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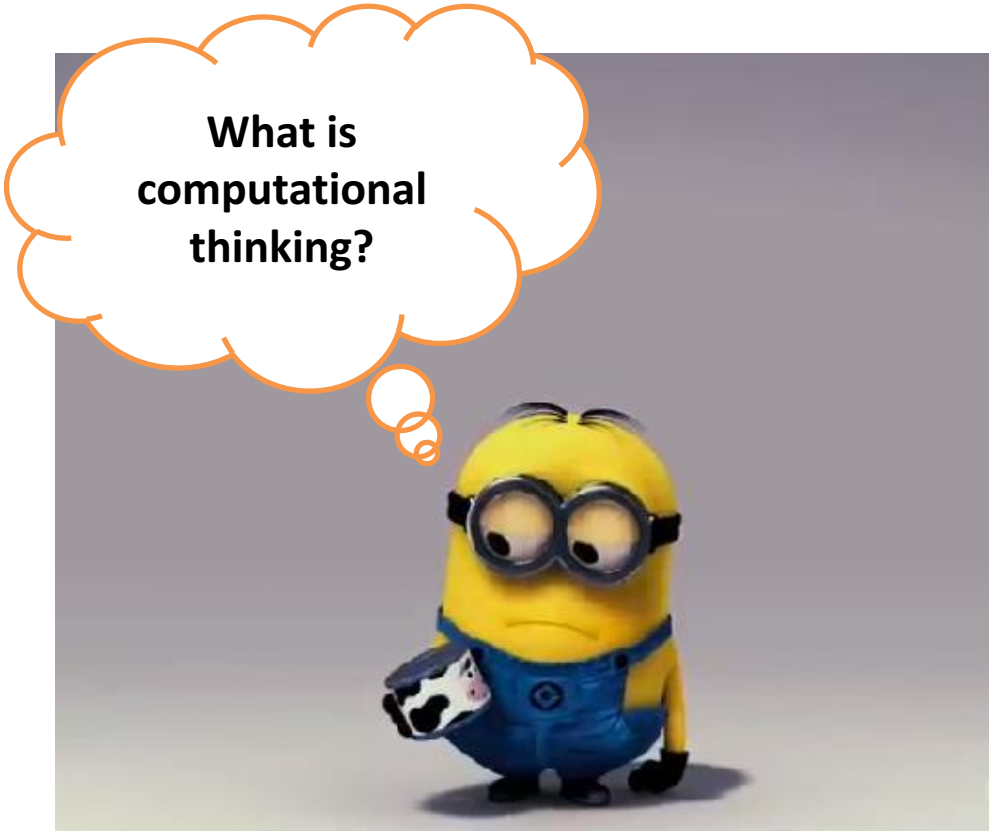
Computational Thinking, Computer Science, and Coding

http://img2.wikia.nocookie.net/__cb20130510160248/despicableme/images/e/e9/Despicable-Me-Minions_thumb10.jpg

Hmm ….



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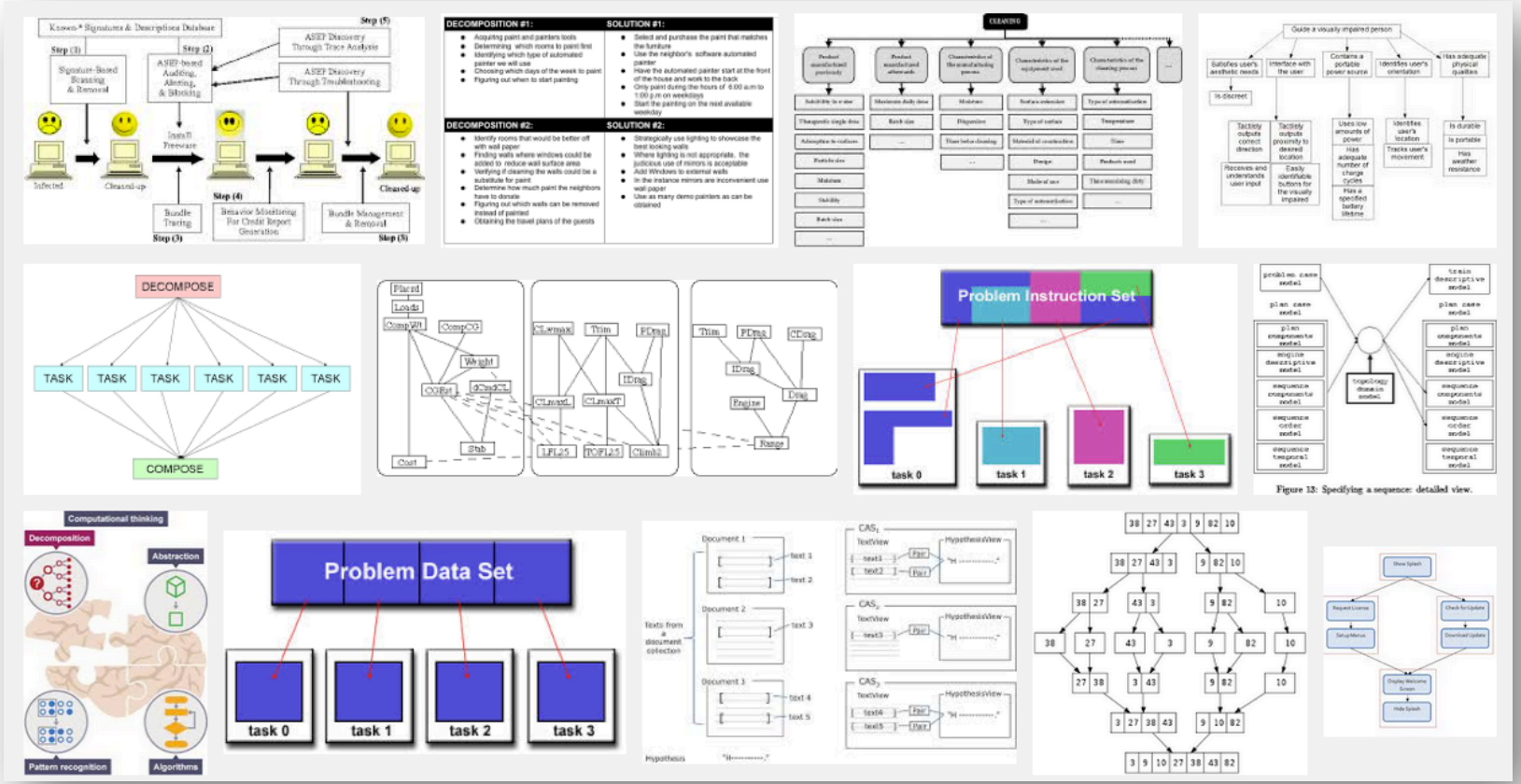
What is Computational Thinking?

