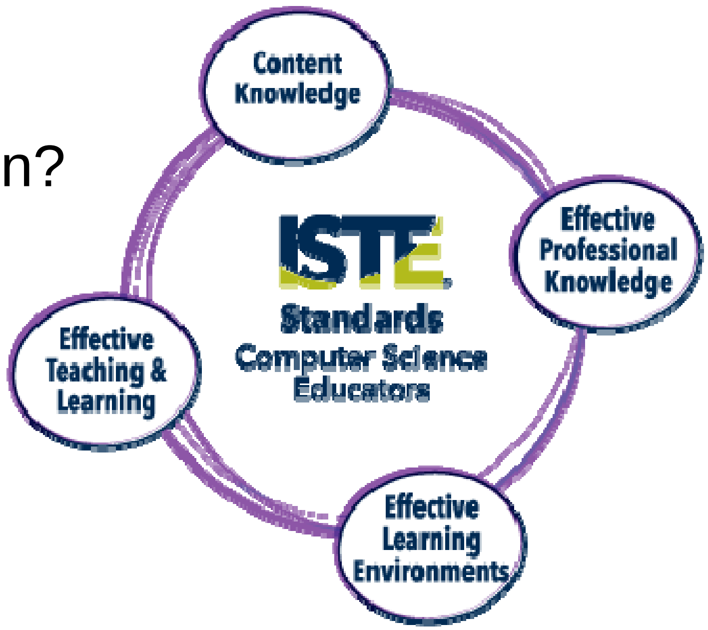
Computational Thinking: An Important Skill for All Students

Joe Kmoch
joe@jkmoch.com
Milwaukee

Karen North
knorth@wt.net
Houston

Session Description

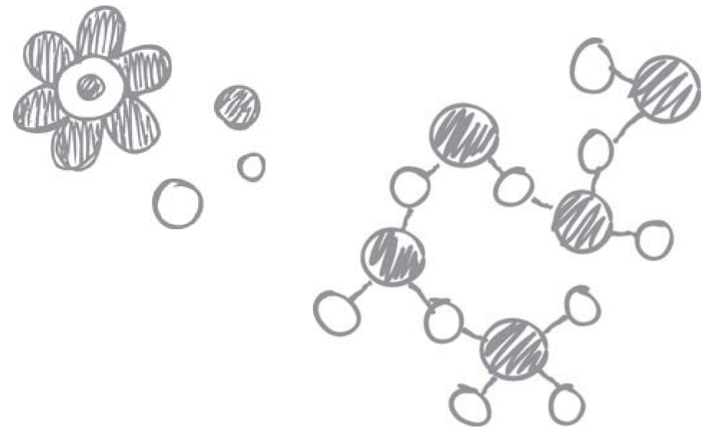
- Computing and computer science are integral to most career paths
- Computational thinking (CT) must be a part of every curriculum.
  - What is CT?
  - Where does CT exist now?
  - How will it affect K-12 education?
  - Resources available



Three Statements about Computational Thinking

- Based on 9 computer science practices
  1. Data Collection
  2. Data Analysis
  3. Data Representation
  4. Problem Decomposition
  5. Abstraction
  6. Algorithms
  7. Automation
  8. Simulation
  9. Parallelization
- Connected to Common Core in Mathematics
- Unrivaled Method to get Computer Science Experiences in K-12

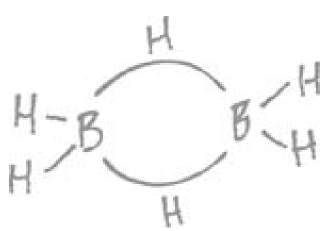
What is CT?



Critical Thinking + Computing Power

= Making Decisions or Innovating Solutions

(Think “Create, Produce, Manipulate”)



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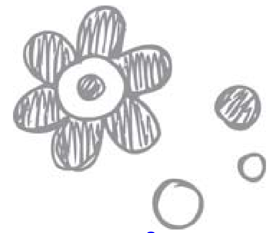

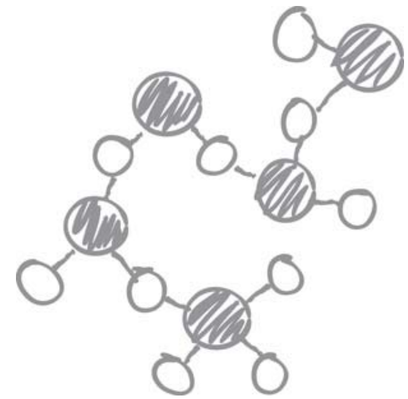

[Here’s a several minute animation describing CT and its importance.]

