Tapestry Workshop

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Computational Thinking in K-12 Education

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Project CS4EDU

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

Objective

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

Highlights

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

New Courses

- Contemporary Issues in Computing
- Methods of Teaching Computer Science

CS4EDU

Our Work with Ed Majors

Short Term Goal

- Prepare future educators from all subject areas to integrate computational thinking in their teaching

Long Term Goal

- K-12 students will have greater exposure to CS

Our Approach

- Develop new modules on CT (in class & web based)
- Embed in required courses for all education majors
- Survey the students before/after taking the modules

(Yadav et al., SIGCSE 2011)

What is Computational Thinking?

- Approach to problem solving using concepts from CS
- Fundamental skill for everyone [Wing, CACM 2006]

Informal Definition of CT

Informally, computational thinking describes the mental activity in formulating a problem to admit a computational solution. The solution can be carried out by a human or machine, or more generally, by combinations of humans and machines.

Jeannette M. Wing

see "The Link" CMU Newsletter, Spring 2011

Operational Definition of CT

CT is a problem-solving process that includes:

- Formulating problems [to enable computation]
- Logically organizing and analyzing data
- Representing data through abstractions
- Automating solutions through algorithmic thinking
- Identifying, analyzing, and implementing possible solutions
- Generalizing and transferring this problem solving process

http://csta.acm.org/Curriculum/sub/CompThinking.html

Daily Examples of CT

- Looking up a name in an alphabetically sorted list (Binary Search)
  - e.g., 100 names per page in list of 150,000 names
  - How to minimize the number of pages to look at?

- You and a friend are buying tickets for a movie (Parallel Processing)
  - There are 3 independent lines
  - How do you get your tickets ASAP?

Important Concepts of Computational Thinking

CT Concept: Abstraction

- Decomposition
  - Reformulating a seemingly difficult problem into one we know how to solve

- Abstraction
  - Pulling out the important details
  - Identifying principles that apply to other situations

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

Abstraction: Queues vs Stacks

[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)

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.

Abstraction: Graphs vs Trees

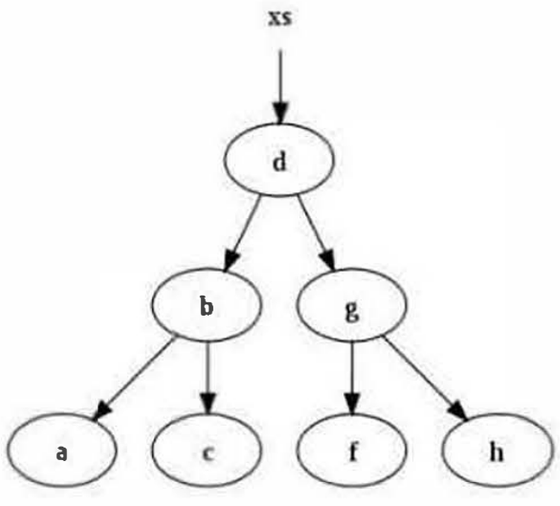
[A] Files and directories on a hard disk (tree)

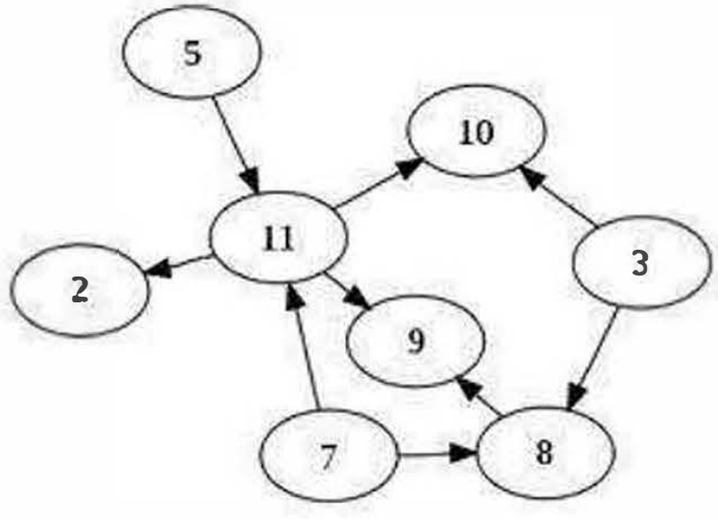
[B] Parents and children in a pedigree chart (tree)