- A way of thinking for *logically* and *methodically* solving problems
  - E.g., *purposeful*, *describable*, *replicable*
- Includes *skills* such as
  - Decomposition
  - Pattern Recognition
  - Abstraction
  - Generalization
  - Algorithm Design
  - Evaluation

Decomposition

- Breaking down a process into a set of smaller sub-processes to allow us to describe, understand, or execute the process better
  - Dividing a task into a sequence of subtasks
  - Identifying elements or parts of a complex system

Decomposition



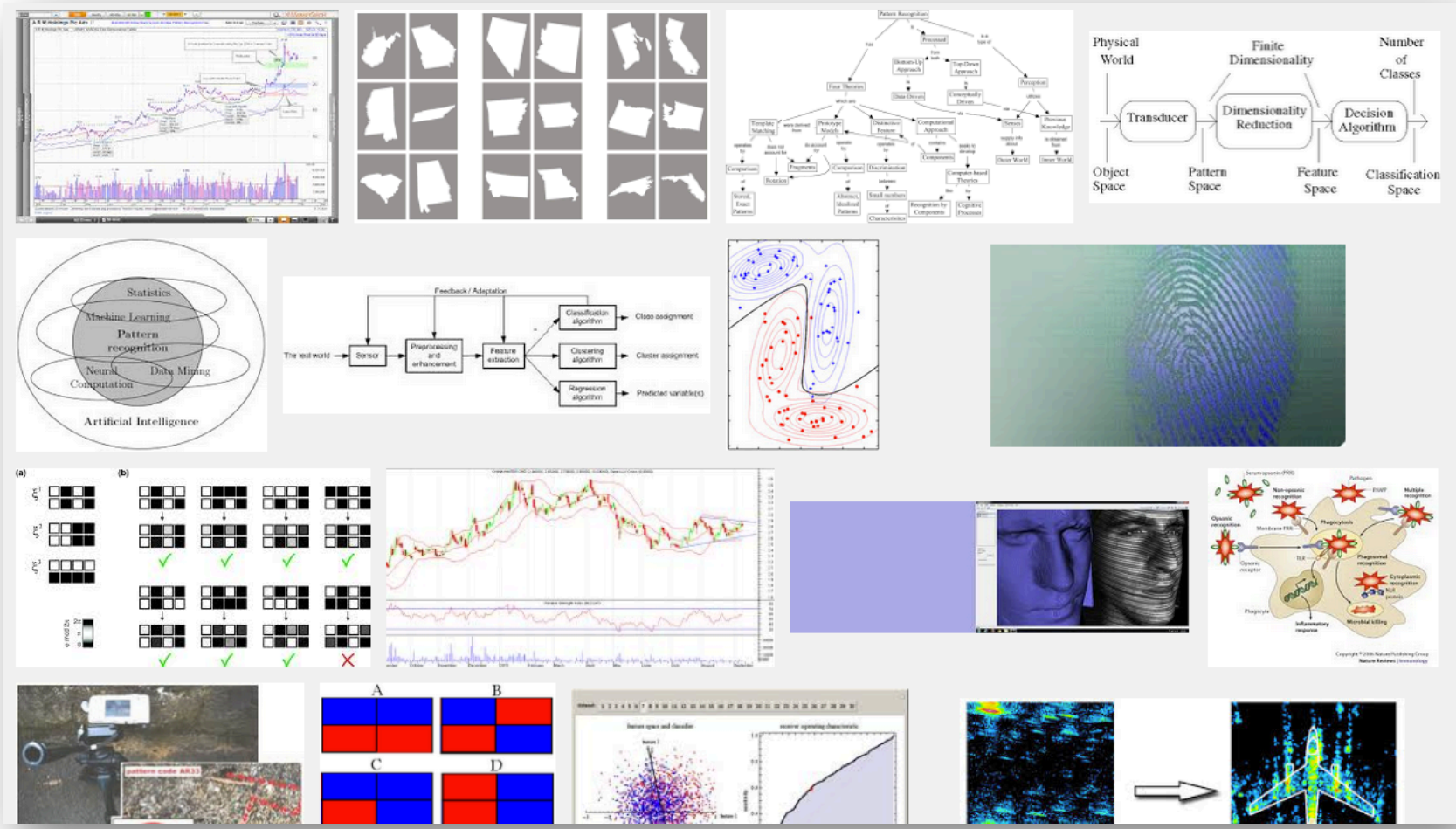
Examples of Decomposition

- When we taste an unfamiliar dish and identify several ingredients based on the flavor, we are decomposing that dish into its individual ingredients
- When we give someone directions to our house, we are *decomposing* the process of getting from one place to another (e.g., city, interstate, etc.)
- When we break a course project into several steps, we are decomposing the task into smaller, more manageable subtasks
- In mathematics, we can *decompose* a number such as **256.37** as follows: $\mathbf{2}*10^{2}+\mathbf{5}*10^{1}+\mathbf{6}*10^{0}+\mathbf{3}*10^{-1}+\mathbf{7}*10^{-2}$

Pattern Recognition

- Noticing or identifying similarities or common differences that will help us make predictions or lead us to shortcuts
  - We look for *patterns* when we play games to decide when to do certain things
  - Based on experience, we develop shortcuts mapping problem characteristics to solution

Pattern Recognition



Examples of Pattern Recognition

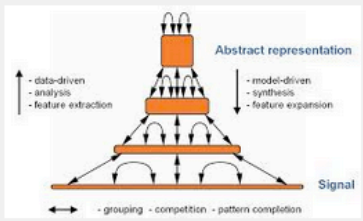
- We look for patterns when choosing a registrar when we checkout
- Drivers look for patterns in traffic to decide whether and when to switch lanes
- People look for patterns in stock prices to decide when to buy and sell
- Scientists look for patterns in data to derive theories and models
- We look for patterns and learn from them to avoid repeating the same mistake
  - "Last time we did this, it was … let's try something different …"

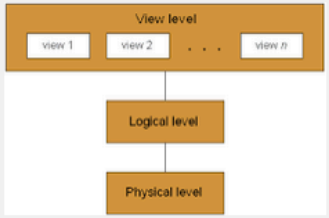
Abstraction

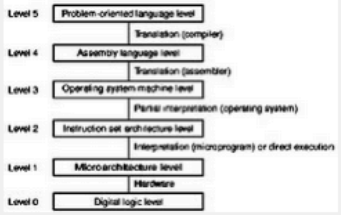
- Preserving information that is relevant in a context, and forgetting or suppressing information that is irrelevant in that context to solve a problem
  - We use abstraction to **organize** things:
    - A human is a mammal, a mammal is an animal, and so on
  - A "big picture" so we can reason without thinking about the details
  - Transfer learning or learning by analogy

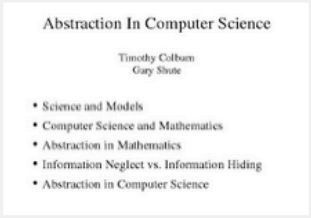
Guttag, John V. (2013-01-18). Introduction to Computation and Programming Using Python (Spring 2013 edition ed.). Cambridge, Massachusetts: The MIT Press. ISBN 9780262519632.

