Teaching AI in K-12: Examples, Issues & Guidance from K-12 CS Education Research

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HEP Vaud, Lausanne, Switzerland

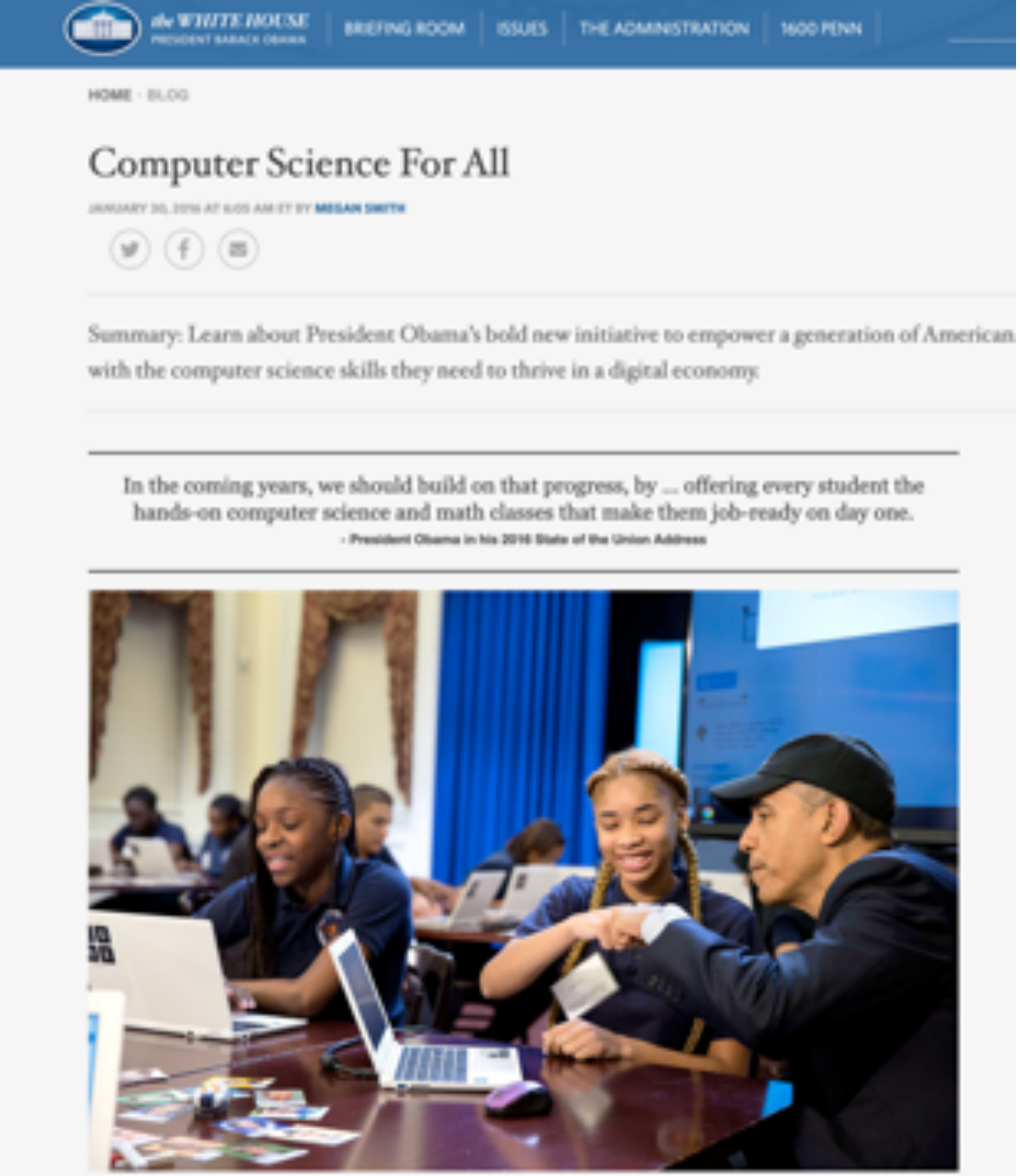
September 1990

Why K-12 AI Ed?
(aka AI & the coming tsunami!)

State of AI education in K-12
+
Examples

Lessons from K-12 CS Ed
(i.e. let's not repeat the same mistakes or reinvent the wheel!)

Challenges, open issues, & recommendations
(➔ we'll get through this!!!)


the WHITE HOUSE
PRESIDENT BARACK OBAMA
BRIEFING ROOM
ISSUES
THE ADMINISTRATION
1600 PENN
HOME · BLOG
Computer Science For All
JANUARY 30, 2016 AT 6:05 AM ET BY MEGAN SMITH
Summary: Learn about President Obama's bold new initiative to empower a generation of American
with the computer science skills they need to thrive in a digital economy.
In the coming years, we should build on that progress, by ... offering every student the hands-on computer science and math classes that make them job-ready on day one.
- President Obama in his 2016 State of the Union Address


Computational
computer
science
thinking
humans
Computer
data
computers
systems
computational
think
problems
problem
solve
scientists
power
way
like
computing
engineering
fundamental
learning
search
machine
skill
one
just

New Amazon grant to boost computer science education in Duval elementary schools

Web Supervisor / August 4, 2023 / District, Elementary, Stem

Bringing computer science education to 11 million students

Branstad: Incentivize computer science in schools

Teaching China's next generation to express themselves in code

K-12 schools may see new computer science mandate

Microsoft expands computer science education program to Juarez, Mexico, and expands reach across 18 U.S. cities to improve high school students' access and equity

Southampton participates in global computer science campaign

Computer Science Education

3 ways teachers can navigate the evolving field of computer science


the A.I.
TSUNAMI


Artificial Intelligence

The New ChatGPT Can 'See' and 'Talk.' Here's What It's Like.

