



COMPUTATIONAL X: INTEGRATING COMPUTATIONAL THINKING ACROSS DISCIPLINES

AUSTIN CORY BART, DENNIS KAFURA, CLIFFORD A. SHAFFER

VIRGINIA TECH

WHO ARE WE?

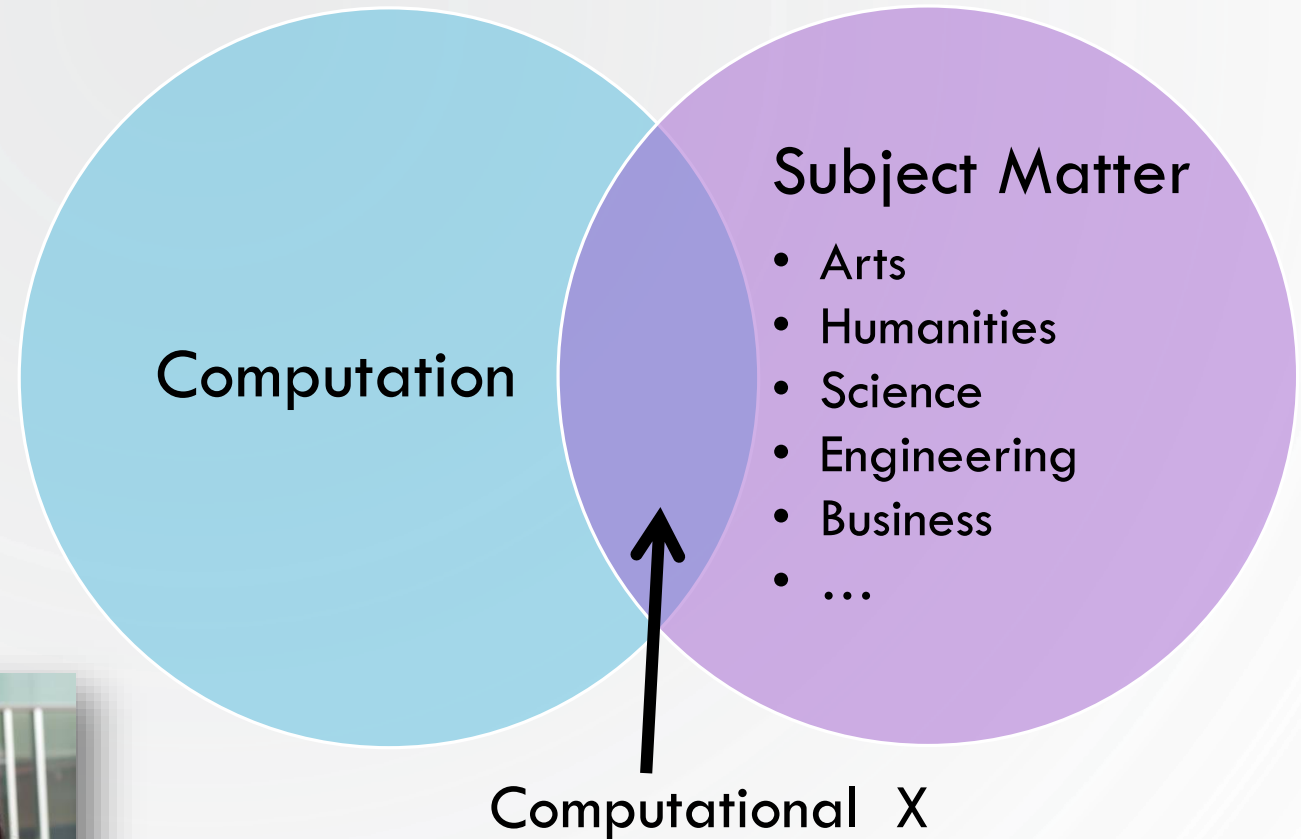
- Cory Bart
- Dennis Kafura
- Clifford A. Shaffer



WHAT IS IT?