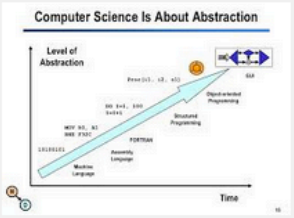
Abstraction

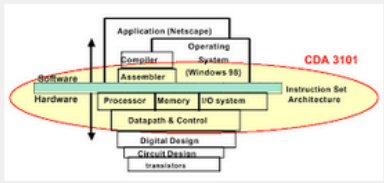


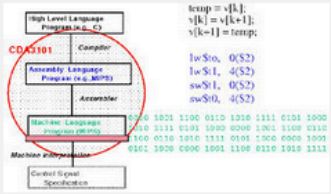


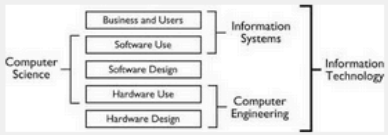


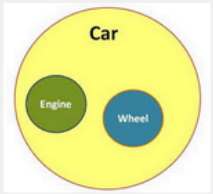


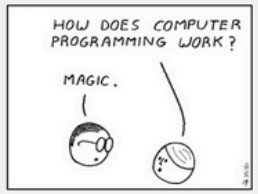


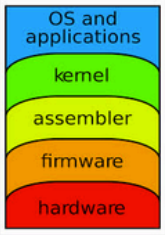


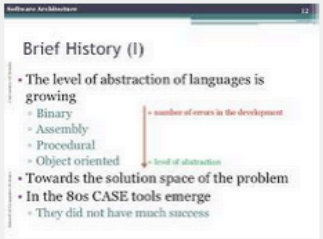


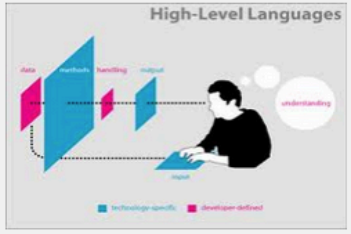


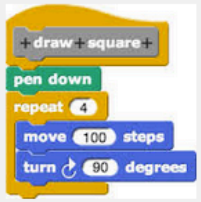


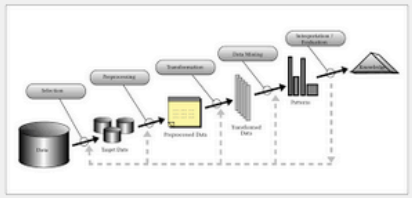


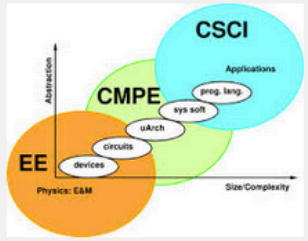


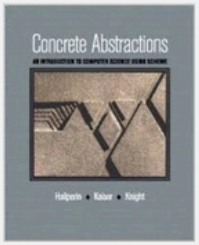


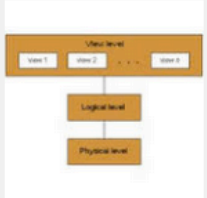












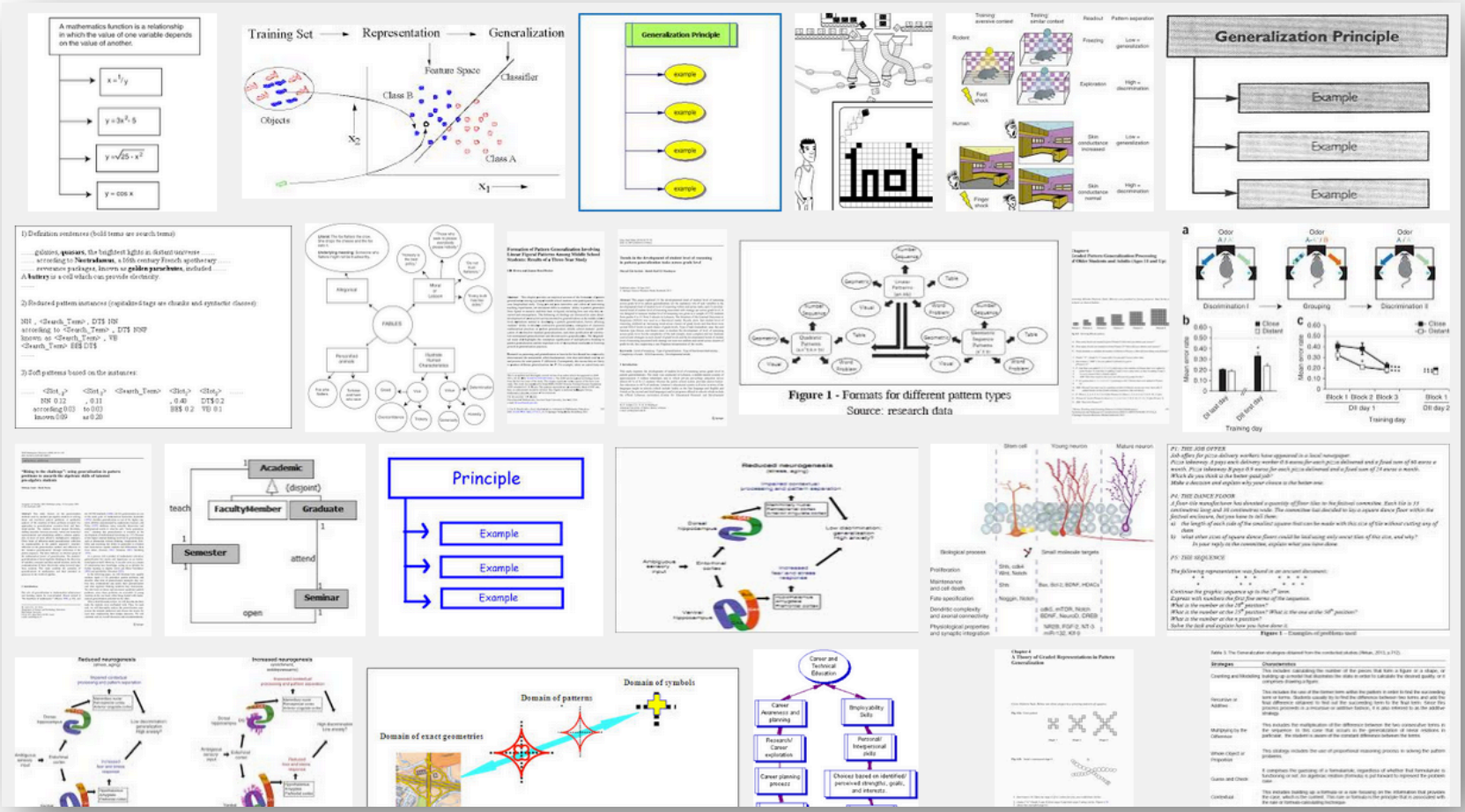
Examples of Abstraction

- A world map is an *abstraction* of the earth in terms of longitude and latitude, helping us describe the location and geography of a place
- A sign of an aisle in a store—e.g., Walmart—is an *abstraction* of the items available in that aisle
- When we write a book report, we summarize and discuss only the theme or key aspects of the book, it is abstraction
- *When we tell a story or describe a movie to our friends, why don't we describe every single detail of the story or movie?*