Job postings mentioning AI have more than doubled in two years, LinkedIn data shows

Published Wed, Oct 4 2023·1:49 AM EDT

Home > Strategy

AI, Automation and Growth Mindset Key to 2024 Plans

CHRIS CAMPBELL | OCTOBER 4, 2023

Next-Level Care: Generative AI Poised for $22B Growth in Healthcare

The future is here

AI promises to remake the world. In many ways, it already has. Do we like what we've created?

npr

Can AI predict, and try to prevent, homelessness?

ARTIFICIAL INTELLIGENCE

'Counterfeit people': The dangers posed by Meta's AI celebrity lookalike chatbots

Generative AI Is the Newest Tool in the Dictator's Handbook

Trapped in a Dangerous Loop: Humans Inherit Artificial Intelligence Biases

TOPICS: Artificial Intelligence Psychology

By DEUSTO UNIVERSITY OCTOBER 3, 2023

AI advances 'supercharge' online disinformation, censorship and surveillance in growing threat to human rights, report warns

ARTIFICIAL INTELLIGENCE

Actor Tom Hanks Warns of Ad With AI Imposter

Overcoming Racial Bias In AI Systems And Startlingly Even In AI Self-Driving Cars

Racial bias in a medical algorithm favors white patients over sicker black patients

AI expert calls for end to UK use of 'racially biased' algorithms

AI Bias Could Put Women's Lives At Risk - A Challenge For Regulators

Gender bias in AI: building fairer algorithms

Bias in AI: A problem recognized but still unresolved

Amazon, Apple, Google, IBM, and Microsoft worse at transcribing black people's voices than white people's with AI voice recognition, study finds

Millions of black people affected by racial bias in health-care algorithms

Study reveals rampant racism in decision-making software used by US hospitals – and highlights ways to correct it.

When It Comes to Gorillas, Google Photos Remains Blind

Google promised a fix after its photo-categorization software labeled black people as gorillas in 2015. More than two years later, it hasn't found one.

The Week in Tech: Algorithmic Bias Is Bad. Uncovering It Is Good.

Google 'fixed' its racist algorithm by removing gorillas from its image-labeling tech

Artificial Intelligence has a gender bias problem – just ask Siri

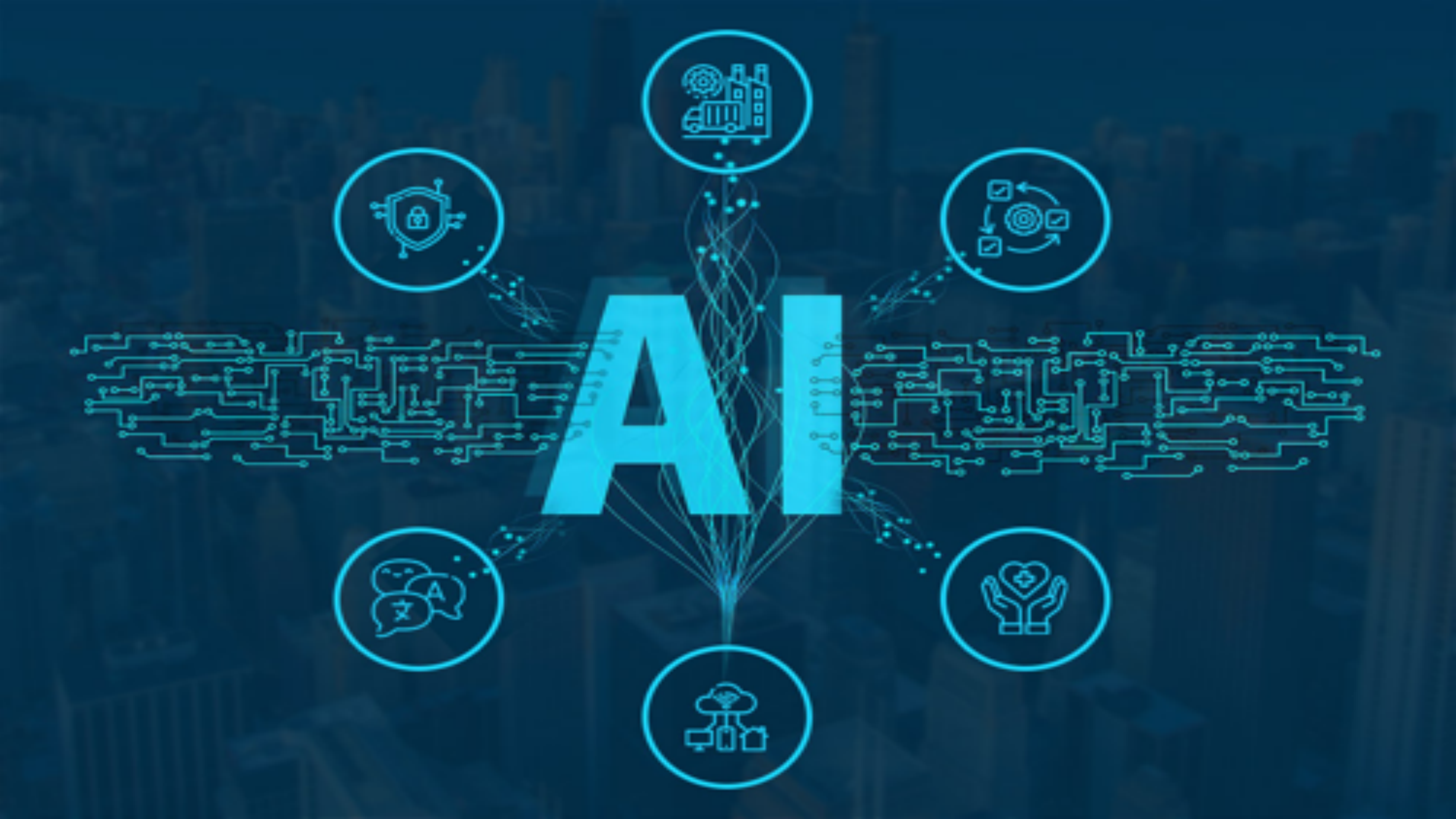
The Best Algorithms Struggle to Recognize Black Faces Equally

US government tests find even top-performing facial recognition systems misidentify blacks at rates five to 10 times higher than they do whites.

