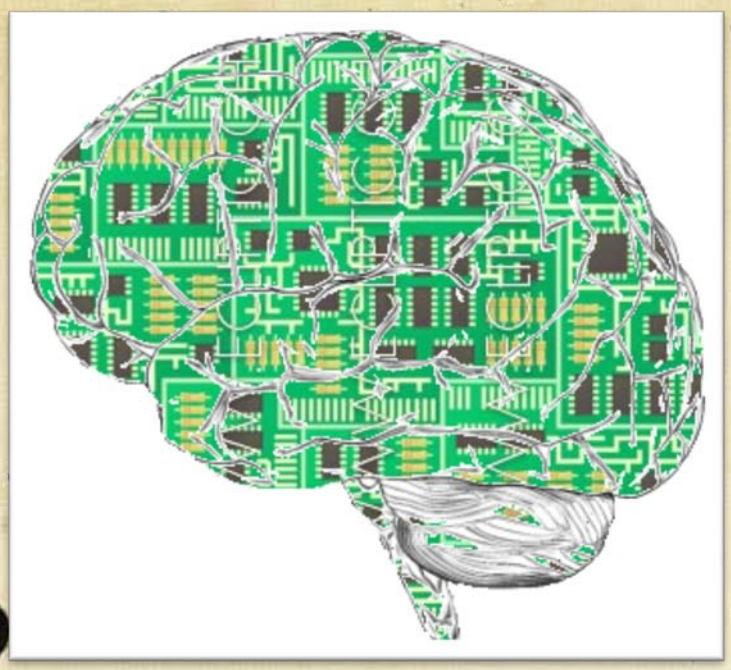

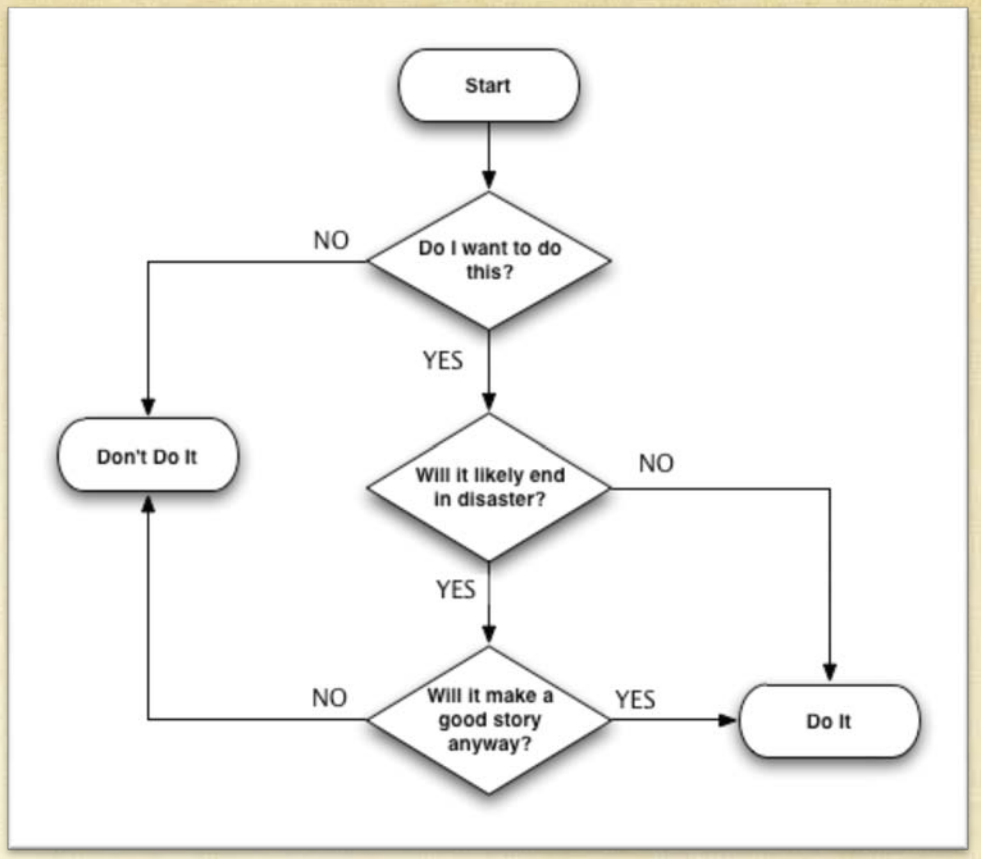

Computational Thinking in K-12 Education

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February 14, 2011

PURDUE
UNIVERSITY

Review: Elements of CT (1)