Generalization

- Identifying common or shared characteristics between two domains or problems such that models or solutions of one could be adapted or applied to the other
  - Mammals are warm blooded, give live birth, have hair, and so on. An elephant is a mammal. Therefore, it is warm blooded, give live birth, have hair …
  - Group project A successful because of good teamwork strategy. Apply same good teamwork strategy to group project B should work too.
  - Deals with trends, norms, outliers, scalability

Generalization



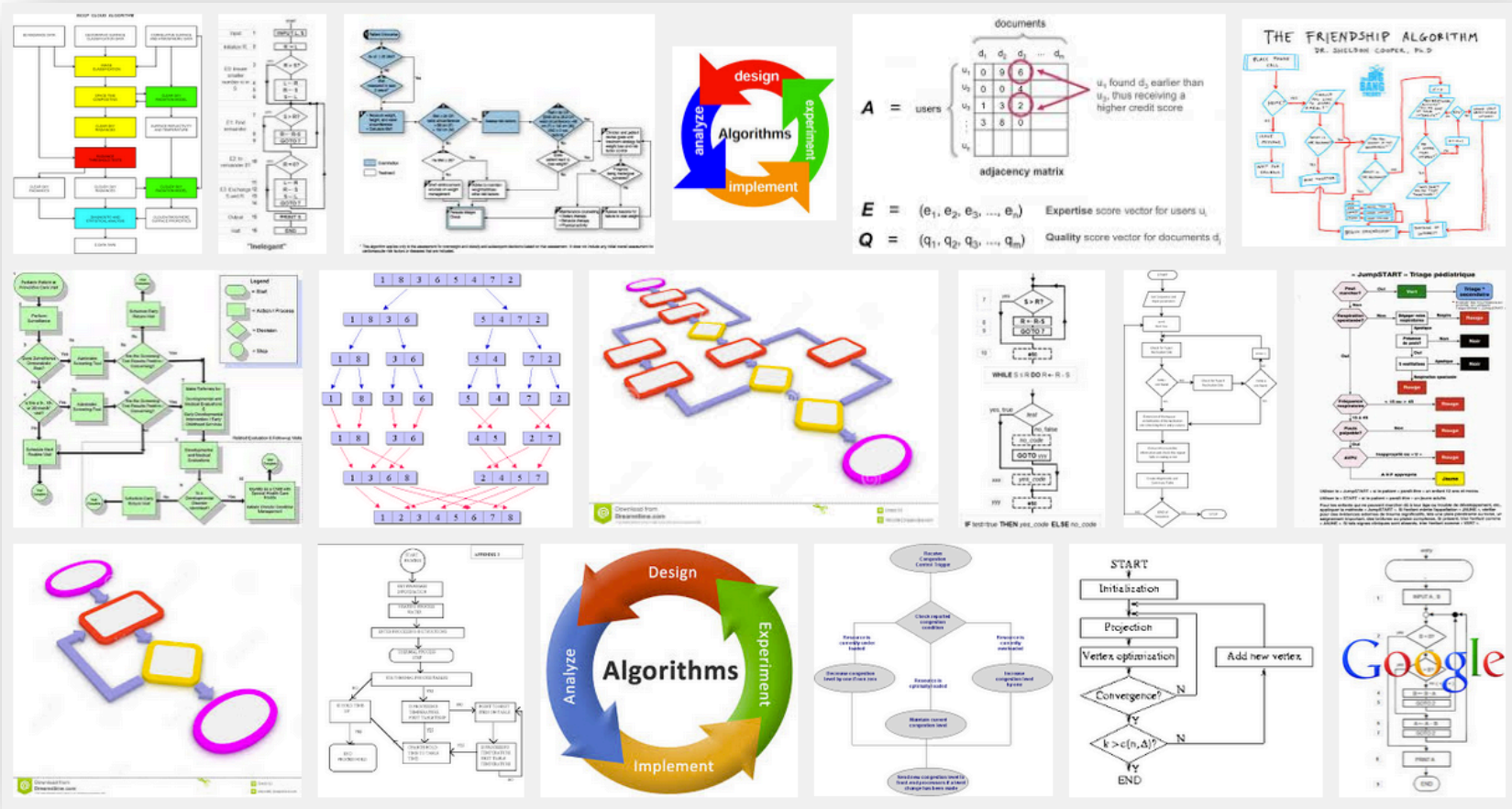
Examples of Generalization

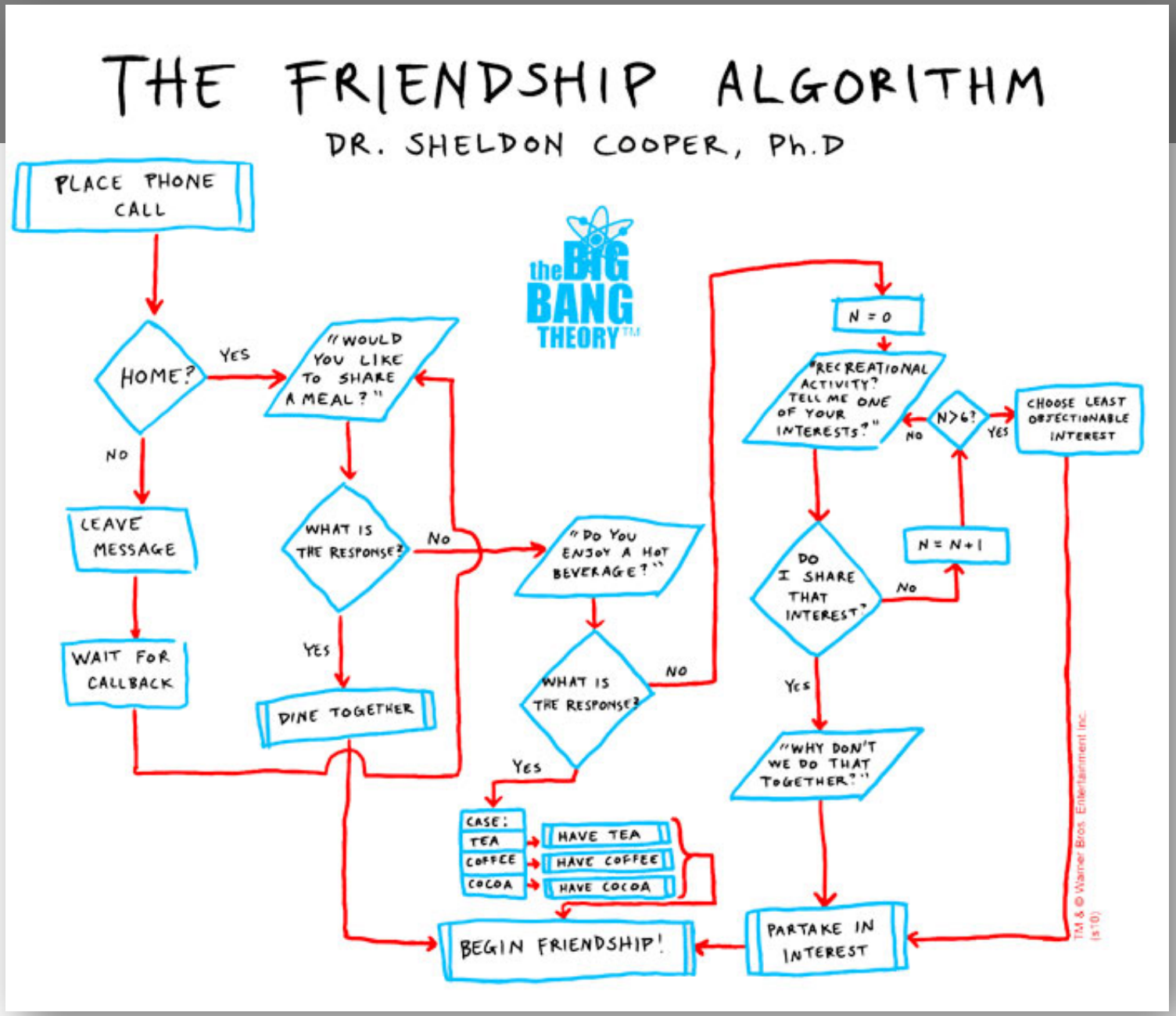
- Facebook tries to recommend ads to users based on what they generalize from what our friends like
- Google search identifies popular keywords in different regions at different times and suggests those keywords (in autocomplete and also correction) using a generalization-like process
- Amazon.com and Netflix model and categorize their customers, use generalization—*inferencing*—to predict what their customers are interested in, and make recommendations accordingly
- *When we don't have complete information, we resort to generalization to make decisions (sometimes incorrectly)*
  - *Think about: biases, stereotypes, superstitions*