Experts disagree over threat posed but artificial intelligence cannot be ignored

Education:

the best strategy FOR thriving &
the best inoculation AGAINST misuse


AI

Menu

AI Guidance For Schools Toolkit

Access Editable Document

AI is transforming our world.

Let's #TeachAI

How To Use This Toolkit

- Incorporate AI in an Education System
- Apply Seven Principles for AI in Education
- View Sample School Guidance
- Revise Existing Policies
- Customize a Presentation
- Engage Parents, Staff, and Students
- Learn How AI was Used in This Toolkit

Doing nothing is not an option

Old Digital Divide

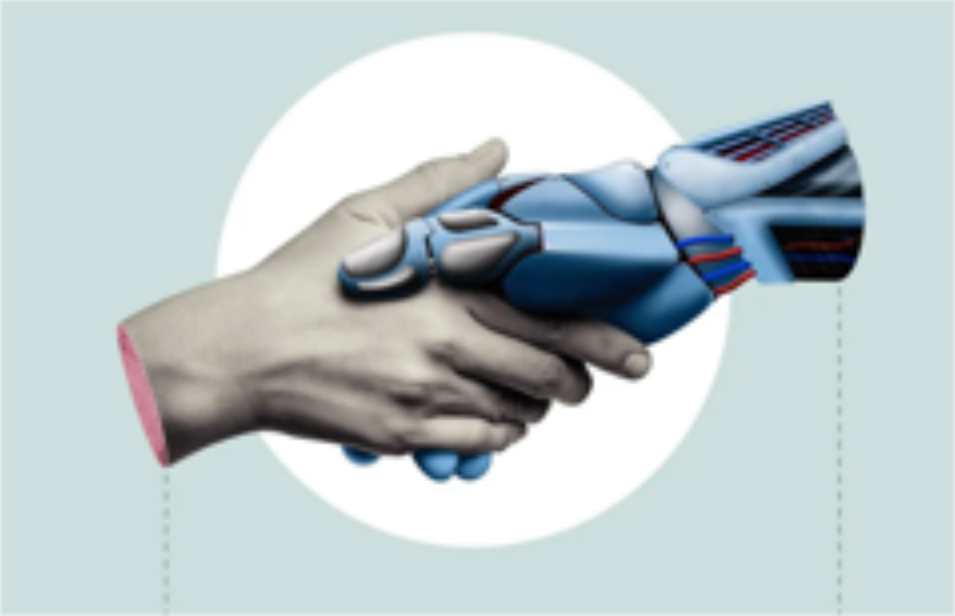
Computers in Schools, High Speed Internet, 1:1 devices…

New Digital Divide

Who is empowered to learn with and about AI

AI and the next digital divide in education

https://www.brookings.edu/articles/ai-and-the-next-digital-divide-in-education/




K-12 CS
Education
K-12 AI
Education

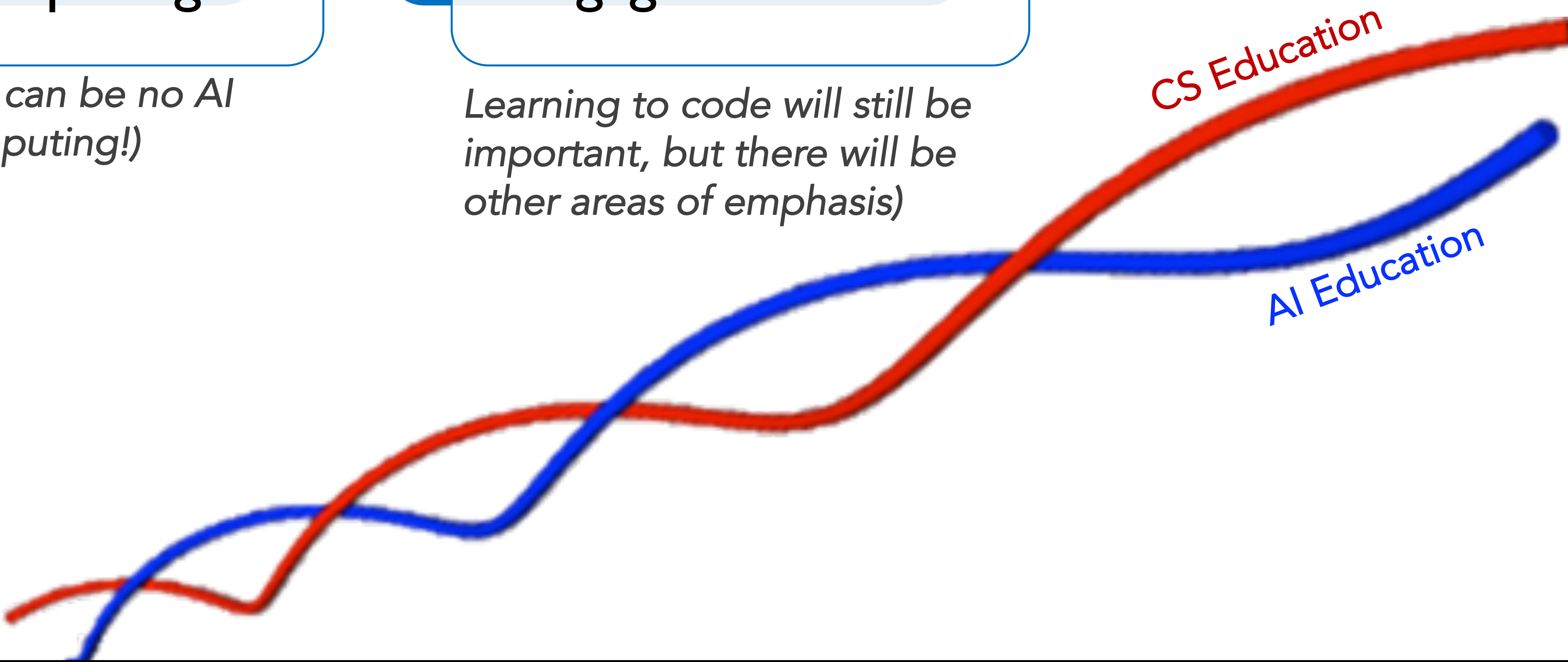
CS Education is not going anywhere!

