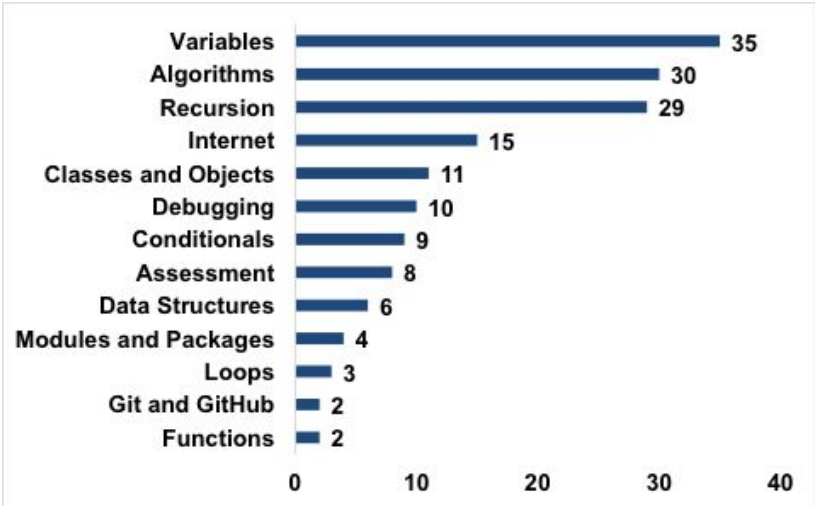
"*I can't ask for more support. I just need time to digest it." (*Non-CS teachers*)*

"The insane amount of examples and downloadable/linkable resources was very useful. I was able to show many different examples. The students really latched onto this section, partially because the concept of a loop is easier to understand, but also because the PD materials helped me be so thorough in teaching the content." (Novice & CS)

PD4CS Usage: Two Cases

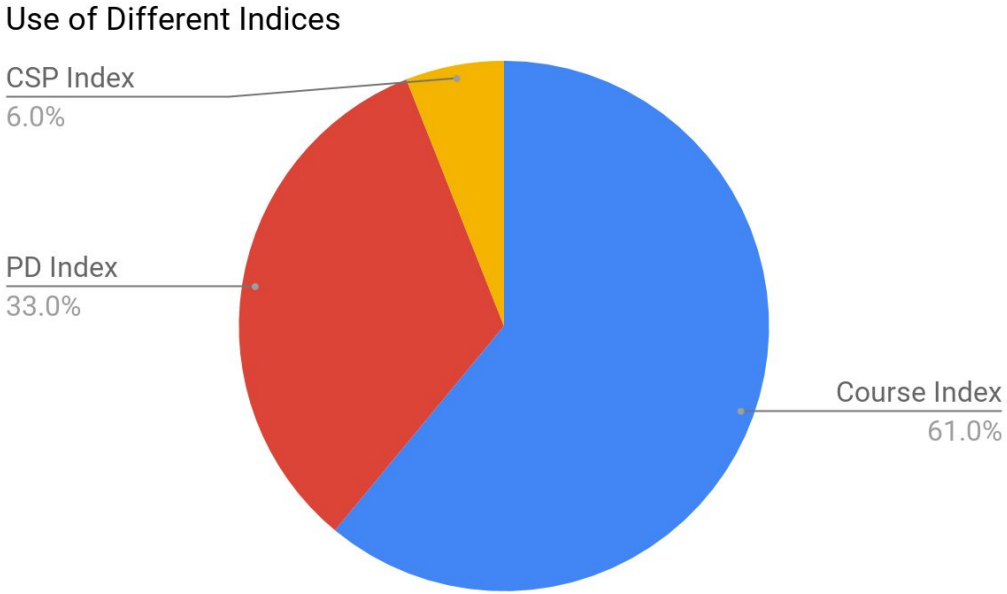


Michelle: A non-CS teacher



Sherri: A CS teacher

PD4CS Usage


Use of Different Indices
CSP Index
6.0%
PD Index
33.0%
Course Index
61.0%

Lessons Learned

- Meeting teachers where they are.
- Align PD to course curriculum
- Role of canned curriculum

Teacher Knowledge and Student Misconceptions

Loops – Student Misconceptions and Challenges

Misconceptions and challenges students have when creating and understanding loop constructs are often related to not yet having fully mastered other concepts. In particular, understanding the change of values assigned to variables, following the flow of execution in a more complex code structure, and the correct use of conditionals. This post discusses the following misconceptions and challenges:

- M&C1. Values of variables
- M&C2. Correct use of lists and arrays
- M&C3. Boolean expressions
- M&C4. Infinite loops
- M&C5. Nested loops
- M&C6. Debugging loops
- M&C7. There is no best loop construct
- M&C8. Using break and continue

