Introducing Computational Thinking in Education Courses

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Project CS4EDU   http://cs4edu.cs.purdue.edu/

Goal
- Create new pathways for undergraduate education majors to become computationally educated secondary teachers

Highlights
- CS teaching endorsement (supplemental licensure)
- Computational thinking module (and WebQuest)

New Courses
- Contemporary Issues in Computing
- Methods of Teaching Computer Science

CS4EDU

Overview

Short Term Goal
- Prepare future educators to present their subject areas using ideas from computational thinking

Long Term Goal
- K-12 students will have greater exposure to computing in general

Our Approach
- Develop a one-week module on CT (what & how)
- Embed CT in required courses for education majors
- Survey the students before/after taking the module
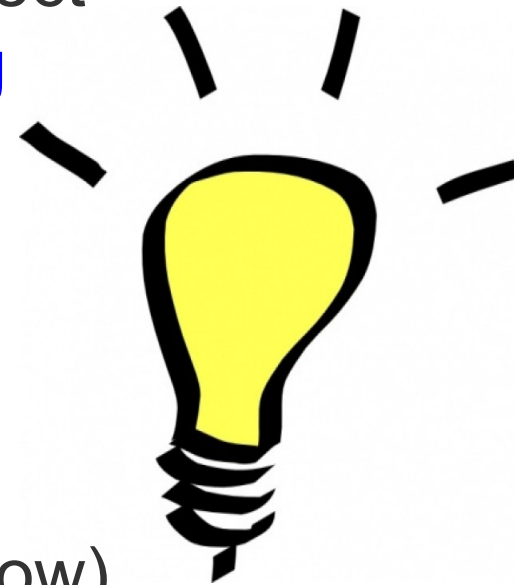
CT Pop Quiz

Which of the following is NOT like the others?

[A] People standing in line at the store

[B] List of print jobs waiting to be printed

[C] Set of tennis balls in their container

[D] Vehicles lined up behind a toll booth

[E] Patients waiting to see the doctor

CT Pop Quiz - Answers
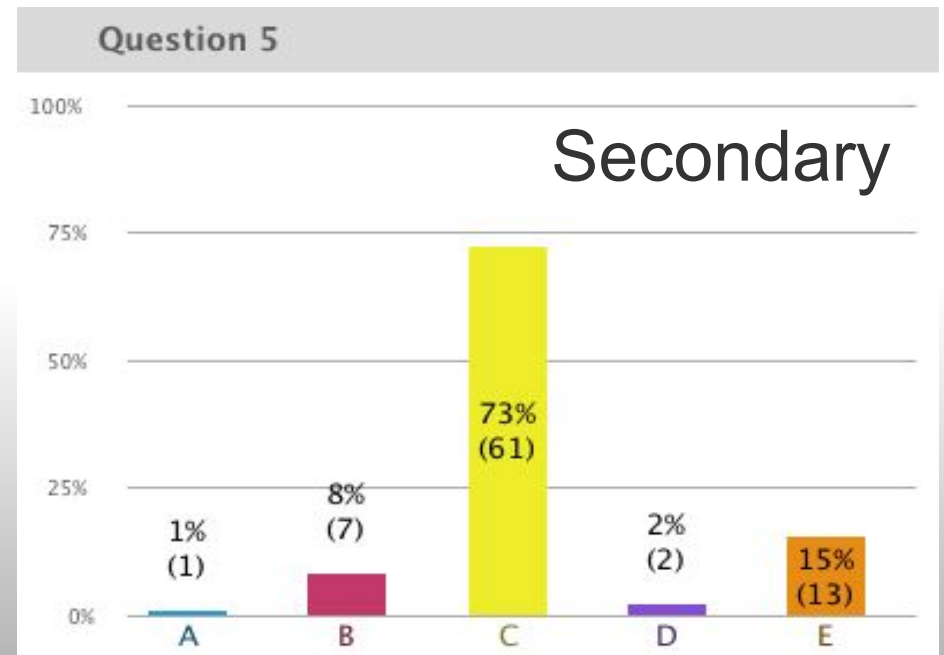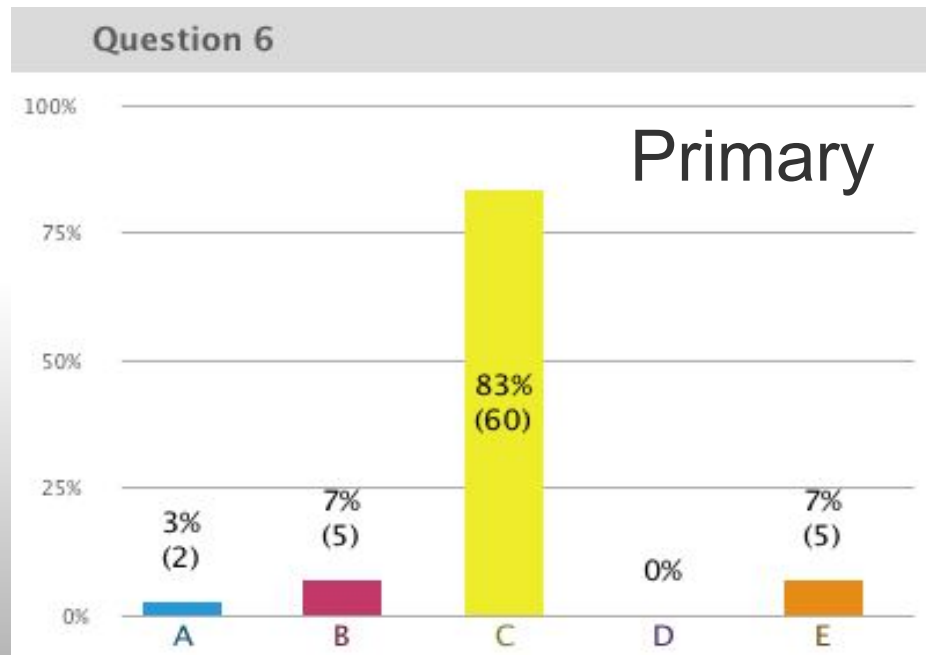
Which of the following is NOT like the others?