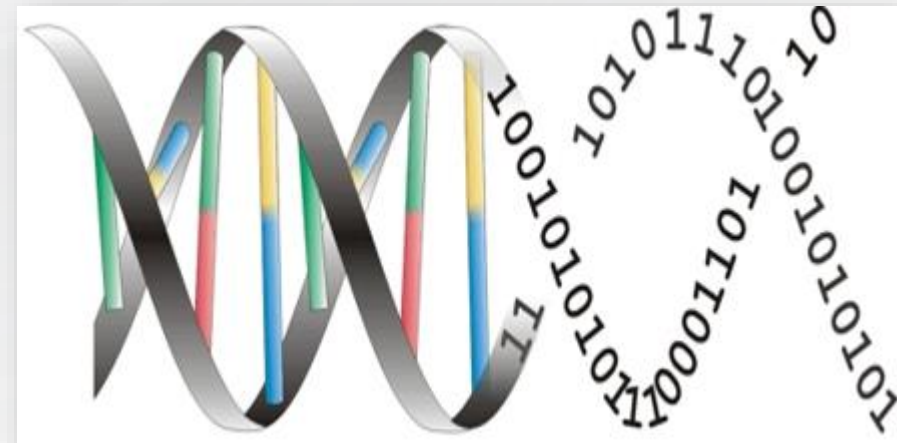
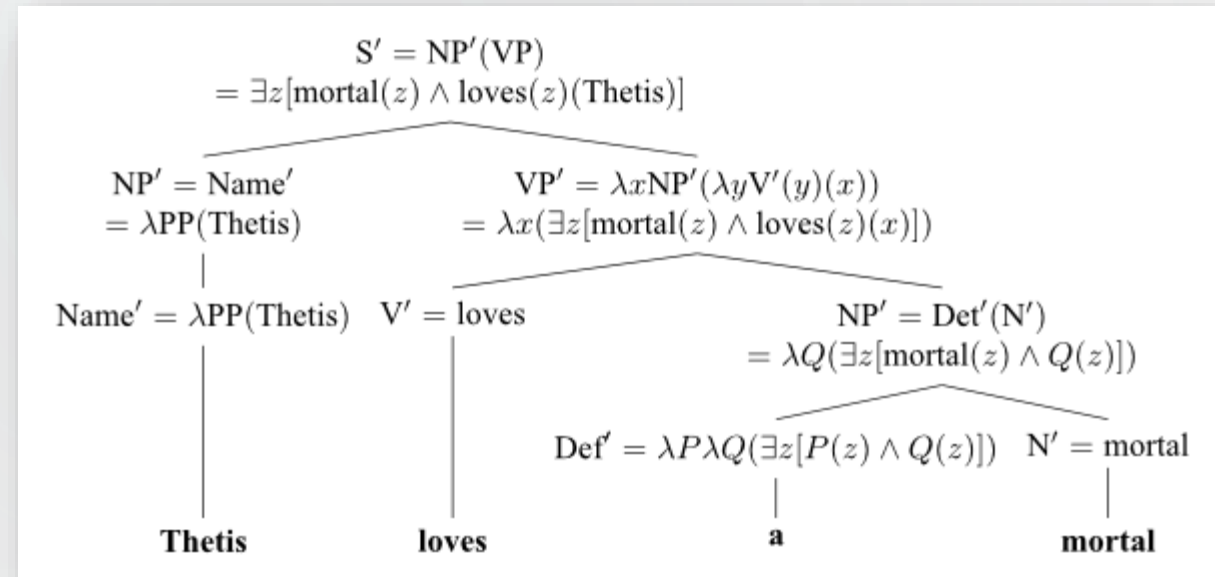
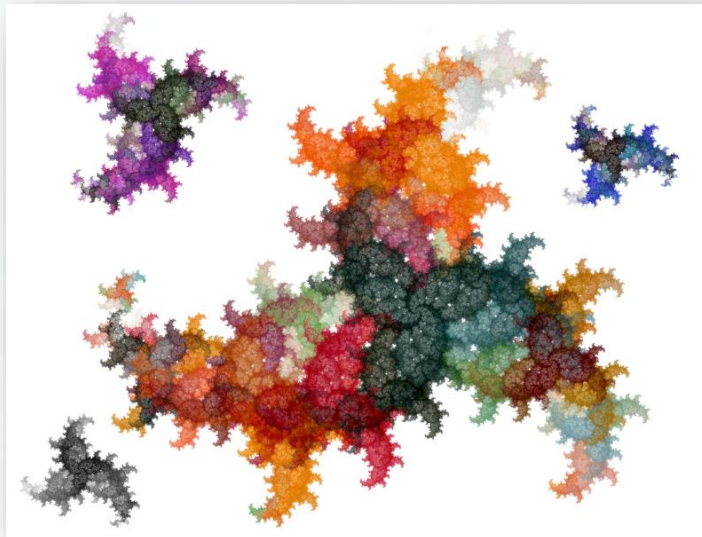
- "Computational Thinking is the thought processes involved in formulating problems and their solutions so that the solutions are represented in a form that can be effectively carried out by an information-processing agent."

-Jeanette Wing, 2006



EXAMPLES

- Computational Biology
- Computational Literature
- Computational Art
- ...



VIRGINIA TECH

- *To this end, Virginia Tech will comprehensively evaluate and modify the current Curriculum for Liberal Education to ... incorporate computational thinking and informatics/digital fluency as basic skills for all students, thereby enabling our students to be engaged citizens and life-long learners."*