Critical Thinking + Computing Power

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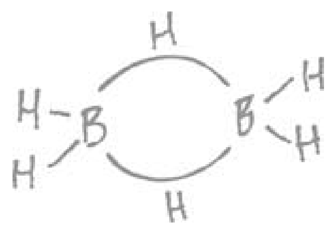
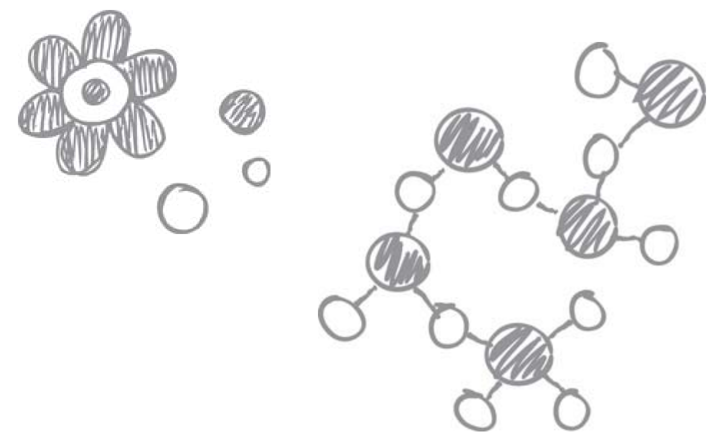
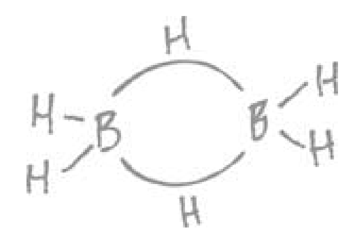


What is CT?

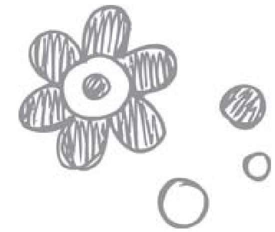


The core principles of Computer Science are the basis for Computational Thinking.

CT is the use of CS principles in problem domains

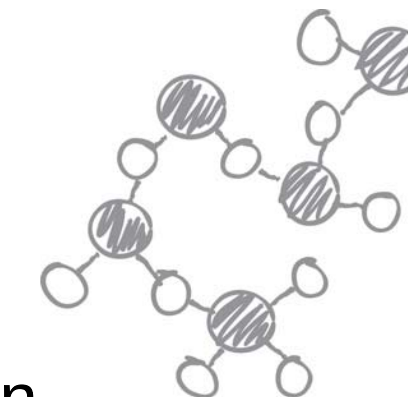


What are these core principles?

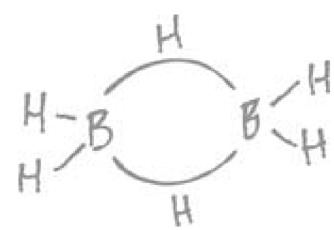


There are 9 concepts

- Data Collection, Data Analysis, Data Representation
- Problem Decomposition, Abstraction
- Algorithms, Automation
- Simulation and Modeling, Parallelization

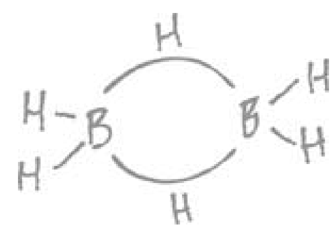


These are all essential to computer science



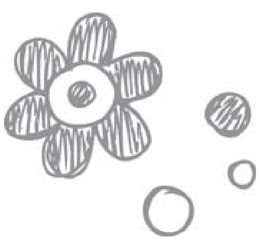
What are these core principles?

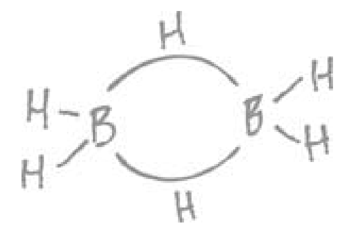
- There are 5 dispositions
  - Confidence with complexity
  - Persistence in working through problems
  - Ability to deal with open ended problems
  - Ability to communicate and collaborate to achieve a common goal
  - Tolerance for ambiguity



What are these core principles?