[A] People standing in line at the store (queue)

[B] List of print jobs waiting to be printed (queue)

[C] Set of tennis balls in their container (stack)

[D] Vehicles lined up behind a toll booth (queue)

[E] Patients waiting to see the doctor (queue)

Student Responses - Queues vs Stack

Why students picked the tennis balls:
- *"...were not waiting to go anywhere."*
- *"...had nothing to do with people."*
- *"...were not moving towards a goal."*

Question 6 — Primary

	A	B	C	D	E
	3% (2)	7% (5)	83% (60)	0%	7% (5)

Question 5 — Secondary

	A	B	C	D	E
	1% (1)	8% (7)	73% (61)	2% (2)	15% (13)

CT Module Overview

Concepts from CT that we presented to the students

What is Computational Thinking?

Definition
- "CT involves solving problems, designing systems, and understanding human behavior, by drawing on the concepts fundamental to computer science."

Vision
- A fundamental skill used by everyone by the middle of the 21st century (i.e., like reading, writing, and arithmetic).

J.M. Wing, "Computational Thinking," CACM viewpoint, vol. 49 no. 3, March 2006, pp. 33-35.

Overview of Lecture 1

Focus: What is CT?

- CT in daily life
  - Driving directions
  - Buying movie tickets

- Abstraction & logical thinking
  - Recall "queues vs stack"
  - Inductive/Deductive reasoning

- Algorithms and debugging
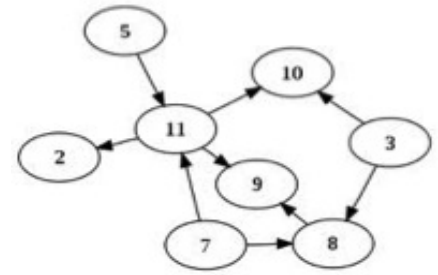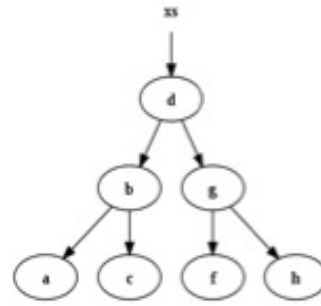 - PB&J sandwich activity

Another Example

Which of the following is NOT like the others?