There is no AI education without some understanding of computing

(Psst…there can be no AI without computing!)

There is no CS education (today) without including engagement w/ AI

Learning to code will still be important, but there will be other areas of emphasis)



Why K-12 AI Ed? (aka AI & the coming tsunami!)

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Examples

Lessons from K-12 CS Ed for K-12 AI Ed

Challenges, open issues, & recommendations

Teaching AI to K-12 Learners: Lessons, Issues, and Guidance

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ABSTRACT

There is growing recognition of the need to teach artificial intelligence (AI) and machine learning (ML) at the school level. This push acknowledges the meteoric growth in the range and diversity of applications of ML in all industries and everyday consumer products, with Large Language Models (LLMs) being only the latest and most compelling example yet. Efforts to bring AI, especially ML education to school learners are being propelled by substantial industry interest, efforts such as AI4K12, as well as technological developments that make sophisticated ML tools readily available to learners of all ages. These early efforts span a variety of learning goals captured by the AI4K12 "big ideas" framework and employ a plurality of pedagogies.This paper provides a sense for the current state of the field

worse) in a myriad different ways every single day. Learning about a consequential new technology is an imperative, and especially one as powerful and versatile as AI, that is also considered accessible for motivating STEM learning and facilitating creativity [61].

The flurry of research, design, and development activity as well as academic writing in AI education in these past years has been intense. While still useful, landscape papers on the state of the art of ML teaching and learning in K-12 from just three years ago (for example, [38]), already seem dated! Symposia and panels on this topic have become a must-attend agenda item at every recent researcher and practitioner STEM education conference. Roughly 5 years into a period of intense research and development in K-12 AI/ML education, this position paper helps make sense of these efforts. Our goal ... recent literature, identify and

Grover, S. 2024. Teaching AI to K-12 Learners: Lessons, Issues, and Guidance. In Proceedings of SIGCSE 2024, March 20–23, 2024, Portland, OR,USA. ACM, New York, NY, USA

Teaching AI in K-12

Reviews

Ongoing/early research on K-12 AI education

Synthesizes

Key themes from ongoing efforts

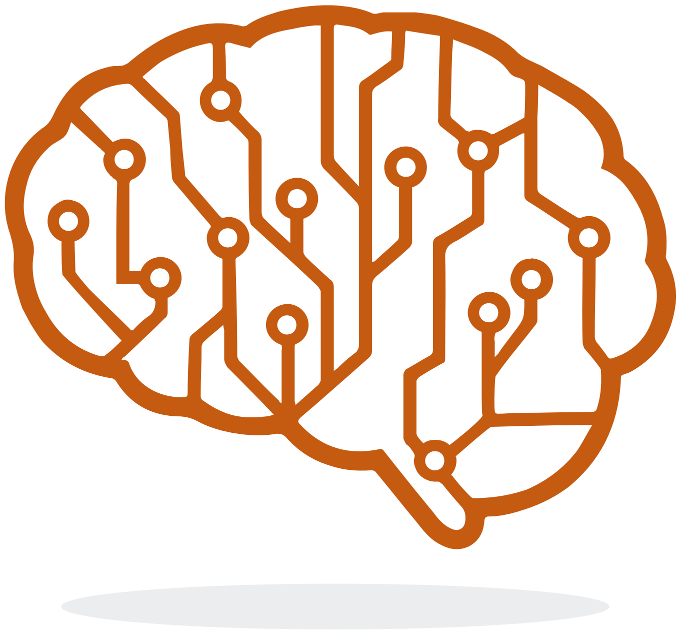
Identifies

Challenges & tensions in tackling "the next new thing"

Suggests

Takeaways & Guidance

Diverse goals of AI research projects



- Developing broad AI literacy (awareness about AI)
- Developing understandings of AI tools & AI/ML techniques
- Designing ethics- and fairness-focused experiences
- Teaching AI basics from a CS topics lens
- Examining the appropriateness of diverse pedagogies for developing understanding about AI (a very technical topic)
- Examining pedagogies that serve well-defined purpose(s) (e.g., broadening participation among women or youth belonging to specific groups,
- Lifting the hood on how AI/ML works (making AI less magical)
- Integrating AI learning into/with other subjects
- Co-designing with teachers and teacher preparation