- The Dispositions are important to preparing solutions to significant problems
- They also match well to the 8 Common Core State Standards – Mathematical Practices
- <http://www.corestandards.org/Math/Practice/>





CT for All Students

The knowledge and skills that students need to **know** and be **able to do** by the time they graduate from secondary school.

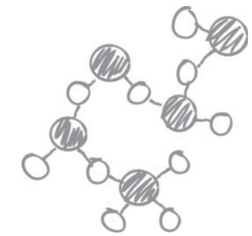
Where do you find CT?

In CS

- CSTA K-12 Computer Science Standards
  - Exploring Computer Science course
  - APCS Principles course

- Required for any National Science Foundation "Computing Education for the 21st Century" Proposal

Where else do you find CT?



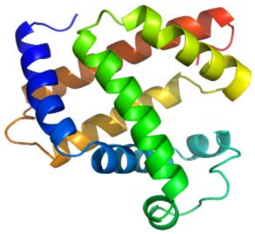
- technology and more specifically CS is part of almost all endeavors of life

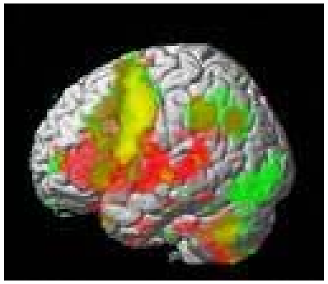
- every 21st century citizen needs to have facility with computational thinking

CT in Other Sciences, Math, and Engineering
some examples from [Jeannette Wing]

Biology

- Algorithms for DNA sequencing of human genome



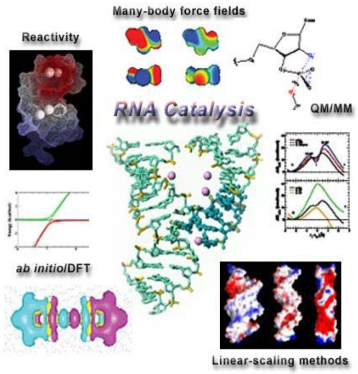


Brain Science

- Modeling the brain as a computer

Chemistry [Madden, Fellow of Royal Society of Edinburgh]

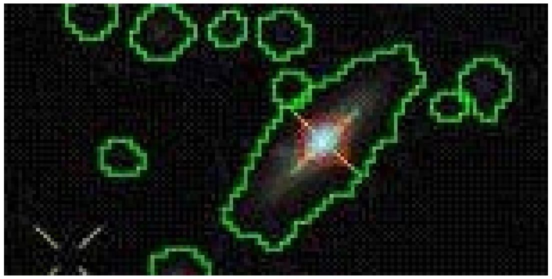
- Optimization and searching algorithms identify best chemicals for improving reaction conditions to improve yields

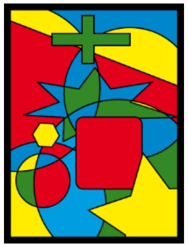


CT in more sciences

Geology
- Abstraction boundaries and hierarchies of complexity model the earth and our atmosphere

Astronomy
- Sloan Digital Sky Server brings a telescope to every child





Mathematics
- Four-color theorem proof

Engineering (electrical, civil, mechanical ...)
- Boeing 777 tested via computer simulation alone, not in a wind tunnel

CT for Society

Economics

- Automated mechanism design underlies electronic commerce, e.g., ad placement, on-line auctions, kidney exchange

Social Sciences

- Statistical machine learning is used for recommendation and reputation services, e.g., Netflix, affinity card

CT for Society

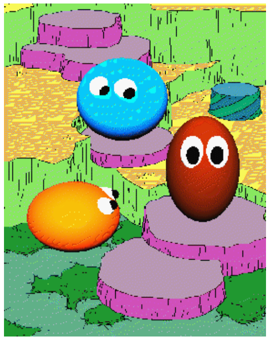
Medicine

- Electronic health records require privacy technologies
- Robotic Surgery

Law

- Approaches include AI, temporal logic,
  state machines, process algebras, petri nets
- Sherlock Project on crime scene investigation