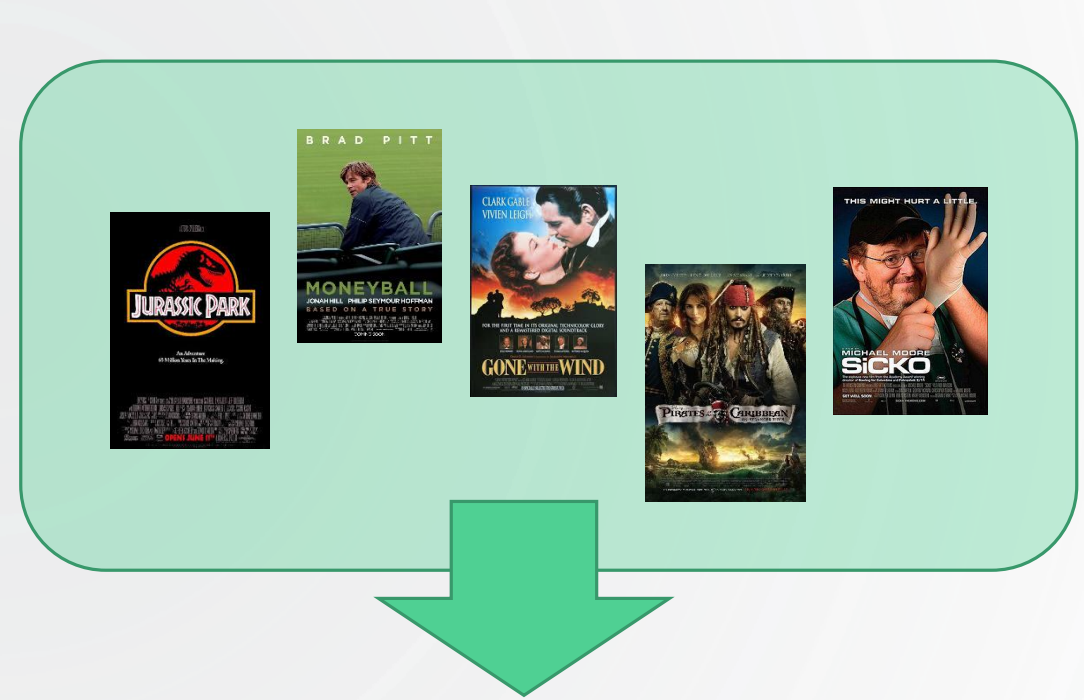
CRITICAL ELEMENTS OF CT

- Abstraction
- Algorithms
- Social Impacts



ABSTRACTION

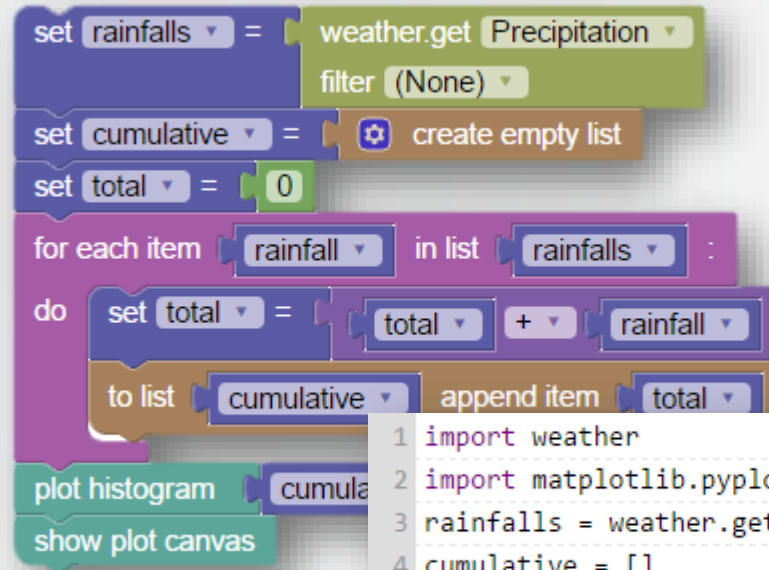
- Representing the real-world with data by removing unnecessary details
 - Spreadsheets
 - Databases
 - Files
- What data do you have in your field?



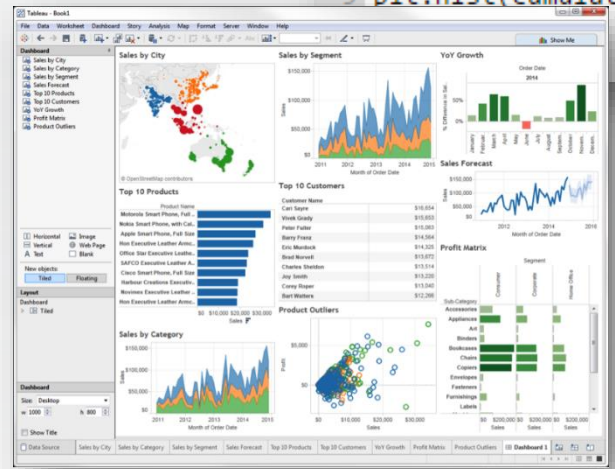
Movie			On-Line Customer		
Title (string)	Year (int)	Length (int)	Genre (string)	Format (string)	Price (float)
"Moneyball"	2011	133	"Sports"	"Blu-ray"	15.00
"Gone With the Wind"	1939	219	"Drama"	"DVD"	10.95
"Jurassic Park"	1993	127	"SciFi"	"DVD"	12.50
"Pirates of the Caribbean"	2003	143	"Comedy"	"Blu-ray"	17.50
"Sicko"	2007	116	"Documentary"	"Streaming"	11.75

ALGORITHMS

- Manipulating data with concrete instructions to solving problems at scale
 - Programming
 - Software
- What tools do you have in your field?