Key Emergent Themes & Outcomes

- What we should be teaching in schools about AI
- Data Primacy & 'CT 2.0'
- Importance of ethics, bias, and critical examination of AI
- Pedagogies & instructional approaches
- Ways to integrate AI into other subjects
- Curricular co-design & teacher preparation

+ A plethora of free curricular resources

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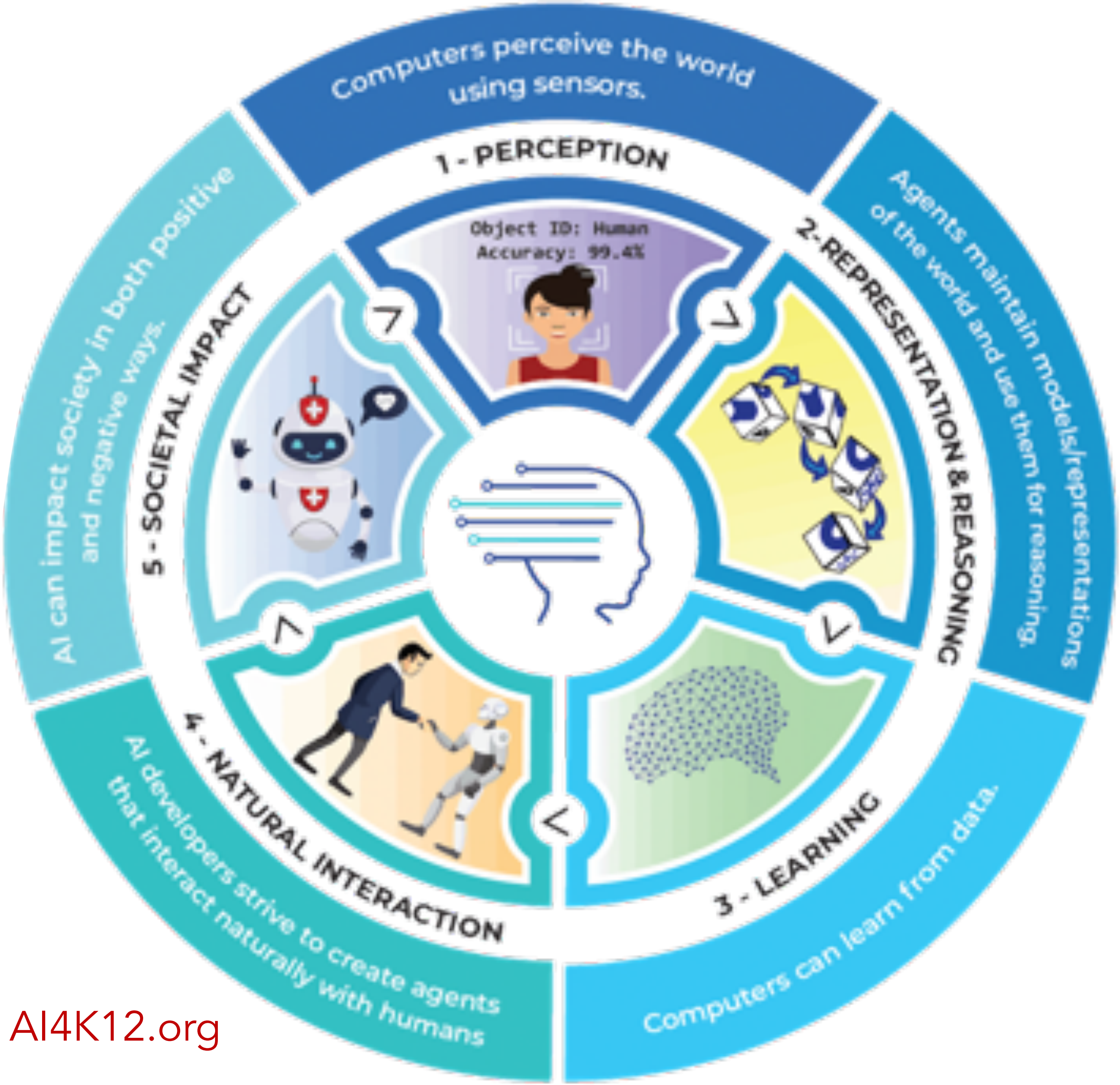
What learners should know & be able to do



AI4K12.org

Five Big Ideas in Artificial Intelligence

1. Perception

Computers perceive the world using sensors. Perception is the process of extracting meaning from sensory signals. Making computers "see" and "hear" well enough for practical use is one of the most significant achievements of AI to date.

2. Representation & Reasoning

Agents maintain representations of the world and use them for reasoning. Representation is one of the fundamental problems of intelligence, both natural and artificial. Computers construct representations using data structures, and these representations support reasoning algorithms that derive new information from what is already known. While AI agents can reason about very complex problems, they do not think the way a human does.