CT for Society

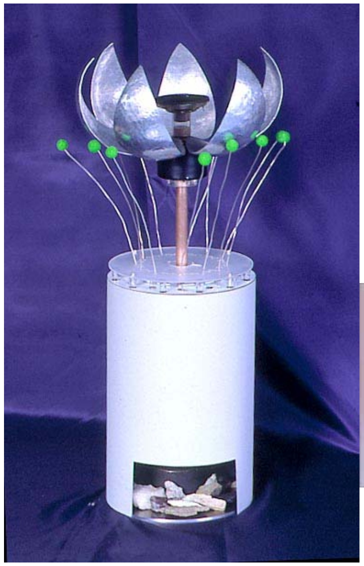


Entertainment

- Games
- Lucas Films uses 2000-node data center to produce *Pirates of the Caribbean.*

Arts

- Art (e.g., Robotticelli)
- Drama, Music, Photography
- Programming for Musicians and Digital Artists



Sports

- Synergy Sports analyzes digital videos NBA games

Stop and "chat"

Here are the 9 CT concepts

- Data Collection, Data Analysis, Data Representation
- Problem Decomposition, Abstraction
- Algorithms, Automation
- Simulation and Modeling, Parallelization

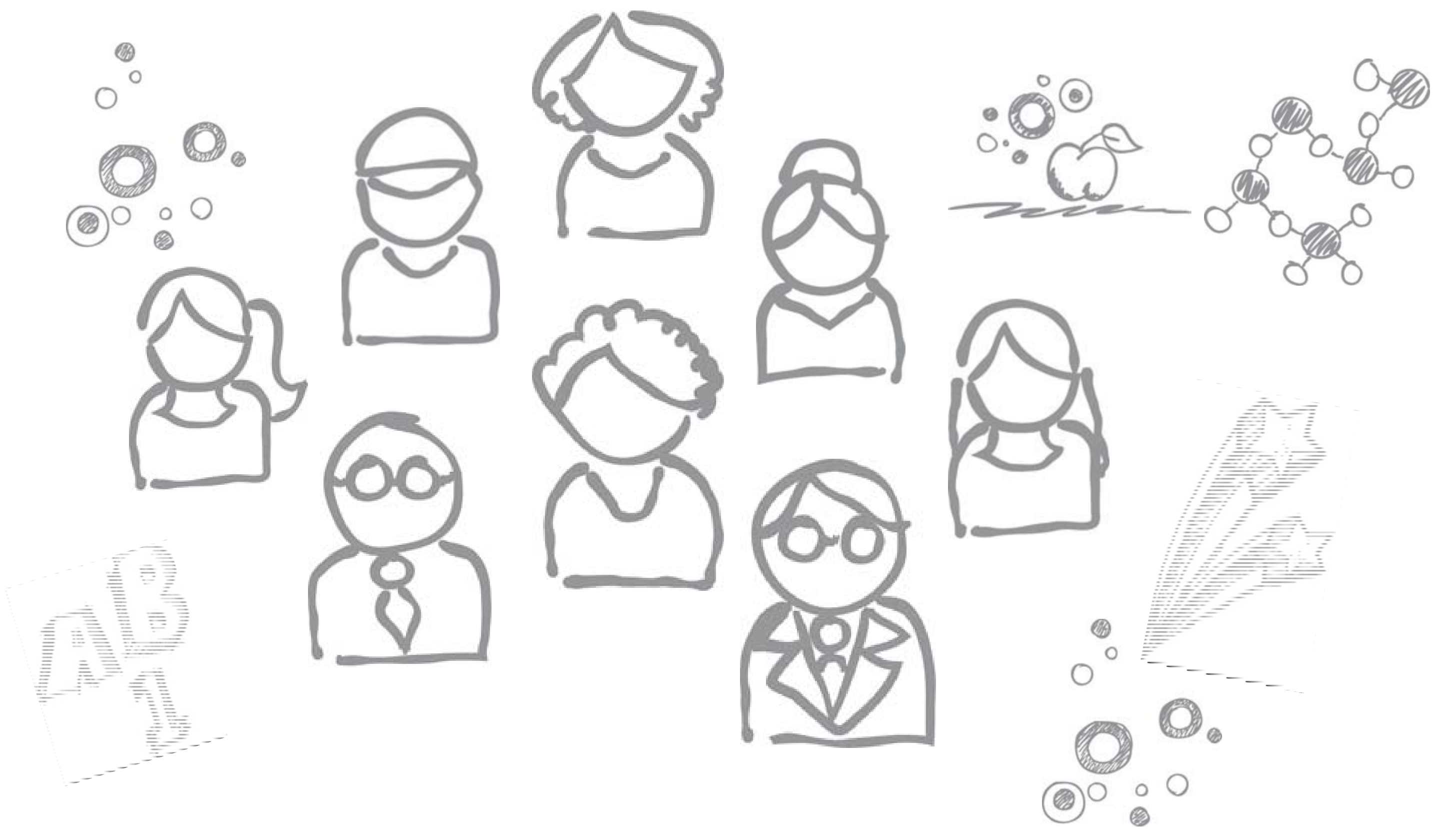
As you think about what you teach, can you think of a lesson, topic, unit where one or more of these concepts would appear?