[A] Files and directories on a hard disk

[B] Parents and children in a pedigree chart

[C] Brackets in the NCAA basketball tournament

[D] My closest friends on Facebook / Twitter
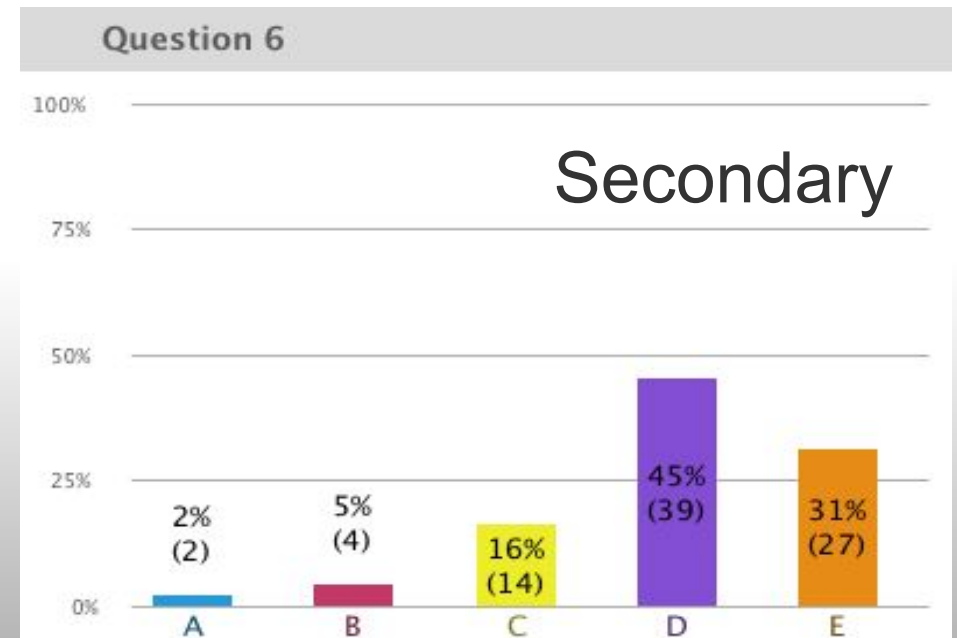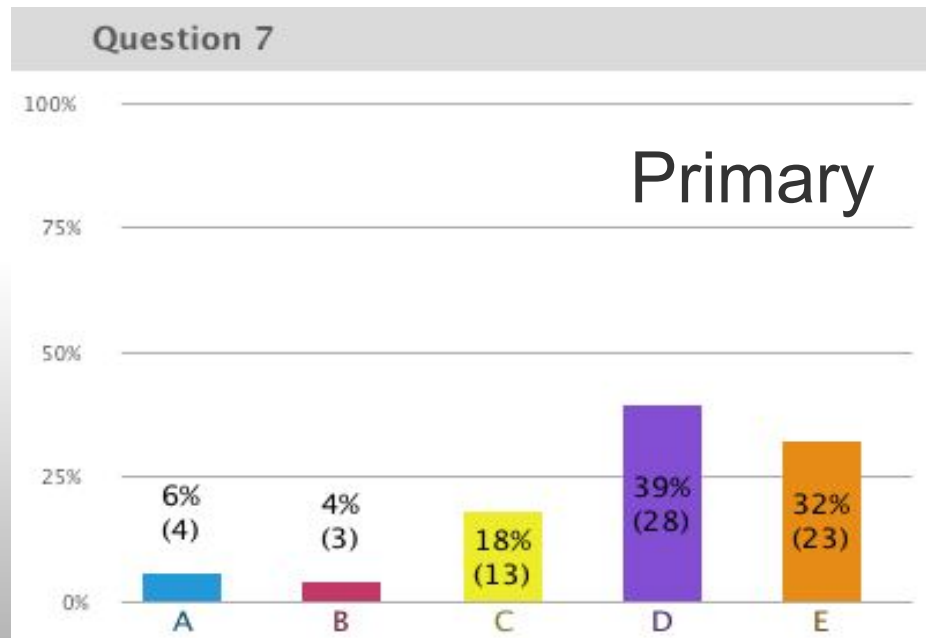
[E] The format of XML or PDF documents

Answers

Which of the following is NOT like the others?

[A] Files and directories on a hard disk (tree)

[B] Parents and children in a pedigree chart (tree)

[C] Brackets in the NCAA basketball tournament (tree)

[D] My closest friends on Facebook / Twitter (graph)

[E] The format of XML or PDF documents (tree)

Student Responses - Trees vs Graph

Some of the confusion:
- [C] *"Brackets branching inward instead of outward."*
- [E] *"All others are linked to you; PDFs are not linked."*
- [E] *"Everything else branches; PDFs not able to branch."*

Question 7 — Primary

	A	B	C	D	E
	6% (4)	4% (3)	18% (13)	39% (28)	32% (23)

Question 6 — Secondary

	A	B	C	D	E
	2% (2)	5% (4)	16% (14)	45% (39)	31% (27)

