Linear Data Structures

A Comparison of Novice and Expert Teacher PCK

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OVERVIEW AND QUESTION

PCK: WHAT IS IT and WHY DOES IT MATTER?

> *Pedagogical content knowledge*, or PCK, describes knowledge of student understanding and knowledge of instructional strategies that teachers draw upon to support student learning (Shulman, 1986).

> PCK is a component of teaching expertise. Expertise develops over time with experience and is influenced by one's context (Berliner, 2001, 2004; Borko & Livingston, 1989; Hashweh, 2005).

> As more teachers enter computing, they will need support around PCK (Ericson et al., 2008; Menekse, 2015).

> If we know where a teacher is in the development of their teaching expertise, could we better support their professional learning?

RESEARCH QUESTION

1. Can we distinguish levels of declarative computing PCK? If so, how?

METHODS

Studying computing PCK is challenging because:

> we don't have a complete map of computing PCK or related progressions
> teaching knowledge varies based on personal and contextual factors

To explore the research question, I:

> asked four high school teachers new to computing to complete a PCK questionnaire after two years of observing their classrooms
> compared their responses against publicly available data sources where experienced computing educators completed *similar, but not identical,* tasks

Participants	Participant Questionnaire	Expert List Data Sources
1. Four U.S. high school teachers 2. Teaching either AP CS A or an Intro CS course 3. Each had 2-3 years of CS teaching experience	1. List the difficulties students have with linear data structures (i.e., arrays and lists in AP CS A, lists in Intro CS). 2. For each difficulty: describe how you address the difficulty.	1. An online repository of computer science teaching tips http://csteachingtips.org 2. Workshop discussions in response to Loughran, Mulhall, and Berry's CoRe instrument for multiple computing topics (Saeli et al., 2010).

REQUEST OF YOU

1. How would you answer these prompts?
2. Are there other ways to categorize these responses?

List the difficulties students have with linear data structures.

Du Boulay's (1986) five areas of programming difficulty were used to categorize responses. Pragmatics and structure were combined into one code.

	Notation Using the syntax & semantics of programming languages	**Pragmatics or Structures** Acquiring standard templates for common tasks; planning, implementing, and testing programs	**Notional Machine** Modeling how computers execute commands	**Orientation** Recognizing what problems programming can solve
Participants	Not realizing the change-by-one block in Snap! means add 1.	Closing the gaps when removing an item from a list. Moving values but preserving order in a list.	---	---
Expert List	One of the first obstacles students need to overcome is that there is only one name for several places where to store values.	Working with temporary variables in arrays	Thinking that assigning one array to point to another array makes a copy of that array. Not distinguishing shallow and deep copies.	---
Both	Students think that arrays start at index 1 instead of 0.	Getting rows and columns backwards. When looping over arrays, mixing up these parameters.	---	---

Describe the methods you use to address student difficulties with linear data structures.

A grounded coding approach was used to categorize methods into one of five categories.

	Present information	**Assign a task**	**Relate to other disciplines**	**Use representations**	**Sequencing**
Participants	I try to keep mentioning that a 2D array is just an array of arrays	We continually give them homework, quizzes, and test questions about this.	---	Labeling 0, 1, 2, etc. on diagrams on the board. While tracing, labeling the arrays. I draw diagrams.	I teach arrays first, so they can see the point of the List, but some books/teachers do it the other way
Expert List	---	Have students translate between Java Array and ArrayList to highlight the differences between the two.	Collaborate with a math teacher to synchronize the teaching of arrays with the teaching of coordinates.	Use everyday items, like an egg carton, to visually demonstrate how 2D arrays are organized.	Do loops before arrays/lists
Both	When teaching null dereferences, show a call that dereferences a null pointer in a debugger to give a snapshot of what is happening	---	---	---	---

Novice-Expert Differences?

Participants

- Most methods focused on presenting information
- Only one participant offered a representation
- Generic tasks given for addressing linear data structures

Expert List

- Mentioned difficulties related to notional machine
- Discussed many representations, metaphors and real-world examples
- Provided specific tasks to support student learning

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