CT is for All Teachers

All teachers can and should be responsible for teaching skills, practice, and assessment of CT. This is not a "computer thing".

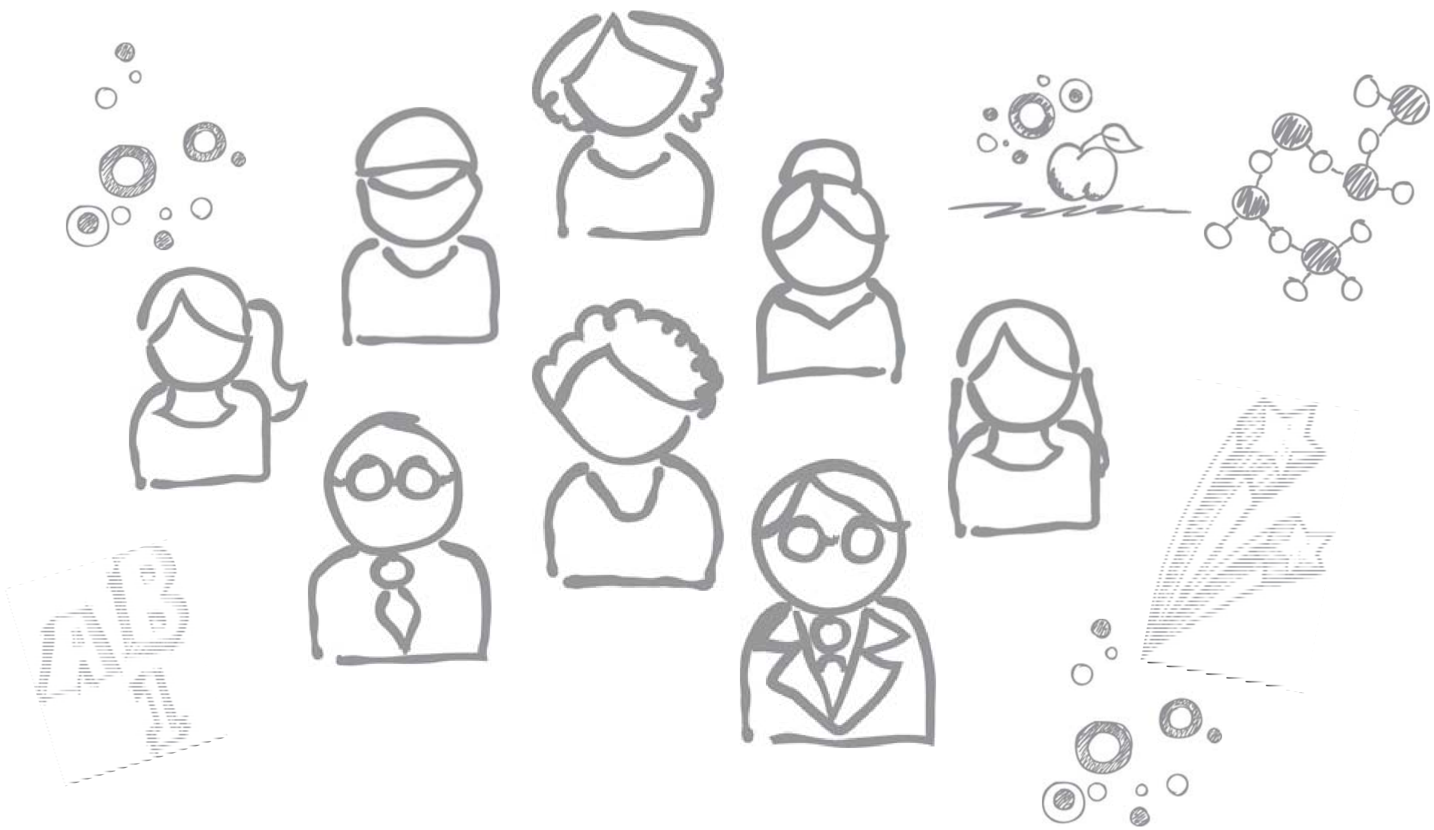
CT for All Teachers

Most teachers already incorporate CT basics, but may not know it.