Overview of Lecture 2

Focus: Teaching CT in K-12

- Connections to educational theory
  - Algorithms vs heuristics

- Ideas for presenting algorithms
  - Towers of Hanoi role play

- Using technology to motivate CT
  - Facebook constellation

- Online resources (new in 2011)
  - CSTA, ACM, CS Ed Week
  - CS Unplugged, CS4FN
  - Google's CT repository
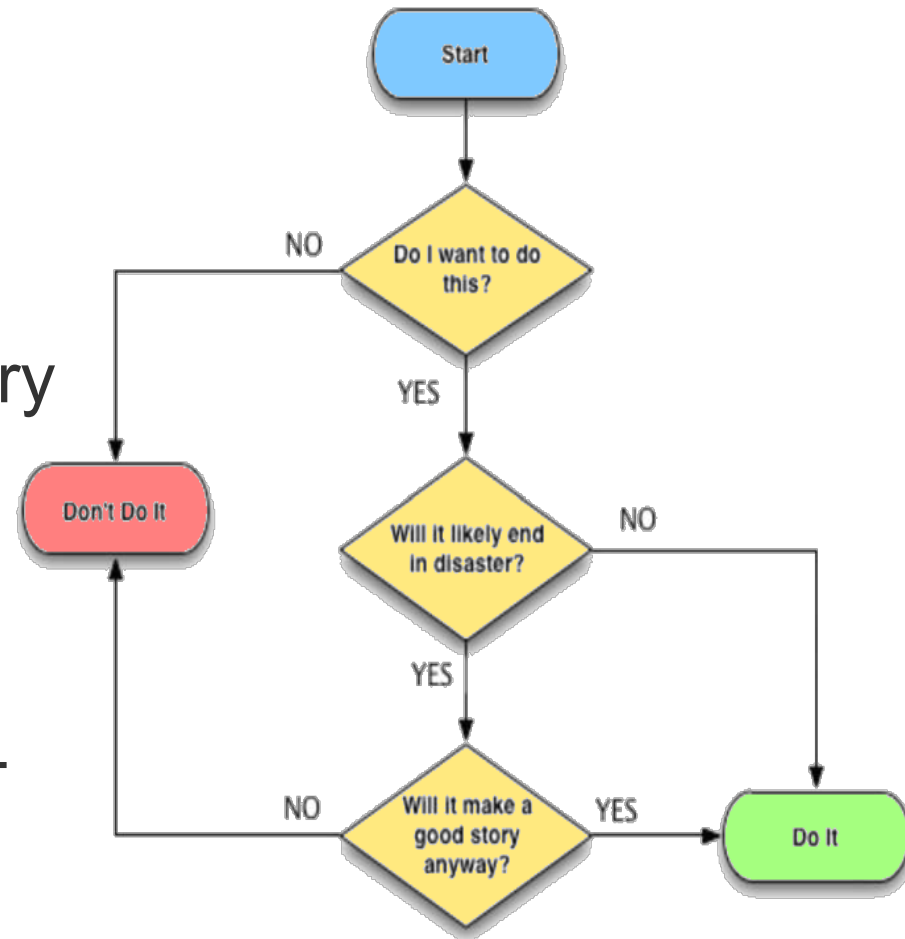
Attitude Survey Results

Research Study

How does knowledge of CT affect one's attitude toward CS?

Pre-Post Design
- Sent survey to 155 education majors
- 100 responded (64.5% return rate)
  - 78 females; 22 males
  - 55 elementary; 45 secondary

Survey Contents
- 16 Likert-scale (adapted from Hoegh & Moskal, 2009)
- 4 free response (e.g., What is CT? How does it relate?)