Algorithm Design

- Developing a step-by-step strategy for solving a problem
  - An algorithm is a sequence of steps that solves a problem
    - Input → output
    - Effective
  - **Algorithmic thinking** involves both *creation* and *execution* of an algorithm

Algorithm Design




THE FRIENDSHIP ALGORITHM
DR. SHELDON COOPER, Ph.D
PLACE PHONE CALL
HOME?
YES
NO
LEAVE MESSAGE
WAIT FOR CALLBACK
"WOULD YOU LIKE TO SHARE A MEAL?"
WHAT IS THE RESPONSE?
YES
DINE TOGETHER
NO
"DO YOU ENJOY A HOT BEVERAGE?"
WHAT IS THE RESPONSE?
YES
NO
CASE:
TEA
COFFEE
COCOA
HAVE TEA
HAVE COFFEE
HAVE COCOA
BEGIN FRIENDSHIP!
N = 0
"RECREATIONAL ACTIVITY? TELL ME ONE OF YOUR INTERESTS."
N>6?
NO
YES
CHOOSE LEAST OBJECTIONABLE INTEREST
N = N+1
DO I SHARE THAT INTEREST?
NO
YES
"WHY DON'T WE DO THAT TOGETHER?"
PARTAKE IN INTEREST
the BIG BANG THEORY™
TM & © Warner Bros. Entertainment Inc. (s'10)

Examples of Algorithm Design

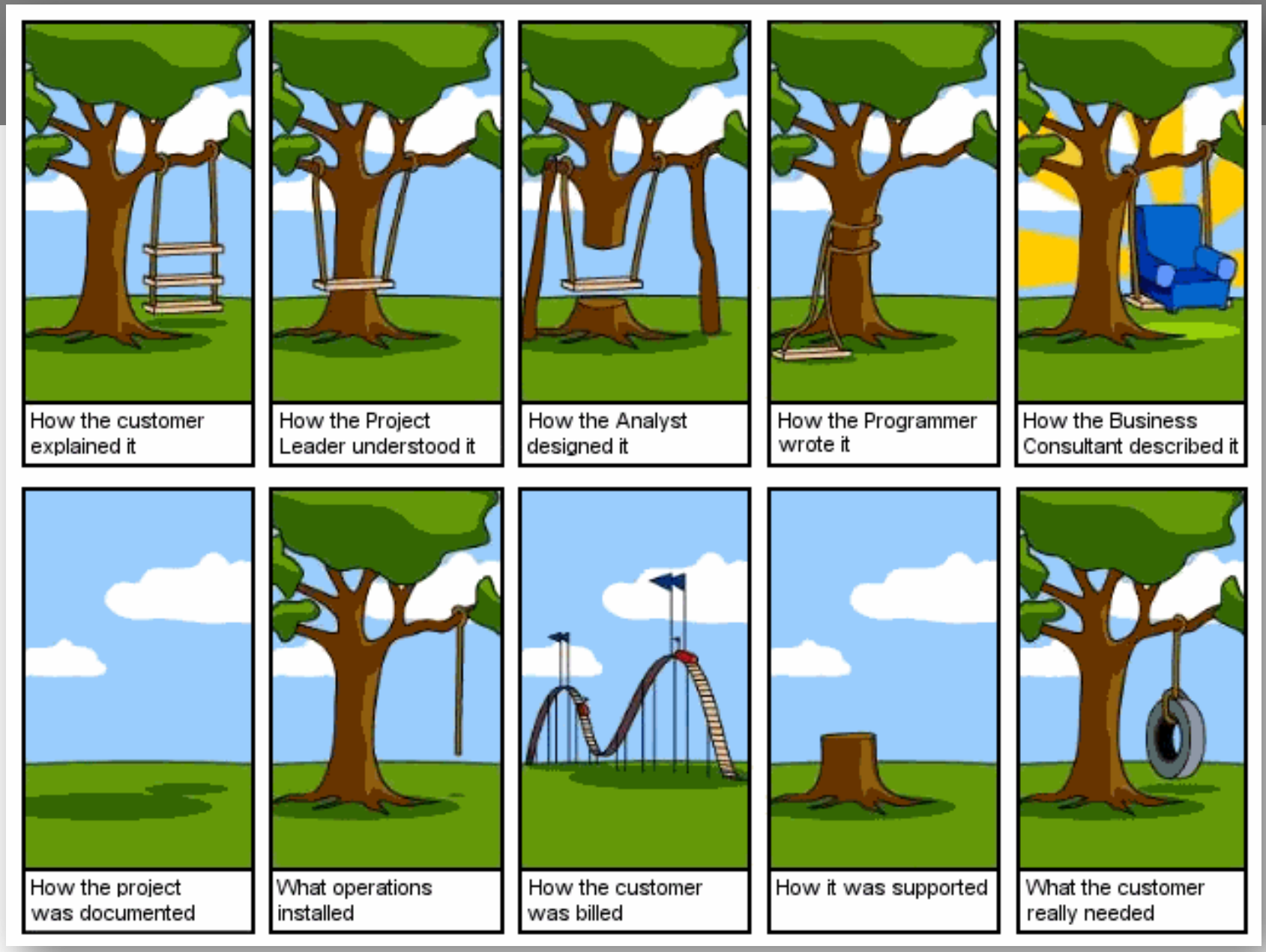
- When a cook writes a recipe for a dish, he or she is creating an algorithm that others can follow to replicate the dish
- When your friend writes down the instruction to get to her house, he or she is specifying a sequence of steps—that is, an algorithm—for you to follow (See Google maps!)
- When a teacher gives a set of instructions to carry out an experiment, he or she is specifying an algorithm for you to follow to collect and analyze data
- When you follow an installation manual to assemble a bookshelf, you are executing an algorithm

Evaluation

- Checking to see whether a solution is good
  - Algorithm correctness
  - Requirements (meeting constraints, design principles, etc.)
  - Performance (usability, efficiency, speed, complexity, reliability, etc.)