- **Computational Thinking**
  - A modern approach to problem solving
  - Key concepts: *Abstraction*, *Logical thinking*
  - "The" fundamental skill of the 21st century

- **Algorithm**
  - Precise sequence of steps to solve a problem
    - make PB&J sandwich
    - find the greatest common divisor of two integers
    - follow a winning strategy in a game
  - Algorithms can generate a correct solution, approximate a correct solution, generate the correct solution with a very high probability

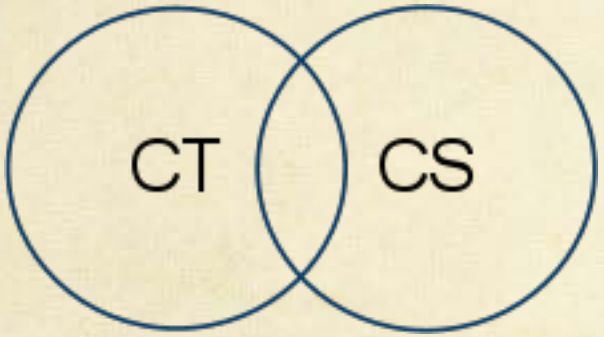
Review: Elements of CT (2)

- **Computer Science**
  - The study of information and computation
  - Study of algorithms is central to computer science
  - Key concepts: *Automation*, *Complexity*
- **Information Technology**
  - computer science is the foundation for tomorrow's information technology
  - being an IT user does often not require being a computer scientist

Clicker Question 1

What is the relationship between CT and CS?

[A]



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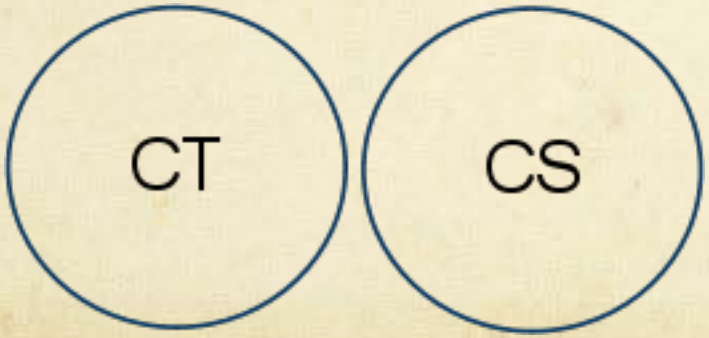

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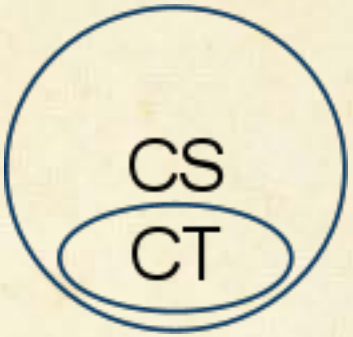

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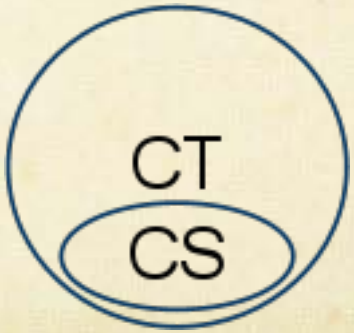


Why is CT important in K-12?

It is a National Priority

- Computing has permeated and transformed our lives.
- The computing professions are among the fastest growing professions in the US economy.
- Despite the transformative importance of computational advances in all sectors of our knowledge-intensive economy, our Nation's youth have few opportunities
  - to gain a foundational understanding of computing
  - to develop competencies in computational thinking
  - to explore the role that computation may play in shaping and refining their career interest.