See the paper for details!
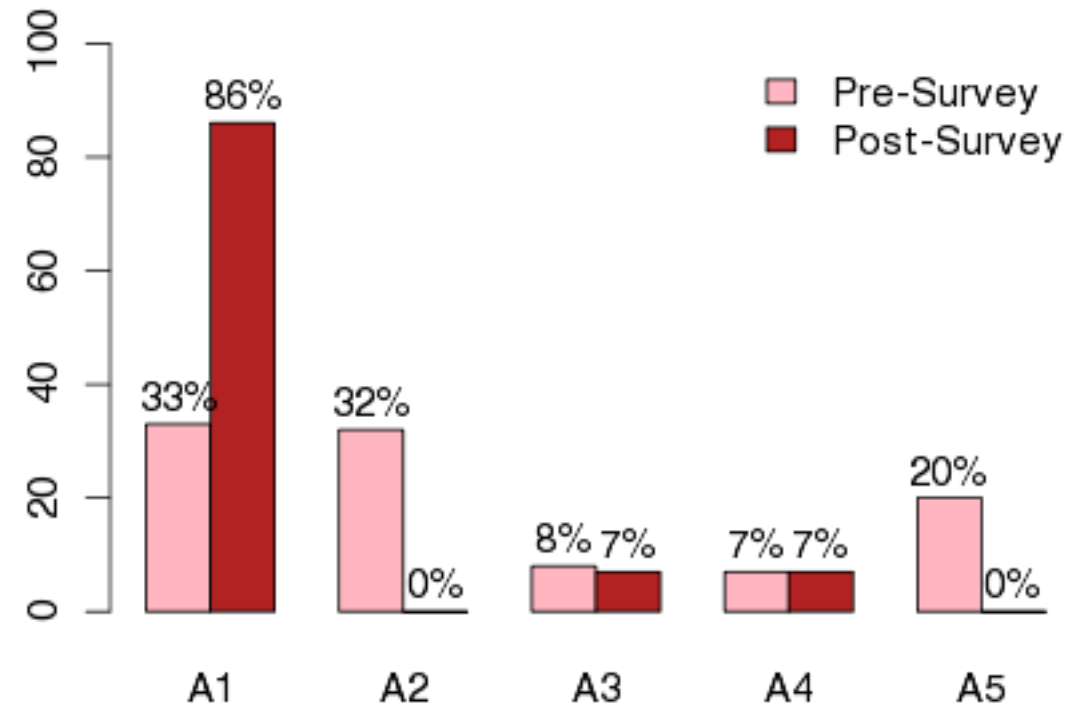
Participants' View of CT

Sample Student Responses

A1: Computational thinking involves problem solving with algorithms and logic.

A2: Knowing how to use computers for problem solving.

A3: It is being able to solve problems in a new way, sometimes like a computer.

A4: Thinking above and beyond what normally comes to mind.

A1: The process of solving problems
A2: To use computers and/or technology to solve a problem or make tasks easier
A3: The study of computers; solving problems like a computer
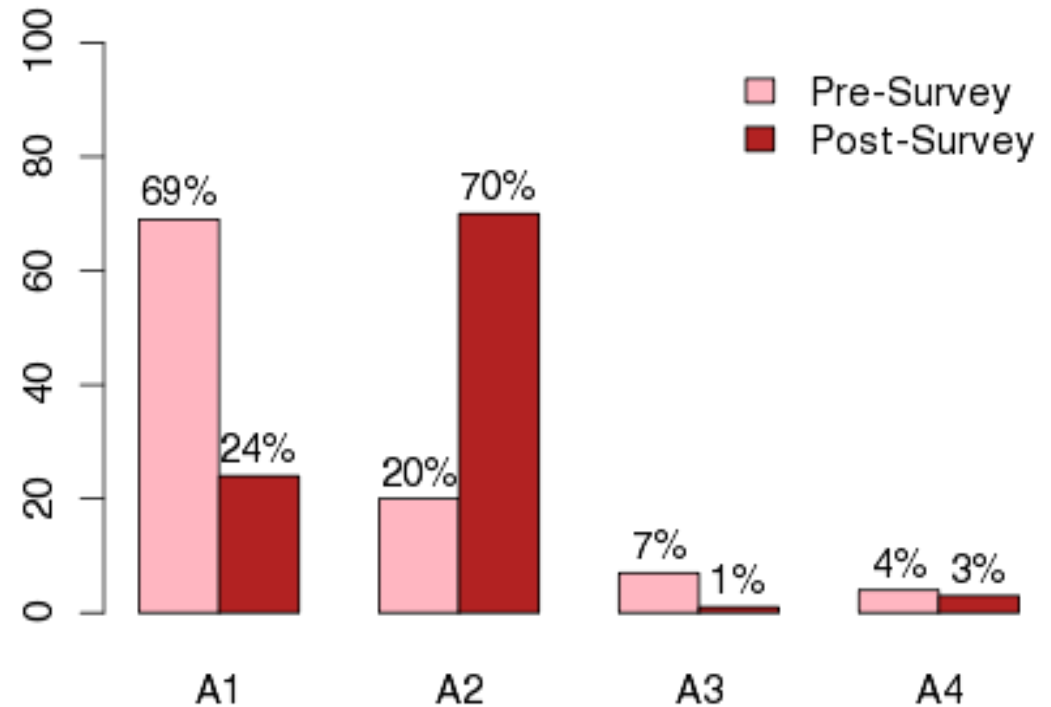A4: Other
A5: Not sure