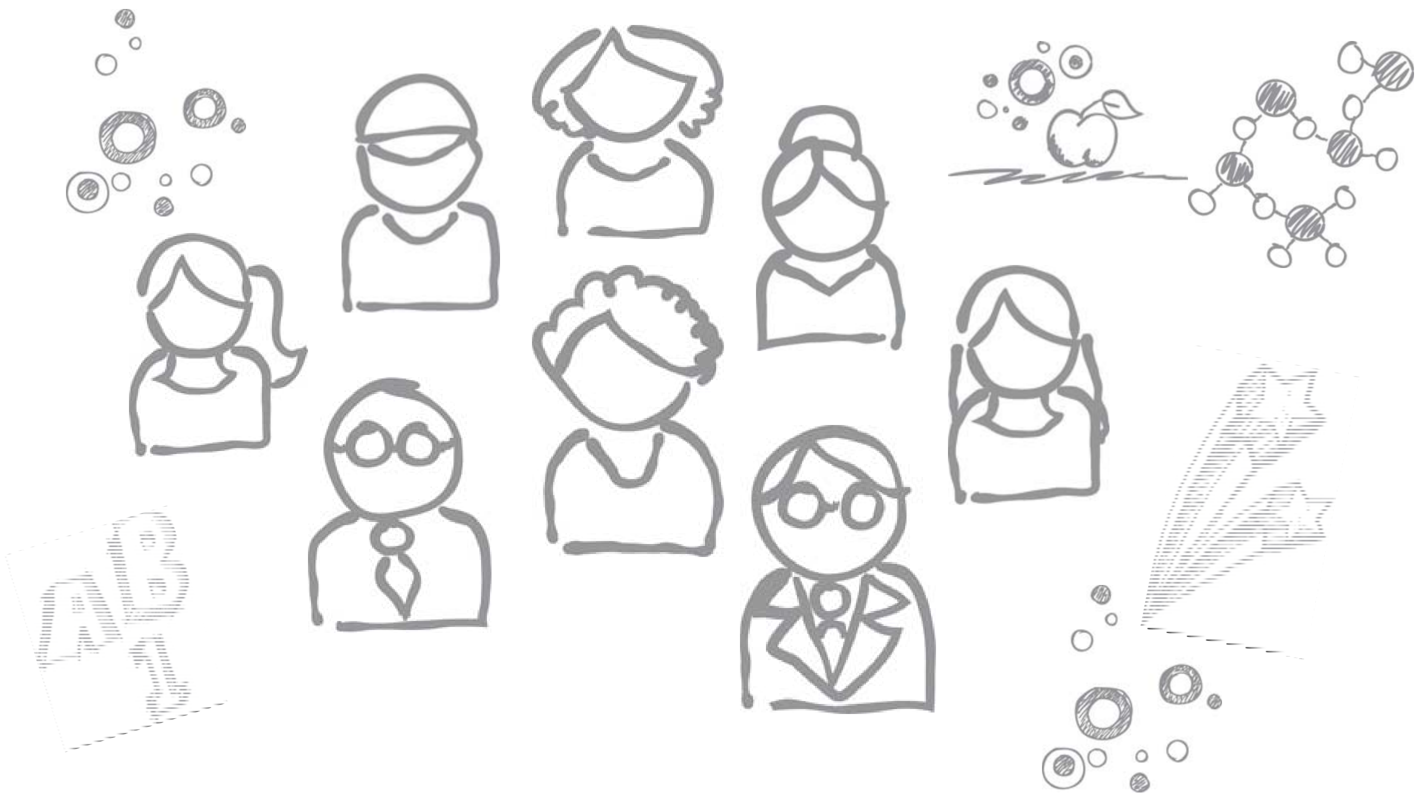
CT for All Teachers

CT has a shared vocabulary that can be highlighted in lessons from every discipline.



CT for All Teachers

CT is made up of foundational building blocks of concepts, skills, and dispositions that get more sophisticated as students get older.