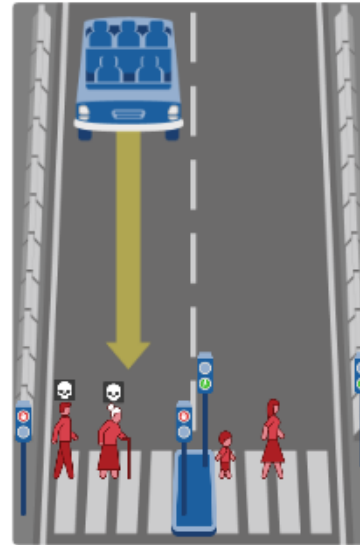
```
1 import weather
2 import matplotlib.pyplot as plt
3 rainfalls = weather.get("Precipitation", "(None)", '')
4 cumulative = []
5 total = 0
6 for rainfall in rainfalls:
7     total = total + rainfall
8     cumulative.append(total)
9 plt.hist(cumulative)
```



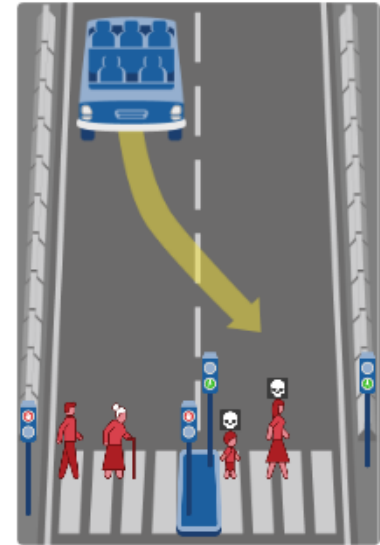
SOCIAL IMPACTS

- Interpreting the meaning of computational results
 - Stakeholders
 - Policy
 - Ethics
- What are the important questions that need to be answered?

What should the self-driving car do?



Show Description



Show Description

“INTRODUCTION TO COMPUTATIONAL THINKING”

- Area 5
- For non-CS major students
- Data Science context
- Modern pedagogy (more on that soon)



40+ DATASETS IN ARTS, SCIENCES, HUMANITIES, BUSINESS, AND MORE

Selection Criteria at wonder.cdc.gov/cancer

1. Organize data source

2. Select event and demographic

3. Select location

4. Select measure of interest

Stream

data stream contains the names and statistics of every baseball player in history, including batting, pitching, and fielding stats. Along with biographical information about each

BATTING													BASE RUNNING					AVERAGES				
P	H	AB	2B	3B	HR	R	REI	RC	TS	ISO	SO	HBP	SH	CS	SB	CS%	GF	AVG	OBP	SLG		
90	194	47	4	37	(18 35)	360	122	130	0	69	6	93	9	1	7	3	25%	21	329	.403	.610	
90	185	40	2	34	(14 20)	331	118	127	121	72	13	69	9	0	4	2	4	33%	20	314	.394	.561
91	212	51	1	43	(21 32)	384	137	124	160	79	12	65	10	0	5	1	83%	13	369	.439	.667	
92	196	51	2	46	(18 28)	389	133	123	143	84	12	53	7	0	9	5	50%	21	331	.415	.657	
91	195	38	2	41	(23 18)	365	115	117	121	72	13	69	9	0	4	2	4	33%	20	314	.394	.561
95	177	32	1	48	(24 25)	359	124	125	143	84	12	53	7	0	9	5	50%	21	331	.415	.657	
95	185	38	1	32	(12 20)	331	115	117	121	72	13	69	9	0	4	2	4	33%	20	314	.394	.561
24	187	44	0	37	(19 18)	342	118	127	121	72	13	69	9	0	4	2	4	33%	20	314	.394	.561
88	186	45	1	47	(22 20)	374	122	125	143	84	12	53	7	0	9	5	50%	21	331	.415	.657	
87	183	39	1	42	(17 25)	350	117	121	121	72	13	69	9	0	4	2	4	33%	20	314	.394	.561
2011	STL	ML	98	386	108	20	0	25	(13 12)	203												
11	MLB	YR	1458	6119	2018	446	15	433	(201 222)	3783												



- Over 114.5 million users per month
- June 2005
- Male-dominated
- 5.2 billion monthly pageviews



ADOLESCENT DATA SET

Emily Parker

History of the DoED

- Original Department of Education created in 1867
- Purpose: to collect info on schools and teaching to establish effective school systems in U.S.
- Established as Cabinet level agency October 17, 1979
- Collecting data has remained primary function over past 130 years



DATA STREAM

- This project uses the Fuel data stream and has information for every car sold in America from 1984-2015. This data includes everything about the vehicles from average combined MPG to number of cylinders.