Participants' View of Computing

Sample Student Responses

A1: *Computing is the use of computers or some other form of technology to solve a problem.*

A2: *Computing is the science of solving a problem using some pre-set method that has been established.*

A3: *Being able to use and apply computer skills to daily life.*

A1: To use computers and/or technology to solve a problem and make tasks easier
A2: The process of solving problems (use of computer or technology not mentioned)
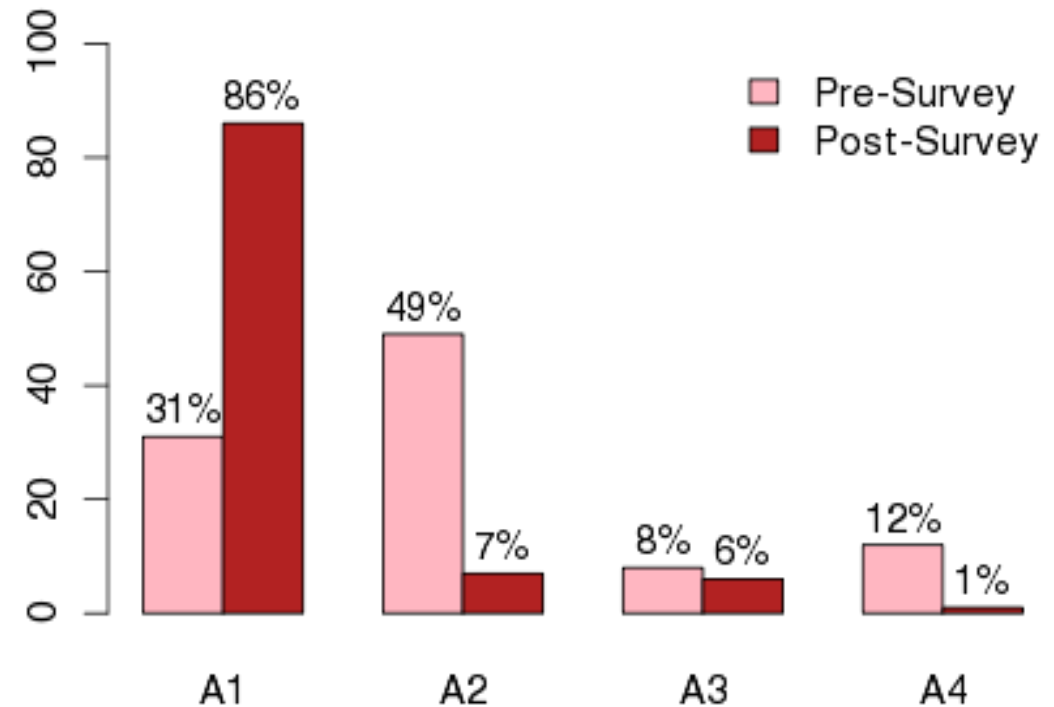A3: The study of computers
A4: Other

Integrating CT into the Classroom

Sample Student Responses

A1: *In the linguistic sense, we can teach students how language is inherently computational, especially in regards to syntax and morphology.*

A2: *Using programs that allow students to learn more about computers.*

A3: *Make it standard in every class.*

A1: Promote problem solving skills / critical thinking in the classroom
A2: Utilizing computers and technology in the classroom
A3: Other
A4: Don't Know

Lessons Learned

CT Module "Version 2.1"

- Module changes
  - Focused more on how CT can be integrated in core content areas
  - Facilitating understanding of CT through additional concrete examples
  - Clicker questions to foster discussion of CT concepts
  - Removed concepts that didn't work
    - e.g. "Towers of Hanoi" demonstration for recursion

- WebQuest - online version of module

- Quasi-experimental study

Future & Ongoing Work

- CS Teaching Endorsement

- CS Teaching Methods Course
  - to provide students with pedagogical and content knowledge and experiences to be effective computer science teachers in high school.

- 2011 workshop about:
  - raising awareness of the CS Principles efforts
  - sharing experiences of challenges and opportunities
  - creating new synergies between computer science faculty, education faculty, and high school teachers

Summary

Approach
- Presenting computational thinking to all education majors

Results
- Attitudes toward computer science become more favorable
- Increased interest in teaching general computing principles

See the paper for:
- Other ideas for module content
- Additional discussion of results
- List of post-survey questions

CT lecture slides: http://cs4edu.cs.purdue.edu/comp_think