3. Learning

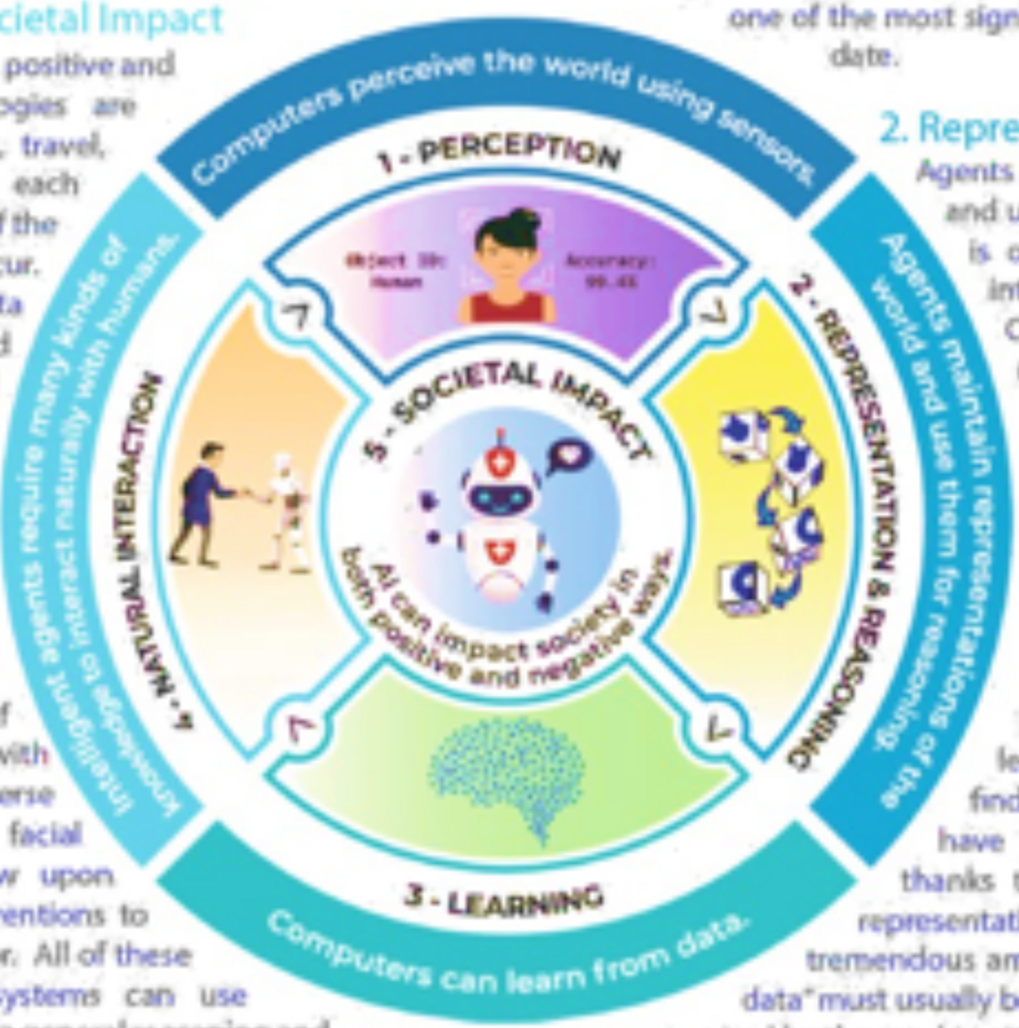
Computers can learn from data. Machine learning is a kind of statistical inference that finds patterns in data. Many areas of AI have progressed significantly in recent years thanks to learning algorithms that create new representations. For the approach to succeed, tremendous amounts of data are required. This "training data" must usually be supplied by people, but is sometimes acquired by the machine itself.

4. Natural Interaction

Intelligent agents require many kinds of knowledge to interact naturally with humans. Agents must be able to converse in human languages, recognize facial expressions and emotions, and draw upon knowledge of culture and social conventions to infer intentions from observed behavior. All of these are difficult problems. Today's AI systems can use language to a limited extent, but lack the general reasoning and conversational capabilities of even a child.

5. Societal Impact

AI can impact society in both positive and negative ways. AI technologies are changing the ways we work, travel, communicate, and care for each other. But we must be mindful of the harms that can potentially occur. For example, biases in the data used to train an AI system could lead to some people being less well served than others. Thus, it is important to discuss the impacts that AI is having on our society and develop criteria for the ethical design and deployment of AI-based systems.



The AI for K-12 initiative is a joint project of the Association for the Advancement of Artificial Intelligence (AAAI) and the Computer Science Teachers Association (CSTA), funded by National Science Foundation award DRL-1846073

AI4K12.org

Cinq grandes idées en intelligence artificielle

1. Perception

Les ordinateurs perçoivent le monde grâce à des capteurs. La perception est le processus qui consiste à extraire un sens des signaux sensoriels. L'une des réalisations les plus significatives de l'IA à ce jour est de permettre aux ordinateurs de « voir » et d'« entendre » suffisamment bien pour être utilisés de manière pratique.

2. Représentation et raisonnement

Les agents entretiennent des représentations du monde et les utilisent pour raisonner. La représentation est l'un des problèmes fondamentaux de l'intelligence, qu'elle soit naturelle ou artificielle. Les ordinateurs construisent des représentations en utilisant des structures de données. Ces représentations sont la base de raisonnements algorithmiques qui déduisent de nouvelles informations à partir de ce qui est déjà connu. Bien que les agents de l'IA soient capables de raisonner des problèmes complexes, ils ne les approchent pas de la même manière que les humains.