Source: http://www.nsf.gov/pubs/2010/nsf10619/nsf10619.htm

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)

Applications of CT in teaching and learning

- How to abstract general principles and apply to other situations
  - Or, how to solve problems by understanding the principles

- Computational thinking as the automation of abstractions
  - Expose students to modeling and simulation
  - Encourage students to build their own models and simulations

- Problem-solving is abstracting existing knowledge and skills to solve an unanswered question

Computational Thinking and Cognitive Processes

- Lower-level processes
  - using basic facts, skills
- Higher-level processes
  - doing something complex with information
- Computational thinking is a higher-level cognitive process
  - manipulating data/information to see patterns
  - involves thinking, reasoning, and abstraction

For a detailed description of Cognitive Processes see Ormrod (2011)

Packing jewels into a backpack

A thief found a treasure chest with different sized jewels but only has a backpack of size 50!

- She can only pack jewels resulting in a total size of at most 50
- She wants to maximize her profit in terms of the value

Example

Jewel	A	B	C	D	E	F
size	30	28	15	10	8	5
value	16	25	24	15	12	2

Clicker Question 2

(A) Arrange the jewels by value, from largest to smallest, and put a jewel into the backpack if it still fits

(B) Choose jewels in random order and put into the backpack if it still fits

(C) Compute the ratio of "value per unit of size" and consider the jewels in order of largest ratio. Put into the backpack if it still fits

(D) Get a larger backpack

Jewel	A	B	C	D	E	F
size	30	28	15	10	8	5
value	16	25	24	15	12	2

Jewel	A	B	C	D	E	F
size	30	28	15	10	8	5
value	16	25	24	15	12	2

(A)Arrange the jewels by value, from largest to smallest, and put a jewel into the backpack if it still fits

takes jewels B, C, and F giving a value of 51 (weight 48)

(B) Choose jewels in random order and put into the backpack if it still fits

any solutions could come up

(C) Compute the ratio of "value per unit of size" and consider the jewels in order of largest ratio.

takes jewels C, D, E, and F giving a value of 53 (weight 38)

(D) Get a larger backpack *cheating ☺*

Heuristics

- A “commonsense” strategy that increases the probability of solving a problem
  - Use readily accessible information
  - Most fundamental heuristic is "trial and error”
  - We use many heuristics and "learn" what works best
- Computational thinking and heuristics
  - Some algorithms are too complex to be useful
    - Heuristics can approximate algorithms
    - Can show probability of success is high
  - For some problems, no algorithm exists!
    - E.g., whether an email attachment has a virus
    - Heuristics also facilitate solving *ill-defined* problems

Clicker Question 3

In which of the following scenarios do you use a heuristic?

[A] Deciding what clothes to put on each day

[B] Figuring out how much to tip at a restaurant

[C] Scanning your computer for viruses / worms

[D] All of the above

[E] None of the above

Clicker Question 4

Which of the following problems should NOT be solved using heuristics?

[A] Scheduling courses at a university

[B] Collision detection in air traffic control

[C] Finding an optimal delivery route

[D] Deciding what to eat for dinner

[E] Selecting ones major at college

Ideas for Teaching Computational Thinking

How to Teach Computational Thinking

- Integrate CT concepts into everyday instruction
  - Start by increasing your own CT knowledge
  - CT examples and resources exist for all grade levels
- Use computational thinking terms for everyday tasks
  - "Let's create an algorithm for setting up our ...”
- Encourage students to critically examine and use information
- Allow students to abstract
  - Provide opportunities for students to transfer their learning to other situations
- Do CT-building activities in class

Clicker Question 5

Looking back at your high school experience, which subject taught you the most about computational thinking?

[A] English

[B] Math

[C] Physics

[D] History

[E] Gym

Example Applications of CT in K-12

Elementary Education
Breaking down a simple daily task such as brushing teeth into 15 separate and distinct steps to build foundations for understanding computer performance.

English
I*dentifying the similarities between raps and poetry, and matching rappers with poets based on their similar styles and characteristics.*

History
Studying historical events and statistic data to investigate what caused immigrations rates to change over time.

Other Applications of CT in K-12

- Students can use spreadsheets, graphs, etc. to analyze complex sets of data
  - To generate knowledge and show patterns among data
    - Facebook Constellation
    - Google Public Data
    - Amazon's and Netflix's recommendation
- Students can use simulations that allow them to formulate and test their hypotheses and examine their results
- Are there other simulations/tools you have used?