Evaluation


comments
ratings
opinions
input
feedback
reviews
replies
surveys
answers
responses
Excellent
Very good
Good
Average
Poor
Teacher Feedback (Evaluation)
360 Employee Evaluation Feedback
Evaluation
OUTSTANDING
Excellent
Very Good
Average
Below Average
EVALUATION
Outstanding
Very Good
Satisfactory
Marginal
Measurable
Specific
Achievable
Time
Realistic
FEEDBACK
EXCELLENT
GOOD
AVERAGE
FEEDBACK
Self Reflection
Student Results
Evaluating and Improving Assessment
Peer Review
Student Experience
AWESOME!
Excellent
Very Good
Satisfactory
Marginal
Poor
FEEDBACK
360°
Product Quality
Excellent
Good
Neutral
Marginal
Poor
FEEDBACK, EVALUATION



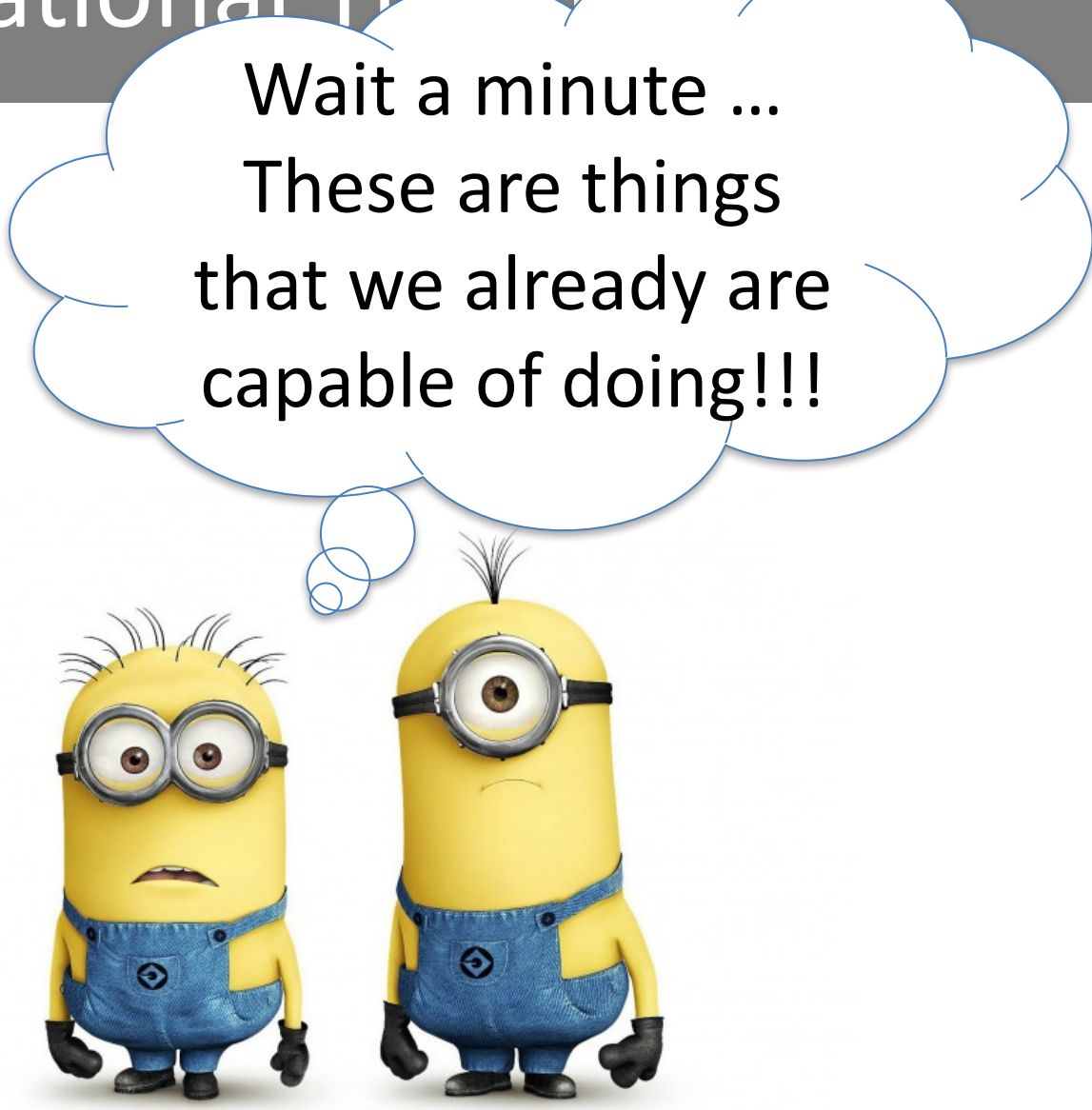
https://medium.com/@FreeCodeCamp/coding-explained-in-25-profound-comics-8847ea03819c

Examples of Evaluation

- When we cook, we taste our dishes and then adjust flavoring accordingly
- When we fold a paper airplane, we test its flight, and then revise either the design or the "execution" to make it fly better
- When we jog or bike, we keep track of our breathing, joints, etc., and decide whether to stop, go slower, or go faster
- When we carry out a physics experiment, say, to find the relationship between temperature and pressure, we check our data, investigate why it does not match the theory, redo our experimental setup, and recollect data points …

So, Computational Thinking is

- **Decomposition**
- **Pattern Recognition**
- **Abstraction**
- **Generalization**
- **Algorithm Design**
- **Evaluation**