3. Apprendre

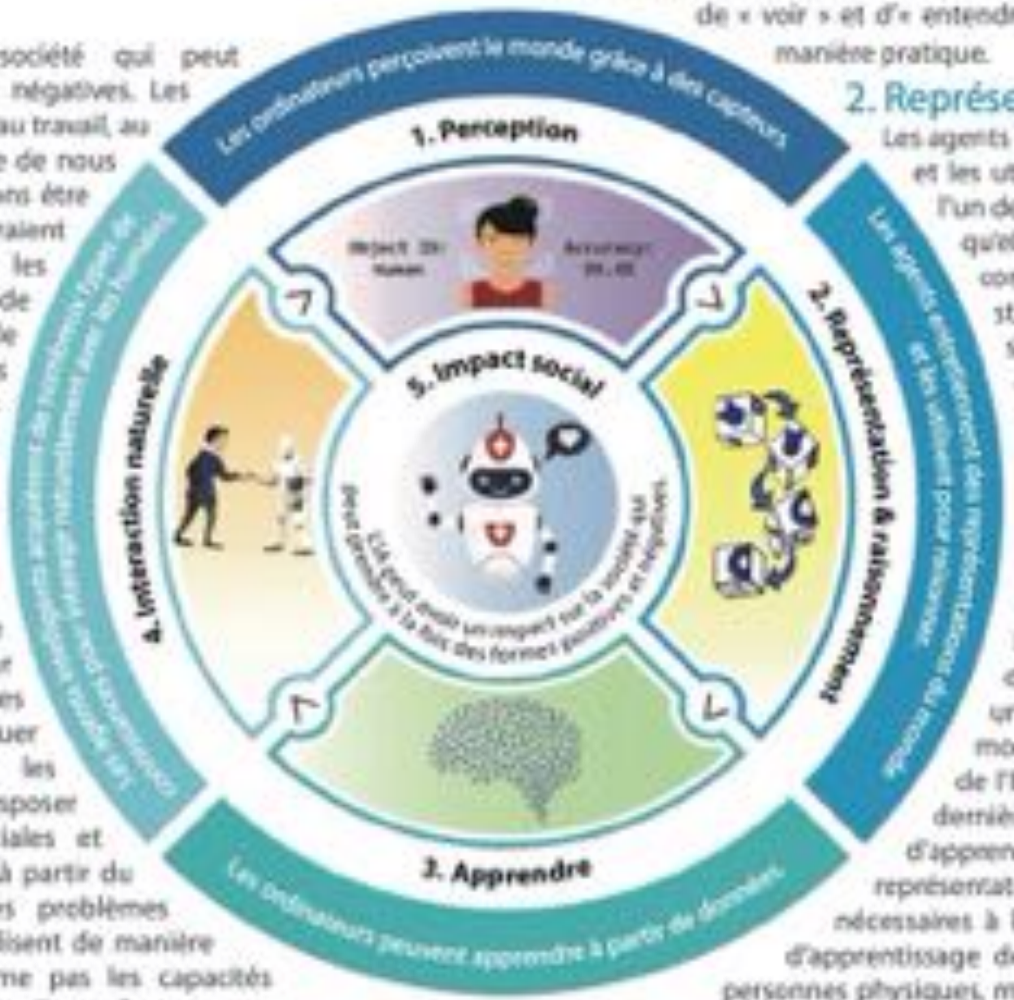
Les ordinateurs peuvent apprendre à partir de données. L'apprentissage automatique est une sorte d'inférence statistique qui permet de modeler les données. De nombreux domaines de l'IA ont progressé de manière significative ces dernières années grâce à des algorithmes d'apprentissage qui créent de nouvelles représentations. D'énormes quantités de données sont nécessaires à la réussite de cette approche. Ces données d'apprentissage doivent être généralement fournies par des personnes physiques, mais parfois elles peuvent être acquises par la machine elle-même.

4. Interaction naturelle

Les agents intelligents acquièrent de nombreux types de connaissances pour interagir naturellement avec les humains. Les agents doivent être capables de communiquer en langage humain, de reconnaître les expressions faciales et les émotions, de disposer des connaissances des conventions sociales et culturelles pour en déduire des intentions à partir du comportement observé. Ce sont là des problèmes complexes. Les systèmes de l'IA actuels utilisent de manière limitée le langage, ils ne possèdent même pas les capacités générales de raisonnement et de conversation d'un enfant.

5. Impact social

L'IA peut avoir un impact sur la société qui peut prendre à la fois des formes positives et négatives. Les technologies de l'IA modifient nos rapports au travail, au voyage, à la communication et à la manière de nous occuper les uns des autres. Mais nous devons être conscients d'éventuels dommages qui pourraient se produire. Par exemple, les biais dans les données utilisés pour alimenter un système de l'IA peuvent engendrer des disparités de traitement envers des personnes. Pour ces raisons, il est important de débattre les impacts de l'IA sur notre société et de développer des critères éthiques pour la conception et l'application des systèmes basés sur l'IA.



AI4K12

Data Agency

Data agency extends the concept of data literacy by emphasizing people's ability to not only understand data, but also to actively control and manipulate information flows and to use them wisely and ethically.

Primacy of Data & Data Science

Data Literacy

Involves understanding what data one creates, what happens to them, and with what consequences

Data Agency

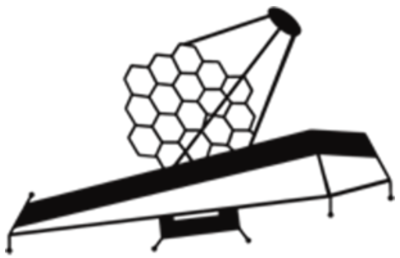
Refers to people's volition, skills, attitudes, and capacity for informed actions that make a difference in their digital world.

A more active concept.

Matti Tedre, Henriikka Vartiainen, Juho Kahila, Tapani Toivonen, Ilkka Jormanainen, Teemu Valtonen. Machine learning introduces new perspectives to data agency in k—12 computing education. In 2020 IEEE Frontiers in Education Conf., pages 1–8. IEEE, 2020.

Computational Thinking

A way of solving problems and designing systems that draw on concepts fundamental to computer science. Learning how AI works is an opportunity to learn computational thinking



- Decomposition: Understanding complex AI problems requires breaking them down into smaller, more manageable parts.
- Pattern Recognition: Machine learning relies on recognizing patterns in data. Students practice and develop skills in identifying patterns and trends.
- Algorithmic Thinking: Learning about AI exposes students to algorithms, step-by-step solutions to a problem, from simple decision trees to more complex processes.
- Debugging: As with any computational task, AI models can sometimes produce unexpected or incorrect results. Solving these issues is central to both AI and computational thinking.
- Evaluation: AI frequently demands the assessment of different solutions; this mirrors a key aspect of computational thinking, where solutions are tested and refined based on outcomes.

