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

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Collaborators

Graduate Students

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Faculty

Susanne Hambrusch  Purdue  Tim Korb  Purdue
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

CS4EDU

CT4EDU

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It is the supreme art of the teacher to awaken joy in creative expression and knowledge.

— Albert Einstein
“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)
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

Training New Teachers

❖ Bugs in the System

➢ Roadblocks

❖ Teacher Professional Development

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.”

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/
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-teacheractually-looks-like-5650540/
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/
Methods of Teaching CS

PD 4 CS
Just-in-time

Reflections

CS Content Knowledge
PD4CS

- Traditional PD
  - Phase 1: Readiness Training
  - Phase 2: Core Training
- Just-in-time online PD
PD4CS: Organization

PD4CS
Professional Development for CS Principles Teaching

Home    CSP Index    PLTW Index    Resources    About    My Progress

Home = Login

Welcome, yadavaman@gmail.com

You're logged in as yadavaman@gmail.com

Home    See My Progress    Admin    Log out

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## PD4CS: Organization

<table>
<thead>
<tr>
<th>Basic Programming</th>
<th>Advanced Programming</th>
<th>Other CSP Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variables</td>
<td>Debugging</td>
<td>Internet</td>
</tr>
<tr>
<td>Conditionals</td>
<td>Classes &amp; Objects</td>
<td>Git &amp; GitHub</td>
</tr>
<tr>
<td>Data Structures</td>
<td>Packages</td>
<td>Information Security</td>
</tr>
<tr>
<td>Loops</td>
<td>Algorithms</td>
<td>Simulation &amp; Modeling</td>
</tr>
<tr>
<td>Functions</td>
<td>Recursion</td>
<td>Big Data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Assessment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Computing Degrees</td>
</tr>
</tbody>
</table>
## CSP Index

<table>
<thead>
<tr>
<th>BIG IDEA 1: CREATIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LO 1.1.1</strong> Apply a creative development process when creating computational artifacts.</td>
</tr>
<tr>
<td>- Loops – Scratch</td>
</tr>
<tr>
<td>- Loops – Nested Loops</td>
</tr>
<tr>
<td>- Functions – A Class Project</td>
</tr>
<tr>
<td>- Algorithms – Solving Problems</td>
</tr>
<tr>
<td><strong>LO 1.2.1</strong> Create a computational artifact for creative expression.</td>
</tr>
<tr>
<td>- Loops – Scratch</td>
</tr>
<tr>
<td>- Loops – Nested Loops</td>
</tr>
<tr>
<td>- Functions – A Class Project</td>
</tr>
<tr>
<td>- Algorithms – Solving Problems</td>
</tr>
<tr>
<td>- Recursion – Algorithms</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>Category</th>
<th>Active Users</th>
<th>% Active</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novice &amp; CS</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Novice &amp; Non-CS</td>
<td>11</td>
<td>6</td>
</tr>
<tr>
<td>Experienced &amp; CS</td>
<td>17</td>
<td>8</td>
</tr>
<tr>
<td>Experienced &amp; Non-CS</td>
<td>43</td>
<td>28</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>77</strong></td>
<td><strong>47</strong></td>
</tr>
</tbody>
</table>
PD4CS Usage

![Bar chart showing PD4CS usage categories: Experienced & CS, Novice & Non-CS, Experienced & Non-CS, Novice & CS.](chart.png)
“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)

“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)

“I can’t ask for more support. I just need time to digest it.” (Non-CS teachers)
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)
Teacher Knowledge and Student Misconceptions

Teachers’ perceptions of student misconceptions in introductory programming

Relationships between teachers’ perceptions and their background
<table>
<thead>
<tr>
<th>Topic</th>
<th># Misconceptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variables</td>
<td>9</td>
</tr>
<tr>
<td>Data Structures</td>
<td>6</td>
</tr>
<tr>
<td>Loops</td>
<td>8</td>
</tr>
<tr>
<td>Functions</td>
<td>9</td>
</tr>
<tr>
<td>OOP</td>
<td>5</td>
</tr>
</tbody>
</table>

**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

<table>
<thead>
<tr>
<th>Novice</th>
<th>12 (27%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experienced</td>
<td>32 (73%)</td>
</tr>
</tbody>
</table>

### Degrees

<table>
<thead>
<tr>
<th>Computer Science</th>
<th>7 (16%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEM</td>
<td>20 (45%)</td>
</tr>
<tr>
<td>Non-STEM</td>
<td>17 (39%)</td>
</tr>
</tbody>
</table>

### Additional Computing Training

<table>
<thead>
<tr>
<th>Low</th>
<th>21 (48%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium</td>
<td>17 (39%)</td>
</tr>
<tr>
<td>High</td>
<td>6 (14%)</td>
</tr>
<tr>
<td></td>
<td>F-score</td>
</tr>
<tr>
<td>-------------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>Overall (all misconceptions)</td>
<td>2.41 (0.36)</td>
</tr>
<tr>
<td>Variables</td>
<td>2.21 (0.41)</td>
</tr>
<tr>
<td>Data Structures</td>
<td>2.49 (0.47)</td>
</tr>
<tr>
<td>Loops</td>
<td>2.48 (0.48)</td>
</tr>
<tr>
<td>Functions</td>
<td>2.46 (0.42)</td>
</tr>
<tr>
<td>Classes &amp; Objects</td>
<td>2.56 (0.63)</td>
</tr>
</tbody>
</table>
Lessons and Implications

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

Dewey (1902)

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
Crowdsourcing