Average Rating: 5 / 5

Teacher Knowledge and Student Misconceptions

PCK involves: “the conceptions and preconceptions that students of different ages and backgrounds bring with them to the learning of those most frequently taught topics and lessons”

Shulman (1986, p. 9)

Source:http://apasseducation.com/4-typical-student-misconceptions-that-every-science-course-writer-must-consider/

Teacher Knowledge and Student Misconceptions

Teachers' perceptions of student misconceptions in introductory programming

Relationships between teachers' perceptions and their background

Topic	# Misconceptions
Variables	9
Data Structures	6
Loops	8
Functions	9
OOP	5

Frequency (*F-score*)
Never (1) to Very Frequently (4)

Importance (I)
Not Important (1) to Very Important (4)

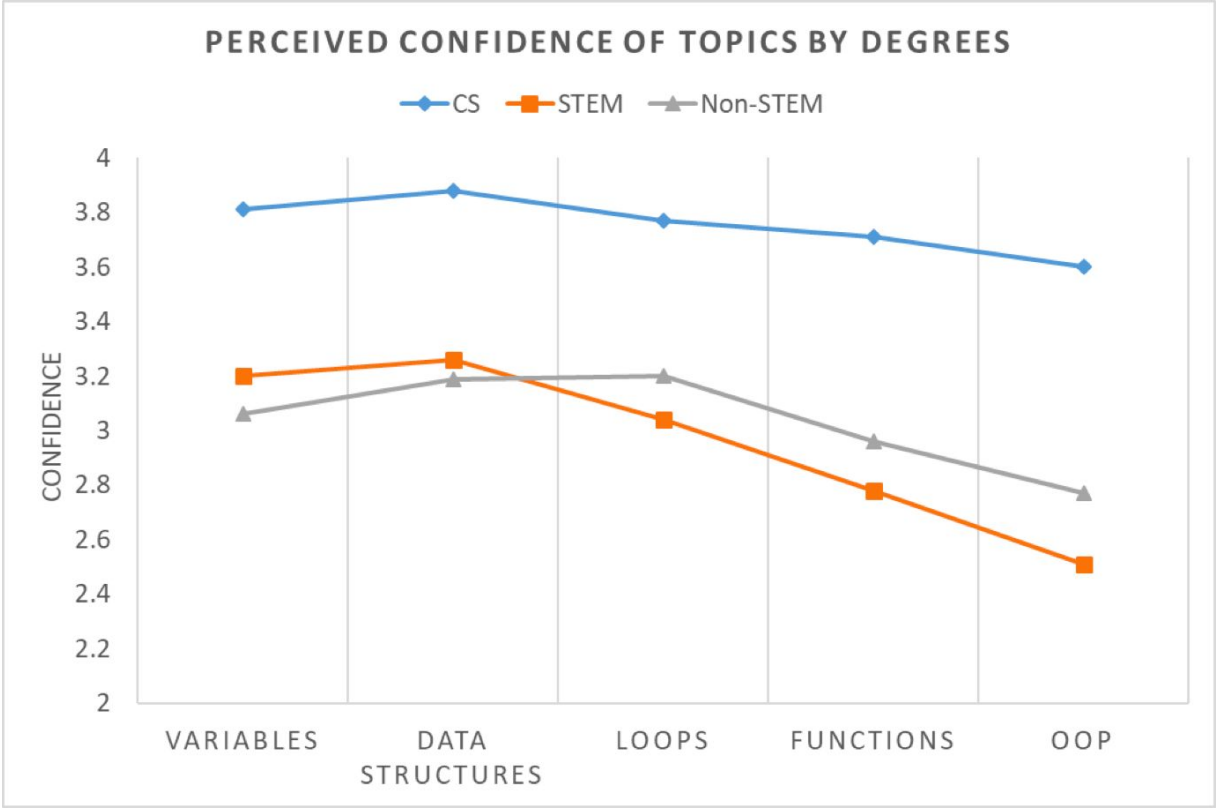
Confidence
Not Confident (1) to Very Confident (4)