Airports Data Stream

DANIEL

MEDIA COMPUTATION

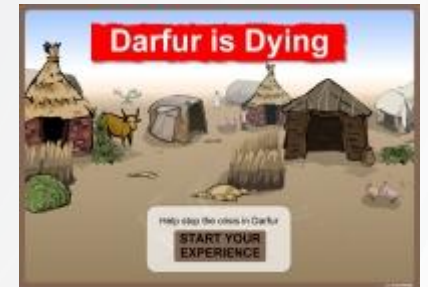
- Using computation to create art and sound



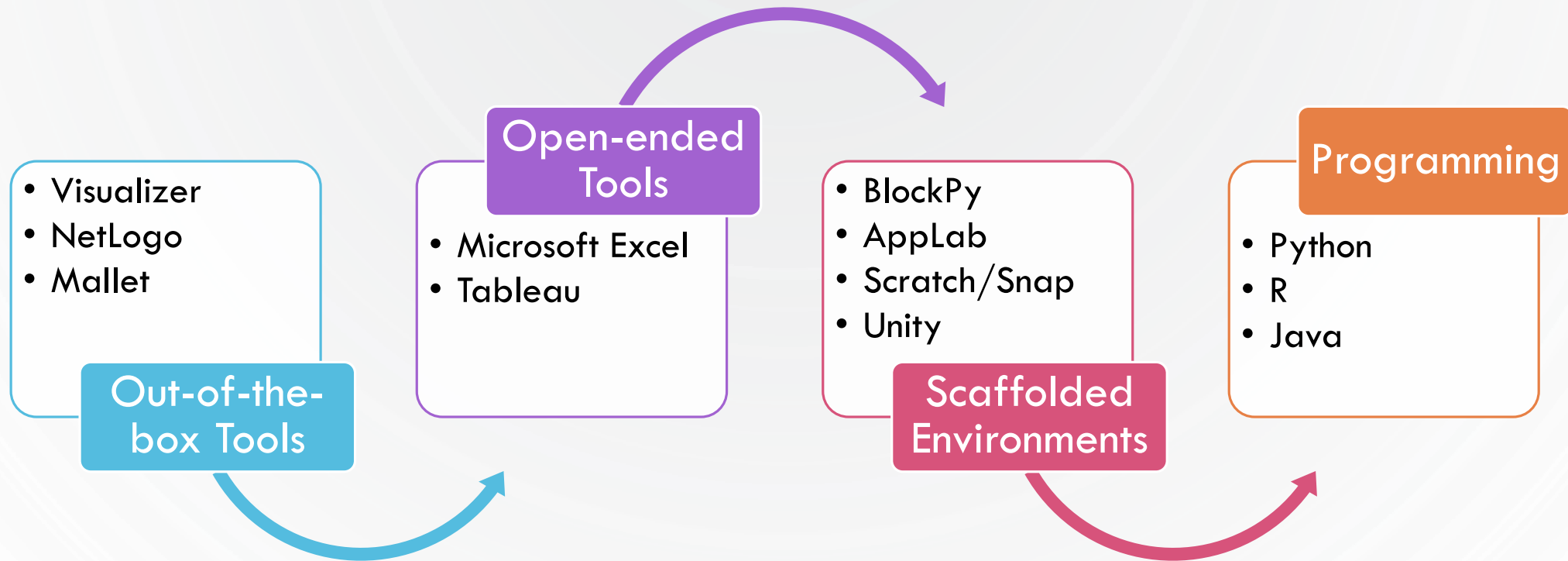
```
When run button pressed
do
  count with x and y from 0 to 399 by 1
  do
    set p to pixel at x x y y on canvas 3
    change red value of pixel p to 255 - red value of pixel p
```

WEB/GAMES/APP DEVELOPMENT

- Actually make games, interactive websites, mobile applications
- For some purpose (to solve a real-world problem)
 - Games for change
 - Educational Games
 - Charitable websites

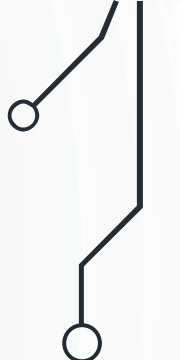


TOOLS FOR TEACHING CT

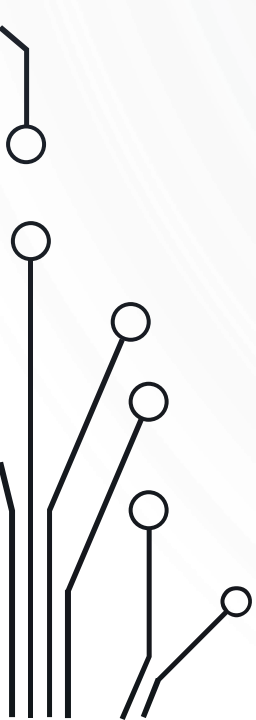
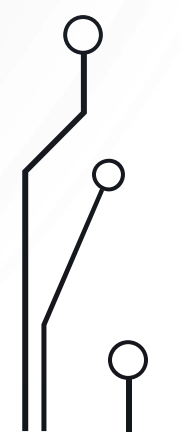




DISCUSSION QUESTIONS

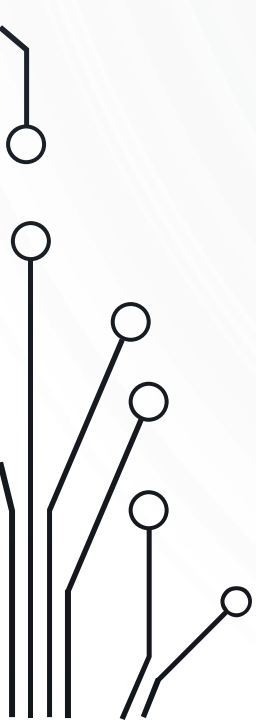
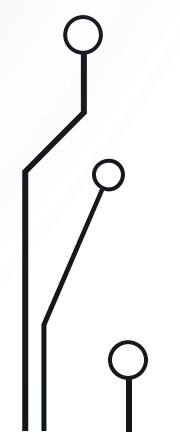