Clicker Question 6 (easy one)

Computational thinking can be integrated into the education of

[A] STEM (Science, Tech, Engineer and Math)

[B] English / History /Social Studies

[C] Art

[D] Physical Education

[E] All above

Resources and Websites

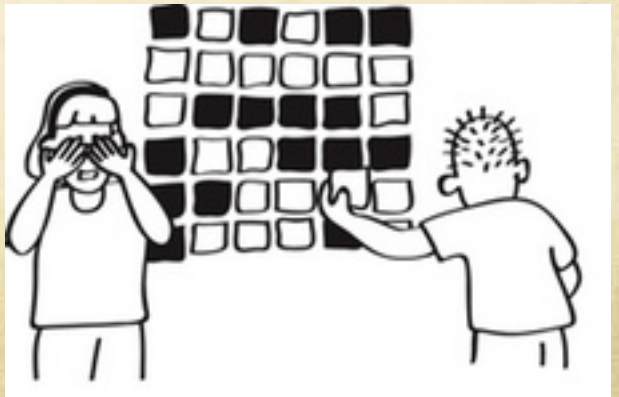
http://csta.acm.org/ (membership is FREE!)

- 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)
- Other initiatives like http://exploringcs.org/

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

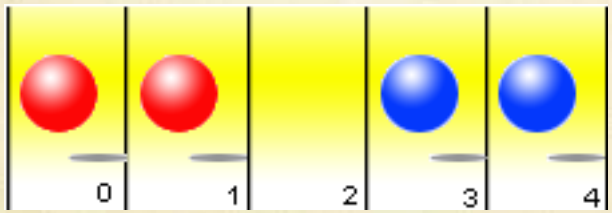


CS4FN
Computer Science For Fun

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

New Opportunities for YOU

State of CS in High Schools

Challenges

- CS often located in Business department rather than Science; an outgrowth of spreadsheets and databases

- CS AP curriculum has been programming focused
  - So, classes tend to focus on details of programming, rather than on broader technical and societal issues

Opportunities

- Broaden CS education to include CT and principles of CS
- Improve CT in the earlier grades

AP Computer Science: Principles

Advance the understanding of the principles and practices of computing to develop a more competitive workforce

Seven big ideas include

- Computing is a creative human activity that engenders innovation and promotes exploration
- Abstraction reduces information and detail to focus on concepts relevant to understanding and solving problems.
- Data and information facilitate the creation of knowledge.
- Algorithms are tools for developing and expressing solutions to computational problems.

http://csprinciples.org/
http://www.collegeboard.com/html/computerscience/

CS Endorsement Program @ Purdue

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

CS Requirements

- Contemporary Issues in Computing
- Programming in Java
- Programming in C or Python
- Foundations of CS/Discrete Math
- Data structures and Algorithms

Education Requirements

- Methods of Teaching Computer Science
- Teaching Practicum (in coordination with the teaching practicum in the primary licensure area)

Don't Forget: Quiz on Wednesday!

See Blackboard for:

- 3-page article by Jeannette Wing (2006)
  - *"Computational Thinking"*
- "CT cards" by Pat Phillips (2008)
  - *"A Problem-Solving Tool for Every Classroom"*
  - Further ideas and websites for integrating CT
  - Includes social studies, fine arts, life sciences, ...
- PDFs of these lecture slides

One Last CT Exercise…

If you have an iPhone, you probably like it. Why?

- easy to use
- easy to learn how to use
- there are probably some changes you could suggest

A phone running Windows Mobile …

To arrange icons use the "*move to front*" feature

Select an icon, choose "move to front;"

- It will be the leftmost icon on top row
- All other icons move to the left by one position

A	B	**5**	C
D	**2**	**6**	E
F	G	**1**	H
I	J	K	**4**
L	**3**	**7**	M
8	N	O	P

Have

1	**2**	**3**	**4**
5	**6**	**7**	**8**
A	B	G	H
I	J	K	E
L	C	F	M
D	N	O	P

Want to have
(don't care about the order of the letters)