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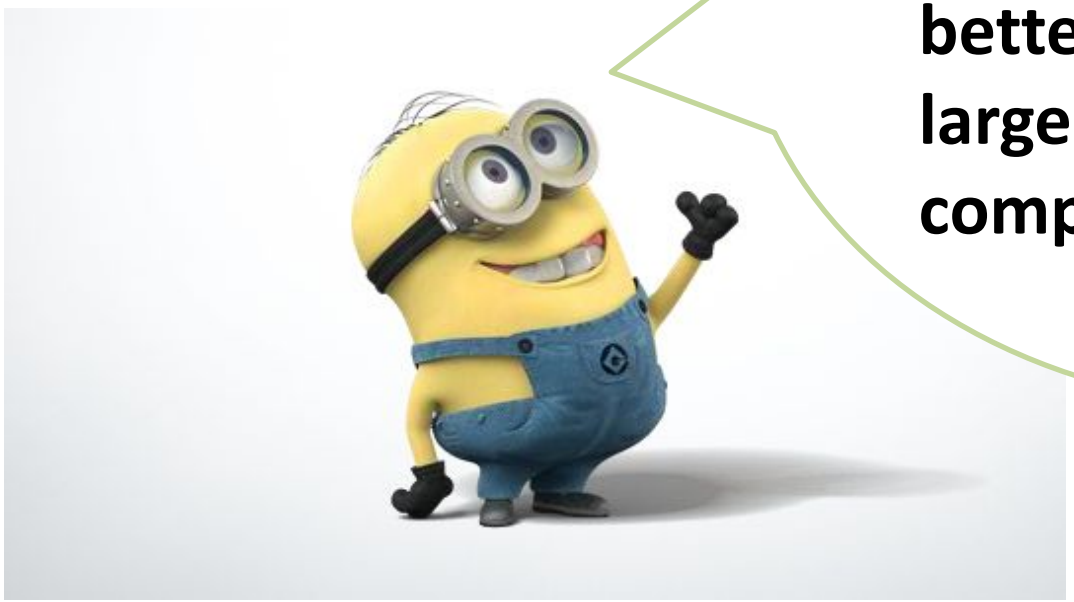
What is Computer Science?

- **There are many definitio**



Computer Science
helps us practice our computational thinking better, faster, with larger and more complex problems …

What is Computer Science?

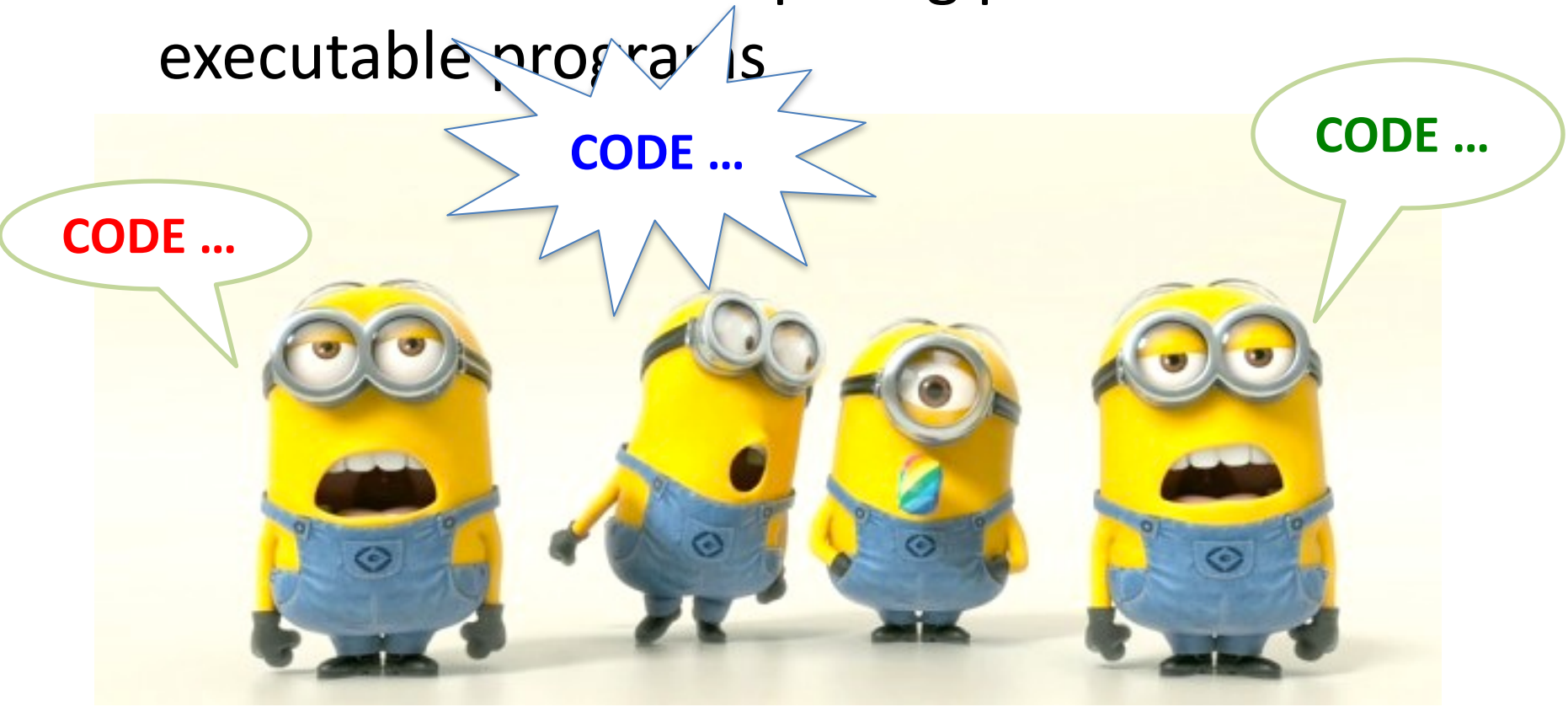
Science: ***We learn, model, and describe how humans think, make decisions, and solve problems …***

Engineering: ***We build computer solutions to support and automate human thinking, decision making, problem solving …***

http://www.zastavki.com/eng/Cartoons/wallpaper-51616.htm
https://www.pinterest.com/pin/357332551655575856/

What is Computer Programming?

- A process that leads from an original formulation of a computing problem to executable programs