TEACHING STRATEGIES

- Peer learning
 - Active Learning
 - Flipped Classroom
 - Situated experience
 - Project-based learning
- 
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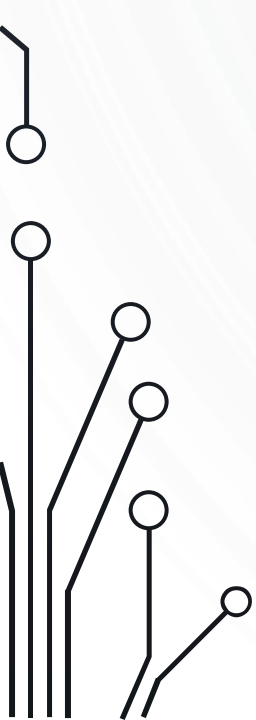
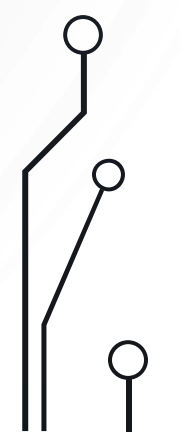


MOTIVATION

- Provide support, reassurances
 - Have plans for how students get help
 - Leverage social learning
 - Get computing allies
 - Set expectations reasonably
 - Sell the experience
- 
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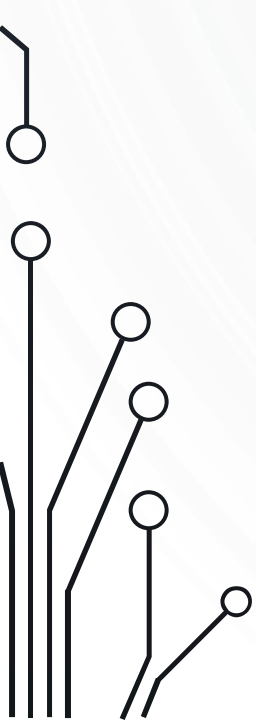


CT PROFESSIONAL DEVELOPMENT

- Read online books (How to Think like a Computer Scientist)
 - Try out CodeCademy
 - Start a project
 - Take a MOOC
- 
- 



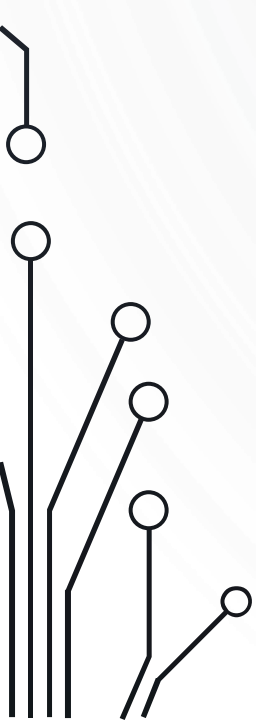
ASSESSMENT IDEAS

- Correctness of algorithms
 - Usefulness of abstractions
 - Value of interpretations
-
- Rubrics
 - Unit tests
- 





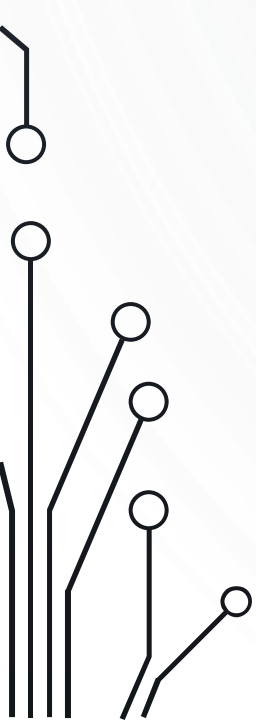
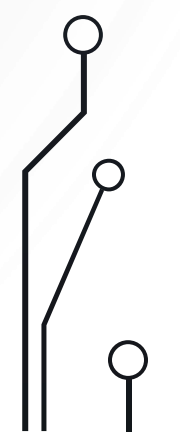
WHAT'S NEXT?

- You probably already do many of these things
 - Push it a bit farther
 - More computational assignments
 - Computational component to a project
 - Use our course as a pre-requisite
- 



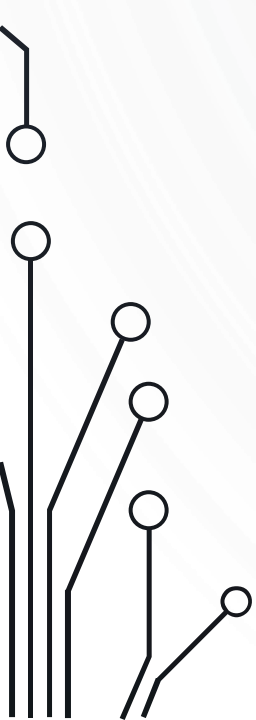
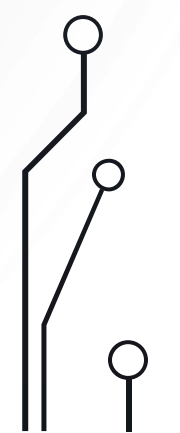