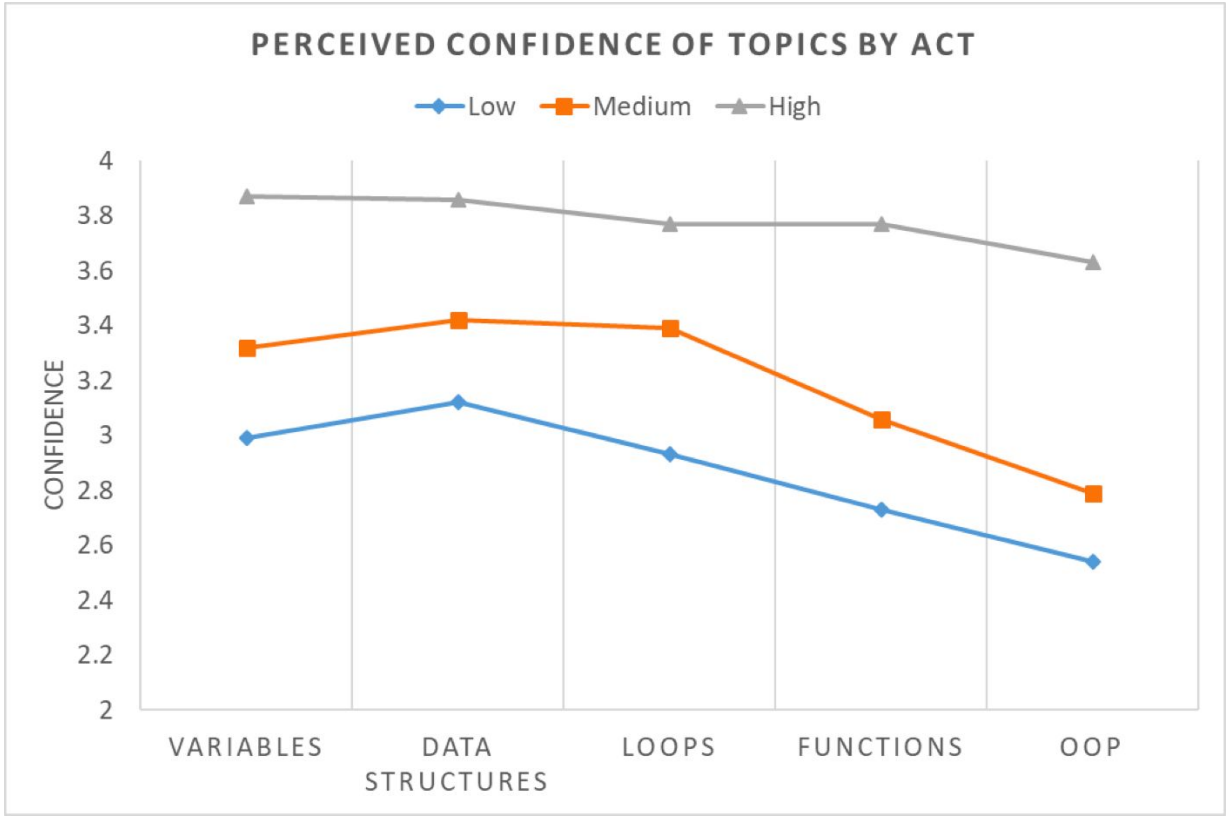
General Teaching Experience	
Novice	12 (27%)
Experienced	32 (73%)

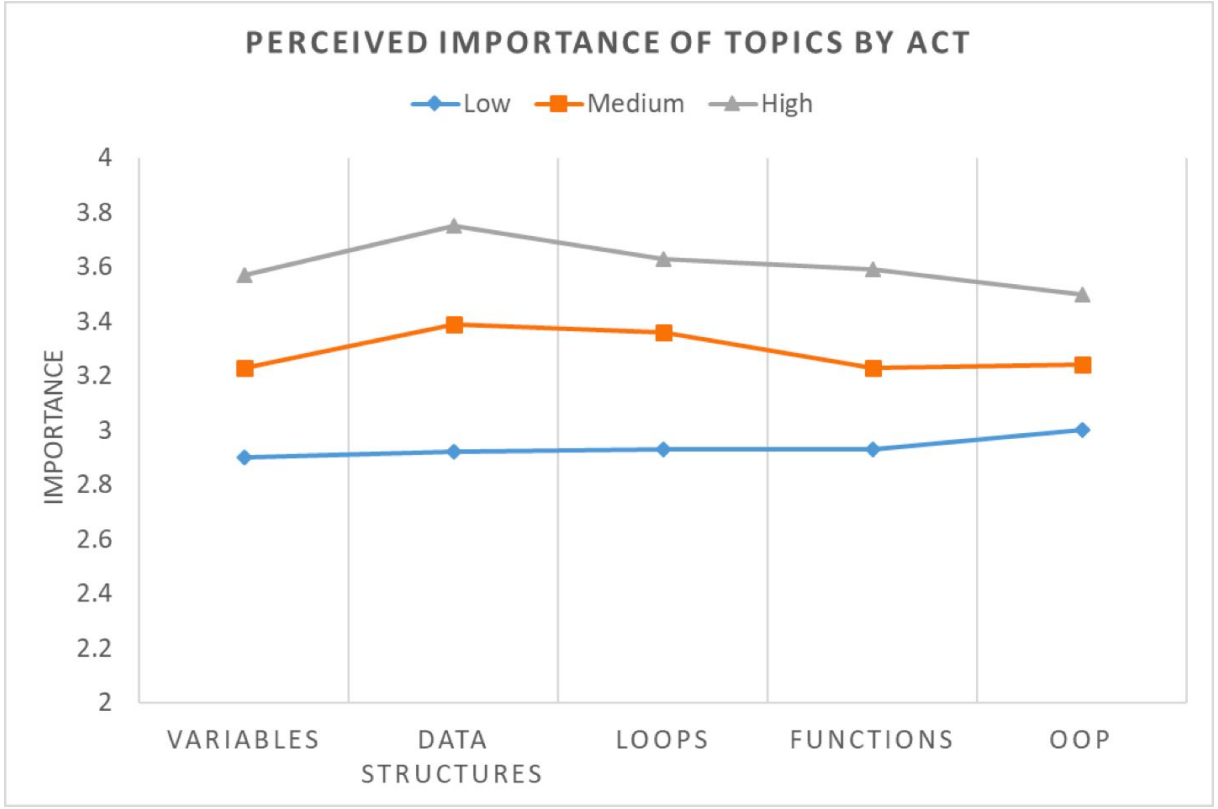
Degrees	
Computer Science	7 (16%)
STEM	20 (45%)
Non-STEM	17 (39%)