CT for All Teachers

CT doesn’t necessarily require computers.

CT Operational Definition (handout)

Operational Definition of Computational Thinking for K–12 Education

Computational thinking (CT) is a problem-solving process that includes (but is not limited to) the following characteristics:

- Formulating problems in a way that enables us to use a computer and other tools to help solve them.
- Logically organizing and analyzing data
- Representing data through abstractions such as models and simulations
- Automating solutions through algorithmic thinking (a series of ordered steps)
- Identifying, analyzing, and implementing possible solutions with the goal of achieving the m(efficient and effective combination of steps and resources
- Generalizing and transferring this problem solving process to a wide variety of problems

CT Operational Definition

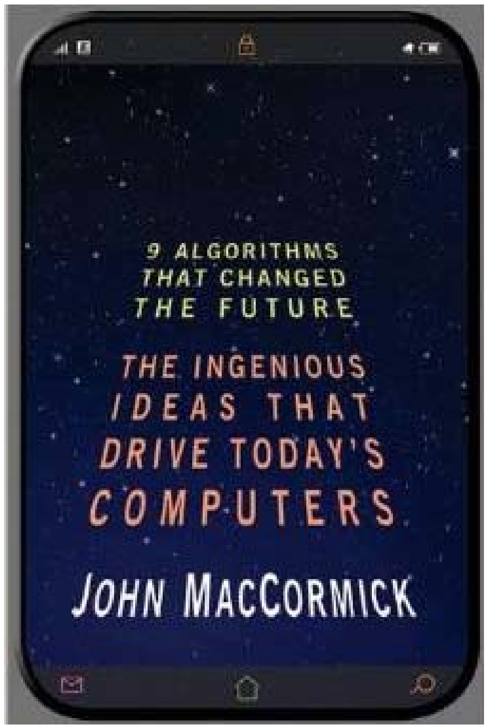
Computational Thinking is

The marriage of

- the big ideas in computer science (such as abstraction, algorithms, modeling, problem decomposition)
- with problems and big ideas in most other subject matter domains

Featured CT Concept: Algorithms

Excellent book and our current SIGCT Book Study



Nine Algorithms that Changed the Future: The Ingenious Ideas that Drive Today's Computers.

John MacCormick

Karen's blog post about this book: http://knorth.edublogs.org/2014/03/24/algrithm-that-change/

CT Building Blocks (handout)

C | CT Vocabulary and Progression Chart

	Definition	Grades PK to 2	Grades 3 to 5
Data Collection	The process of gathering appropriate information	Conduct an experiment to find the fastest toy car down an incline and record the order of cars across the finish line in a chart.	Review examples of writing to identify strategies for writing an essay.
Data Analysis	Making sense of data, finding patterns, and drawing conclusions	Make generalizations about the order of finishing a toy car race based on the characteristics of the car with a focus on weight. Test conclusions by adding weight to cars to change results.	Categorize strong and weak examples of writing samples to develop a rubric.
Data Representation	Depicting and organizing data in appropriate graphs, charts, words, or images	Create a chart or a line drawing that shows how the speed of a toy car changes when its weight is changed.	Match each writing sample to the rubric and create a chart showing which example best fits in each category of the rubric.

CT Building Blocks (handout)

CT Concept, Capability	CS	Math	Science	Social Studies	Language Arts
Data collection	Find a data source for a problem area	Find a data source for a problem area, for example, flipping coins or throwing dice	Collect data from an experiment	Study battle statistics or population data	Do linguistic analysis of sentences
Data analysis	Write a program to do basic statistical calculations on a set of data	Count occurrences of flips, dice throws and analyzing results	Analyze data from an experiment	Identify trends in data from statistics	Identify patterns for different sentence types
Data representation	Use data structures such as array, linked list, stack, queue, graph, hash table, etc.	Use histogram, pie chart, bar chart to represent data; use sets, lists, graphs, etc. To contain data	Summarize data from an experiment	Summarize and represent trends	Represent patterns of different sentence types
Problem Decomposition	Define objects and methods; define main and functions	Apply order of operations in an expression	Do a species classification		Write an outline

graphs, charts, words, or images

is changed.

fits in each category of the rubric.