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

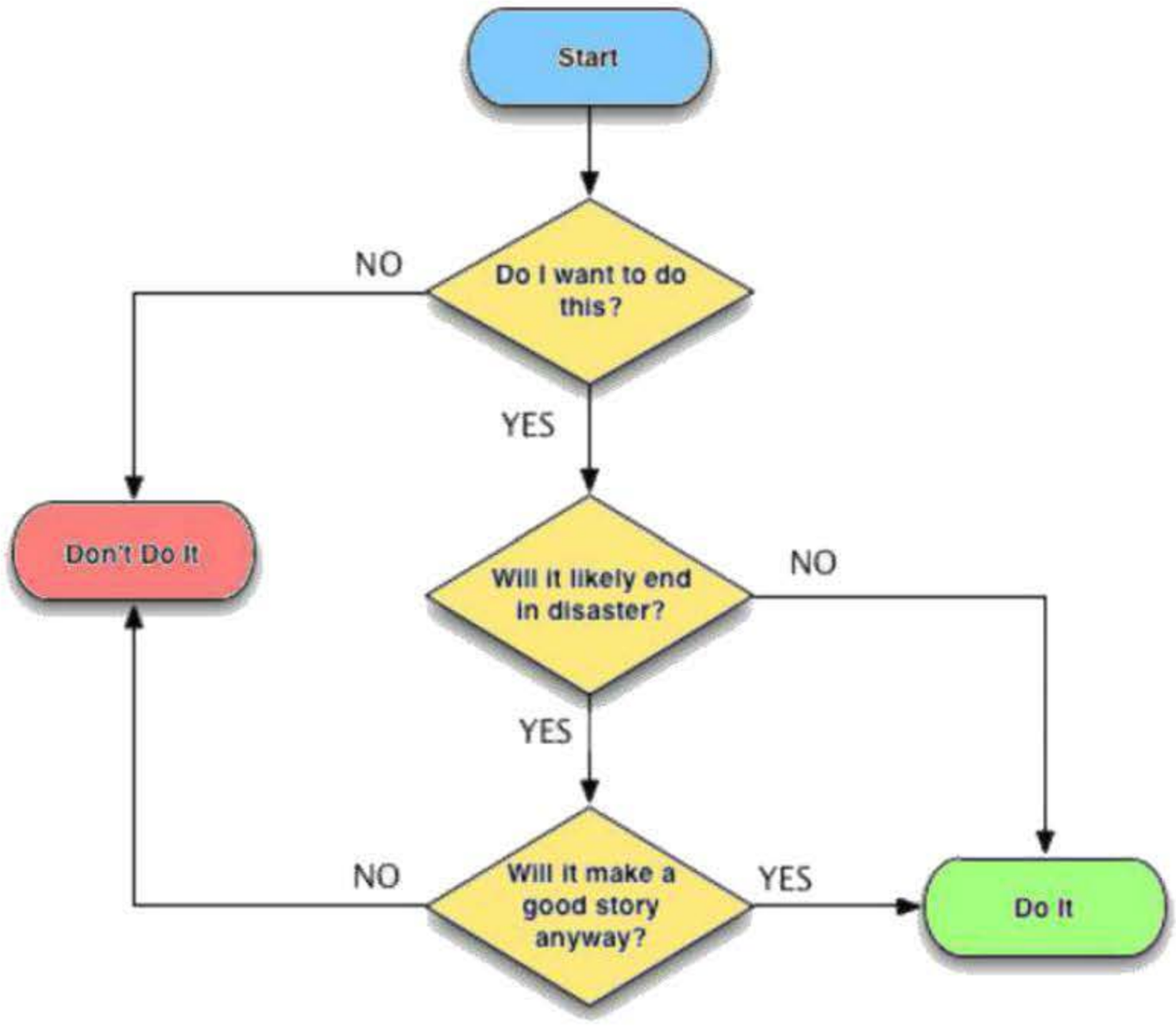
[D] My closest friends on Facebook / Twitter (graph)

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





CT Concept: Algorithms



Algorithm for a PB&J Sandwich

Materials:

- A jar of peanut butter
- A jar of jelly
- A loaf of sliced bread
- One butter knife

Your Task:

- What are the steps to make a peanut butter and jelly sandwich?

Other Daily Examples (by Jeanette Wing)

- Putting things in your child's knapsack for the day
  - Pre-fetching and caching
- Taking your kids to soccer, gymnastics, and swim practice
  - Traveling salesman (with more constraints)
- Cooking a gourmet meal
  - Parallel processing: You don't want the meat to get cold while you're cooking the vegetables
- Cleaning out your garage
  - Garbage collection: Keeping only what you need vs. throwing out stuff when you run out of space
- Storing away your child's Lego pieces scattered on the LR floor
  - Using hashing (e.g., by shape, by color)
- Doing laundry, getting food at a buffet
  - Pipelining the wash, dry, and iron stages; plates, salad, entrée, dessert stations
- Even in grade school, we learn algorithms (long division, factoring, GCD, …) and abstract data types (sets, tables, …)

Benefits of Computational Thinking

- Moves students beyond technology literacy
- Creates problem solvers instead of software users
- Emphasizes creating knowledge and designing processes that can be automated
- Encourages creativity and problem solving
- Enhances many of the problem-solving techniques you already know and teach

(Source: Pat Phillips, NECC 2007, Atlanta)

Resources for Teaching Computational Thinking

http://csta.acm.org/ (membership is FREE!)