COMPUTATIONAL THINKING

- What is it?
 - How do we teach it?
 - How do we know if they learned it?
- 
- 

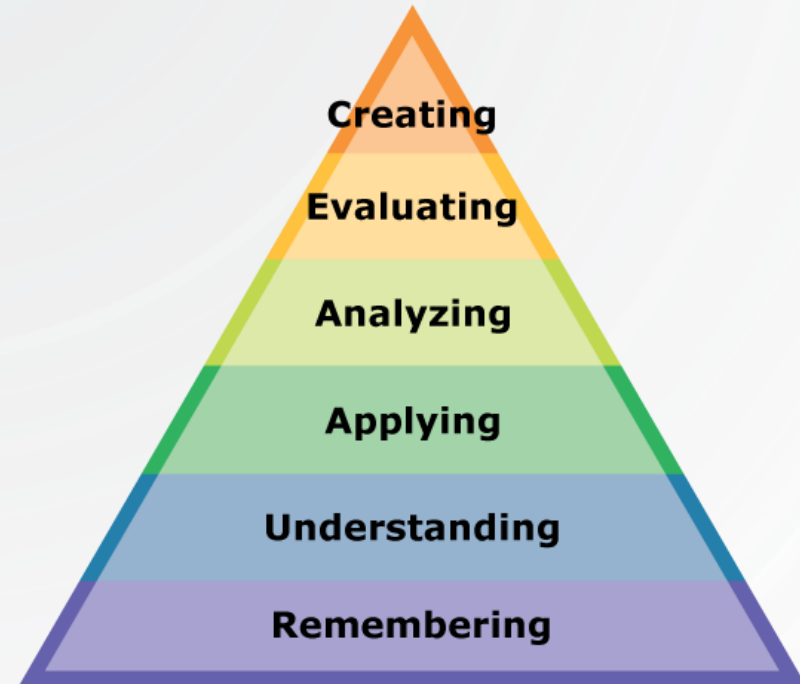


FORMAL LEARNING OBJECTIVES

1. Explain the application of computational or quantitative thinking across multiple knowledge domains.
 2. Apply the foundational principles of computational or quantitative thinking to frame a question and devise a solution in a particular field of study.
 3. Construct a model based on computational methods to analyze complex or large-scale phenomenon.
 4. Identify the impacts of computing and information technology on humanity.
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COURSE INTEGRATION

- Open-ended projects
- Solving practice problems
- Learning how to use a tool
- Learning relevant terminology