Comparing CT Core Dispositions and CCSS Standards for Mathematical Practice

CCSS Standards for Math Practice	Computational Thinking core dispositions
1. Make sense of problems and persevere in solving them	Confidence with complexity Persistence in working through problems
2. Reason abstractly and quantitatively	Ability to deal with open ended problems
3. Construct viable arguments and critique the reasoning of others	Ability to communicate and collaborate to achieve a common goal
4. Model with mathematics	Tolerance for ambiguity
5. Use appropriate tools strategically	Ability to communicate and collaborate to achieve a common goal
6. Attend to precision	Persistence in working through problems
7. Look for and make use of structure	Ability to deal with open-ended problems
8. Look for and express regularity in repeated reasoning	Ability to deal with open-ended problems

<http://www.corestandards.org/the-standards/mathematics/introduction/standards-for-mathematical-practice/>

Comparing CT Core Concepts and CCSS Standards for Mathematical Practice

CCSS Standards for Math Practice	Computational Thinking core concepts
1. Make sense of problems and persevere in solving them	Data collection, analysis, representation Problem Decomposition/Analysis
2. Reason abstractly and quantitatively	Abstraction
3. Construct viable arguments and critique the reasoning of others	Algorithms and Procedures
4. Model with mathematics	Modeling & Simulation
5. Use appropriate tools strategically	Automation
6. Attend to precision	Data collection, analysis, representation
7. Look for and make use of structure	Parallelization Algorithms & Procedures
8. Look for and express regularity in repeated reasoning	Algorithms & Procedures

<http://www.corestandards.org/the-standards/mathematics/introduction/standards-for-mathematical-practice/>

CCSS: Standards for Mathematical Content

High School: Modeling

Modeling Standards

Modeling is best interpreted not as a collection of isolated topics but rather in relation to other standards. Making mathematical models is a Standard for Mathematical Practice, and specific modeling standards appear throughout the high school standards indicated by a star symbol (★).

<http://www.corestandards.org/the-standards/mathematics/high-school-modeling/introduction/>

CT Statement #1

CT is a key interdisciplinary component in preparing students to be successful in a globally competitive workforce.

- If students are going to be successful in postsecondary education and compete for and win jobs, they must have the critical thinking and problem-solving skills that CT provides (Wagner).

From ISTE CT Website, Computational Leadership Toolkit (8/22/11), p 42
Tony Wagner, Innovation Education Fellow, Technology and Entrepreneurship Center, Harvard U

CT Statement #2

CT is a critical enabling skill that will raise the level of achievement for all students, especially those who are traditionally marginalized.

- Successful students must be able to connect and apply academic content to real-world situations, and CT provides a framework for that learning connection (Marzano).

From ISTE CT Website, Computational Leadership Toolkit (8/22/11), p 42
Robert J Marzano, Marzano Research Laboratory

CT Statement #3

CT is already a learning strategy in many classrooms and lessons today. However, we need to more closely examine the uses of CT and identify and expand student and teacher awareness about its impact and power.

- This means we probably do not have to expend large sums of money. We just need to recognize and align CT strategies to current practices.

From ISTE CT Website, Computational Leadership Toolkit (8/22/11), p 42

CT promotes 21st Century Learning

- Consuming content and parroting procedures is 19th and 20th Century
- 21st Century Education is about process, about learning tools and skills to remake content, create new learning and solve problems (think creators, producers)
- Not about just formal education in school but also about informal education – 24 hour learning – the network

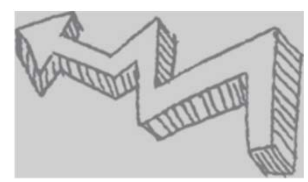
Re-Imagining Learning in the 21st Century: MacArthur Foundation
http://www.youtube.com/watch?v=D6_U6jOKsG4&feature=relmfu
Rethinking Learning: The 21st Century Learner: MacArthur Foundation
http://www.youtube.com/watch?v=c0xa98cy-Rw&feature=relmfu

CT Features

- Contextual
- Multidisciplinary
- Project-based and inquiry based
- Looking deeply at a problem
- Using abstraction + algorithms + analysis + bringing to bear any number of tools + possibly automation/computing

CT Resources

CT Teacher Resources and CT Leadership Toolkit
For free download at www.iste.org/computational-thinking
Coming Soon! CT database for links to research and other teacher resources.



Thank you!

For more information, contact:

computational-thinking@iste.org

Or

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

www.iste.org/computational-thinking

Joe's site: http://computationalthinking.pbworks.com