- Teaching and Learning Materials
  - Submitted by teachers, for teachers
- Brochures, Posters, Videos, Podcasts
- **ACM K-12 Model Curriculum**
  - Detailed lesson plans and activities (K-8, 9-10, 11-12)
- Professional Development (conferences/workshops)

iste International Society for Technology in Education

- **Computational Thinking Toolkit**
  - PowerPoint presentations
  - Handouts and activities
  - Vocabulary & Progression Chart

- Video clips, online animations

- Implementation Strategies
  - Administration, counselors
  - Teachers, students, parents

http://www.iste.org/learn/computational-thinking.aspx

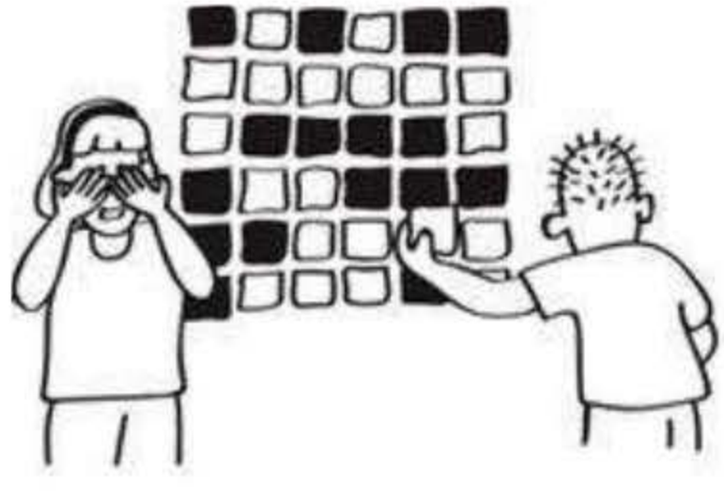
COMPUTER SCIENCE Unplugged

http://csunplugged.org/
(from University of Canterbury, New Zealand)

- **Kinesthetic activities**
  - including lesson plans and handouts

- Video demonstrations:
  http://www.youtube.com/csunplugged

- Great for motivating CT concepts

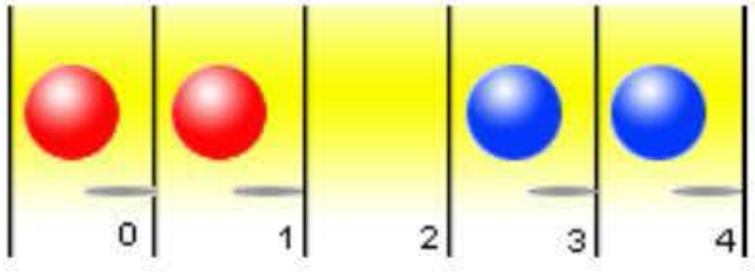


CS4FN
Computer Science For Fun

http://cs4fn.org/
(from Queen Mary University of London)

- **Magazines and Magic Books** (PDF format)

- Interactive applets for computational thinking
  - e.g., http://cs4fn.org/algorithms/swappuzzle/
  - Try to design an algorithm for any size board

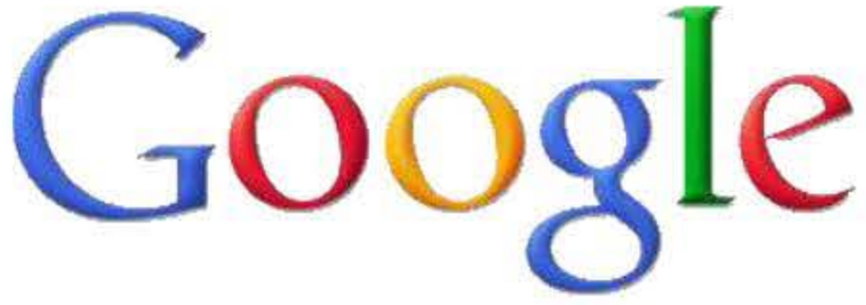


- Lesson plans for in-class group activities

Google's CT Repository

http://www.google.com/edu/computational-thinking/

- **Lessons and Examples** (Math & Science)
  - "Easily incorporate CT into your curriculum"
- Online discussion forums
- Introduction to Python programming
  - Very simple; designed for 6th grade and up



http://www.csedweek.org/resources

- Computer Science Education Week (December 9-15, 2012) is a call to action to:
  - share information and offer activities
  - advocate for computing
  - elevate computer science education
  - for students at all levels