Additional Computing Training	
Low	21 (48%)
Medium	17 (39%)
High	6 (14%)

	F-score	I-score	C-score
Overall (all misconceptions)	**2.41 (0.36)**	**3.17 (0.45)**	**3.13 (0.55)**
Variables	2.21 (0.41)	3.12 (0.52)	3.24 (0.54)
Data Structures	2.49 (0.47)	3.21 (0.55)	3.33 (0.54)
Loops	2.48 (0.48)	3.19 (0.54)	3.22 (0.56)
Functions	2.46 (0.42)	3.14 (0.49)	3.00 (0.70)
Classes & Objects	2.56 (0.63)	3.16 (0.51)	2.78 (0.83)


PERCEIVED CONFIDENCE OF TOPICS BY DEGREES
CS
STEM
Non-STEM
CONFIDENCE
4
3.8
3.6
3.4
3.2
3
2.8
2.6
2.4
2.2
2
VARIABLES
DATA STRUCTURES
LOOPS
FUNCTIONS
OOP

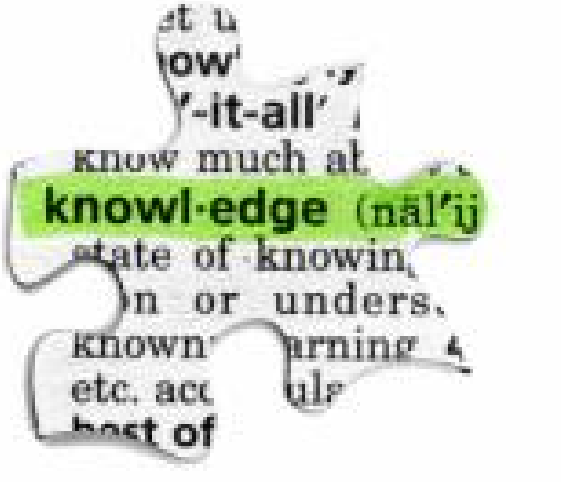

PERCEIVED CONFIDENCE OF TOPICS BY ACT
Low
Medium
High
CONFIDENCE
4
3.8
3.6
3.4
3.2
3
2.8
2.6
2.4
2.2
2
VARIABLES
DATA STRUCTURES
LOOPS
FUNCTIONS
OOP


PERCEIVED IMPORTANCE OF TOPICS BY ACT
Low
Medium
High
IMPORTANCE
4
3.8
3.6
3.4
3.2
3
2.8
2.6
2.4
2.2
2
VARIABLES
DATA STRUCTURES
LOOPS
FUNCTIONS
OOP

Lessons and Implications

Needs of the child and demands of the curriculum are mediated by the teacher

Dewey (1902)



Source:http://myinquirylearningrepresentation.weebly.com/uploads/1/9/4/7/19478893/1389948.jpg?1366423766

Big Picture

How does different conditions influence student outcomes in computer science? +

How does CS teacher learning affects student outcomes? +

How teachers learn successful practices?

Basic research on how do students come to learn computer science ideas?

Adapted from: Bransford, Darling-Hammond, & LePage, 2007

Crowdsource

http://bit.ly/wipsce17key

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