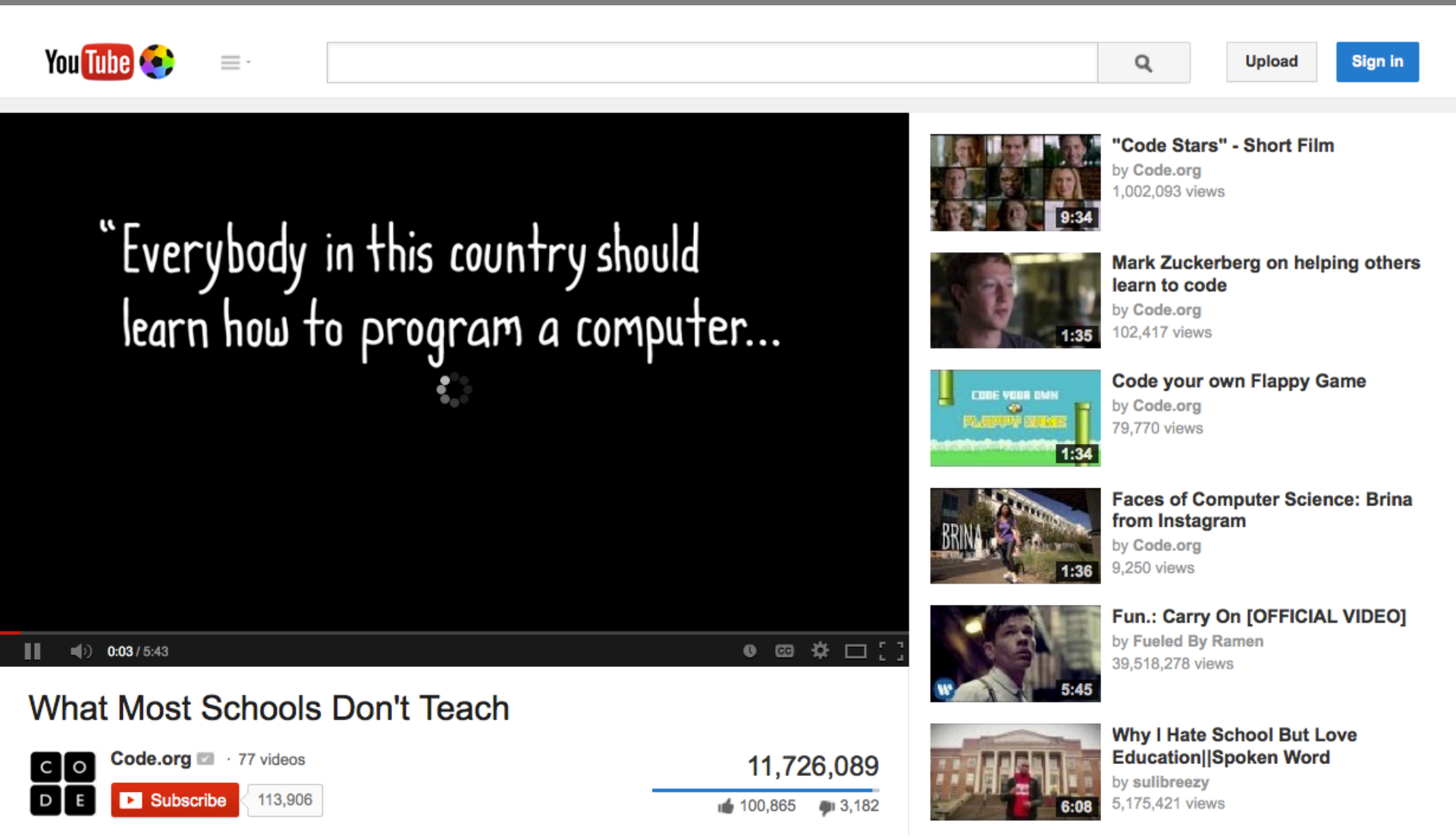


http://www.beyondhollywood.com/despicable-me-2-teaser-trailer-now-with-more-minion-abuse/

http://en.wikipedia.org/wiki/Computer_programming

Code.org

http://code.org



From code.org

Go to Video

Resources

- Many CS & Computational Thinking education/outreach resources available online
  - National Center for Women & Information Technology (NCWIT) “in-a-box” kits **http://ncwit.org**
  - Ensemble, a Portal for Computing Educators **http://www.computingportal.org**
  - CS Education Week **http://www.csedweek.org**
  - Google’s Computer Science for High School (CS4HS) **http://cs4hs.com**
  - Google’s Exploring Computational Thinking **https://edu.google.com/resources/programs/exploring-computational-thinking/**
  - Code.org **http://code.org**
  - …

CS Unplugged

http://csunplugged.org

- "CS Unplugged is a collection of free learning activities that teach Computer Science through engaging games and puzzles that use cards, string, crayons and lots of running around."

"The activities introduce students to underlying concepts such as binary numbers, algorithms and data compression, separated from the distractions and technical details we usually see with computers."

"CS Unplugged is suitable for people of all ages, from elementary school to seniors, and from many countries and backgrounds. Unplugged has been used around the world for over fifteen years, in classrooms, science centers, homes, and even for holiday events in a park! "

CS Unplugged

http://csunplugged.org

Created by Tim Bell, Ian H. Witten, and Mike Fellows, and illustrated by Matt Powell

go

CS Unplugged

As NCWIT's **Computer Science-in-a-Box: Unplug Your Curriculum** (http://www.ncwit.org/resources/computer-science-box-unplug-your-curriculum)

- Examples
  - Magic card show – error detection
  - Treasure island – finite state machines
  - Sorting game – sorting networks

Finally …

"Computational thinking is a fundamental skill for everyone, not just for computer scientists. To reading, writing, and arithmetic, we should add computational thinking to every child's analytical ability." – Jeannette Wing, *CACM* 2006

Finally … Computational Thinking is …

- Conceptualizing, not programming
  - Computer Science is ***not just*** computer programming
- Fundamental, not rote skill
  - A skill needed by everyone to function
- A way that humans, not computers, think
  - Humans are clever and creative; computers take instructions from humans
- Ideas, not artifacts
  - Ideas give birth to artifacts
- It's for everyone
  - ***Not just*** for computer scientist; but for everyone

Special Bond: Computational Thinking and CS

- Articulation of computational thinking skills and processes into reusable computer programs (e.g., instructing machines to do pattern recognition) via **coding** makes us ***more*** aware and attentive of computational thinking
- … and ***more*** efficient and effective in practicing computational thinking in learning, problem solving, etc.

Flavors of Computational Thinking …

Box 1.
Computer Science Teachers Association's Concepts of Computational Thinking:[4]

Formulating problems for computational solution

Logically organizing and analyzing data

Abstractions including models and simulations

Algorithmic thinking

Evaluation for efficiency and correctness

Generalizing and transferring to other domains

Supported by: dispositions of confidence in dealing with complexity, persistence with difficult problems, tolerance for ambiguity, open-ended problems, communication and collaboration

Box 2.
Computing at School's Concepts of Computational Thinking:[3]

Logical reasoning

Algorithmic thinking

Decomposition

Generalization

Patterns

Abstraction

Representation

Evaluation

Supported by: techniques of reflecting, coding, designing, analyzing, and applying

Box 3.
ISTE's Standards for Students in Computational Thinking:[15]

Leverage the power of technological methods to develop and test solutions

Collect data

Analyze data

Represent data

Decomposition

Abstraction

Algorithms

Automation

Testing

Parallelization

Simulation

Supported by: empowered learner, digital citizen, knowledge constructor, designer, communicator, collaborator

Denning, P. (2017). Remaining Trouble Spots with Computational Thinking, *Communications of the ACM*, **60**(6):33-39.

References

- http://www.google.com/edu/computational-thinking
- Paul Curzon's "So What is Computational Thinking"
- Jeannette M. Wing's "Computational Thinking", *Communications of the ACM*, March 2006, pp. 33-35
- https://en.wikipedia.org/wiki/Computer_science

“It's an energy field created by all living things. It surrounds us and penetrates us; it binds the galaxy together.”

Obi-Wan Kenobi introduced Luke Skywalker and most of us to the **Force** for the first time in Star Wars: A New Hope

“It's a skill practiced by all living things. It surrounds us and penetrates us; it binds problem solving (and learning, discovery, …) together.”

Leen-Kiat Soh on the fundamentality of Computational Thinking.

“May computational thinking be with you.”

https://images-na.ssl-images-amazon.com/images/G/01/aplusautomation/vendorimages/65fa961e-8f22-4fe6-a420-3c3c26dd2953.jpg._CB289161999__SL300__.jpg