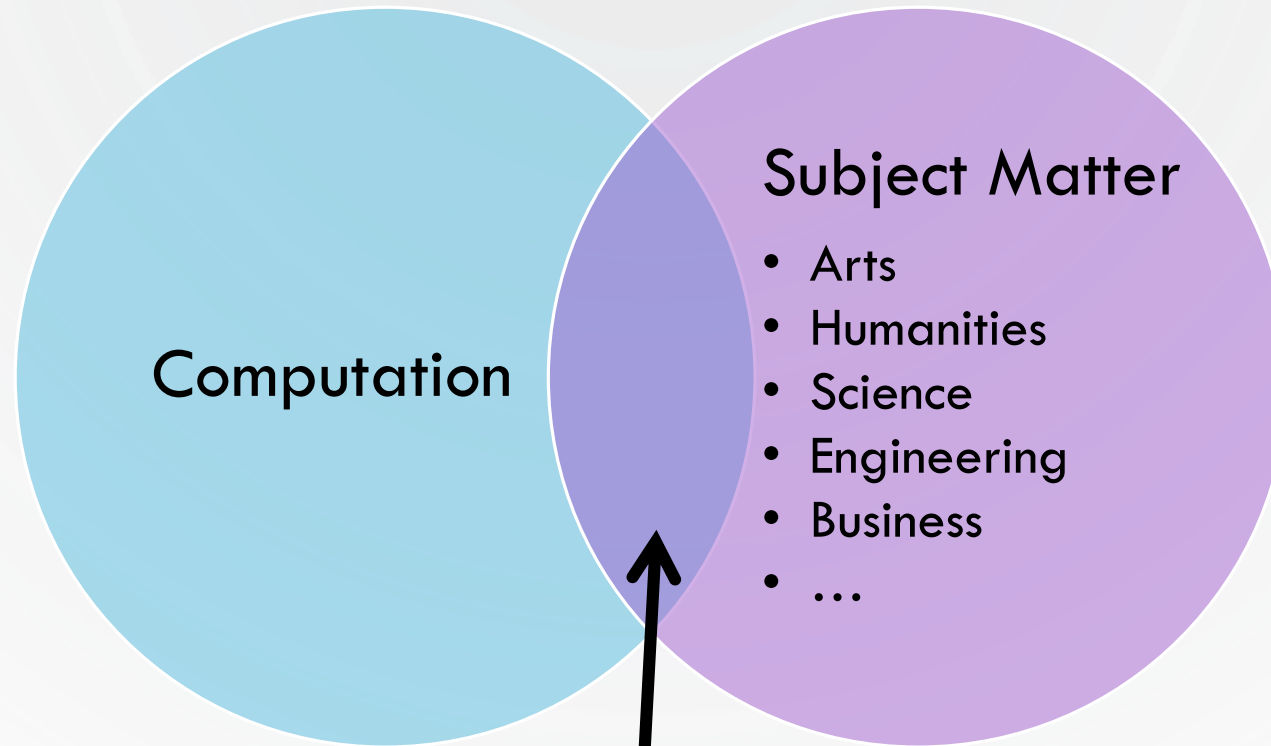
HISTORY

- "Computational Thinking is the thought processes involved in formulating problems and their solutions so that the solutions are represented in a form that can be effectively carried out by an information-processing agent."

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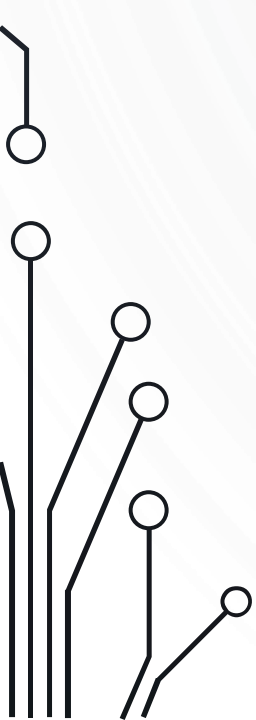

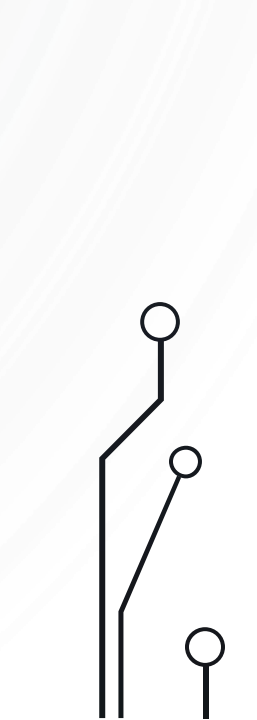
COMPUTATIONAL X



Computational X

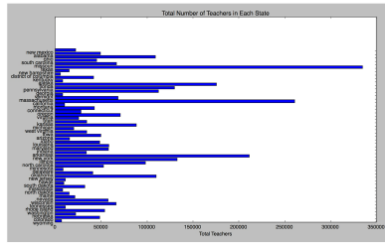


GLOBAL DEMAND

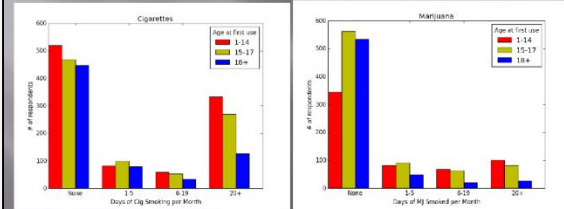
- End-user programmers are growing!
 - More and more jobs involve computation
 - *Need a compelling quote here*
- 
- 
- 

FINAL PROJECT: OPEN-ENDED DATA SCIENCE

What is the distribution of teachers in each state?

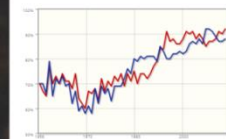


What You Want to See



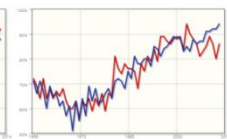
Average Party Unity Scores, House

Percentage of house party unity votes on which a member voted in agreement with a majority of his or her own party



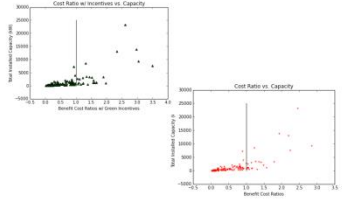
Average Party Unity Scores, Senate

Percentage of Senate party unity votes on which a member voted in agreement with a majority of his or her own party



Courtesy of CD Roll Call

Visualizations

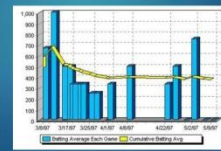


Conclusions

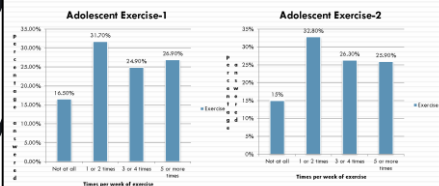


Approach

- I averaged each game player and compared them to the player being evaluated.
- If the player has superior stats to the Hall of Fame players in half of the categories, he is worth acquiring.



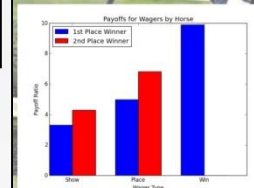
Visualizations



Wave-1 Exercise Data

Wave-2 Exercise Data

Results for Question Three:



There actually is a huge payoff difference between a win bet and a place bet. However, if you look at betting on the first place winner for a place bet, or betting on the second place winner in a show bet, you can see that the payoff is almost the same, so I would urge people to bet for the second place winner in show because the chances of payout are greater.