PROBLEM SOLVING WORKFLOWS

CT 1.0 (RULE-DRIVEN)	CT 2.0 (DATA-DRIVEN)
Formalize the problem	Describe the job and collect data from the intended context
Design an algorithmic solution	Filter and clean the data. Label the data
Implement a solution in a stepwise program	Train a model from the available data
Compile and execute the program	Evaluate and use the model

Matti Tedre, Tapani Toivonen, Juho Kahila, Henriikka Vartiainen, Teemu Valtonen, Ilkka Jormanainen, and Arnold Pears. 2021. Teaching Machine Learning in K–12 Classroom: Pedagogical and Technological Trajectories for Artificial Intelligence Education. IEEE Access 9 (2021), 110558–110572.

Paradigmatic Differences in Machine Learning

~~CONCEPTUAL CHANGES IN COMPUTING EDUCATION~~

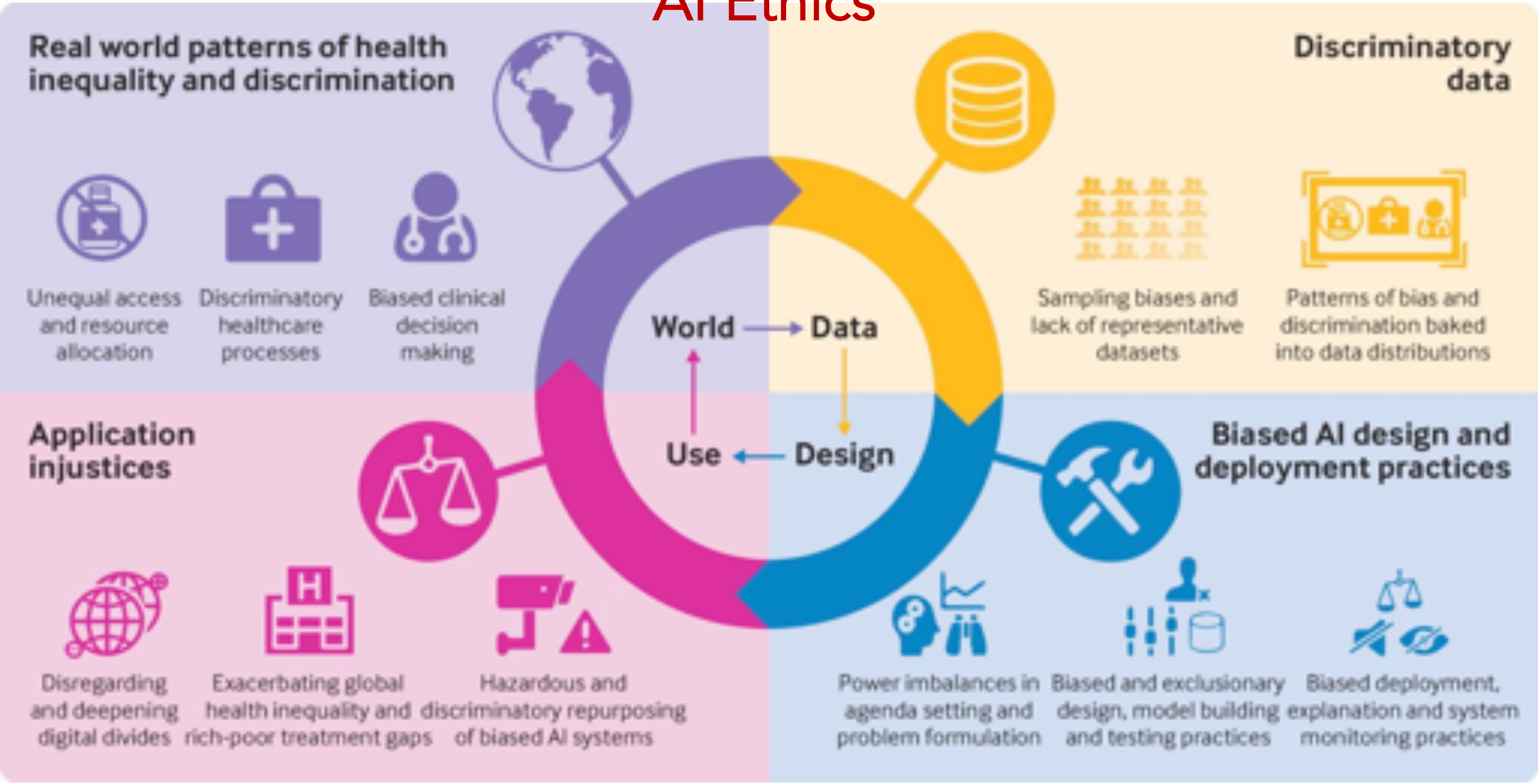
CT 1.0	CT 2.0
Correctness can be formally proven	Models may display higher or lower confidence, efficiency
Debugging: Tracking and tracing	Evaluate the model wrt predictions
Deductive problem-solving	Inductive problem-solving
Transparent structure	Black-boxed
Stepwise, deterministic, discrete flow of program through states	Parallel, possibly nondeterministic passing data through a network
Structured data	Unstructured data

Paradigmatic Differences in Machine Learning

~~CONCEPTUAL CHANGES IN COMPUTING EDUCATION~~

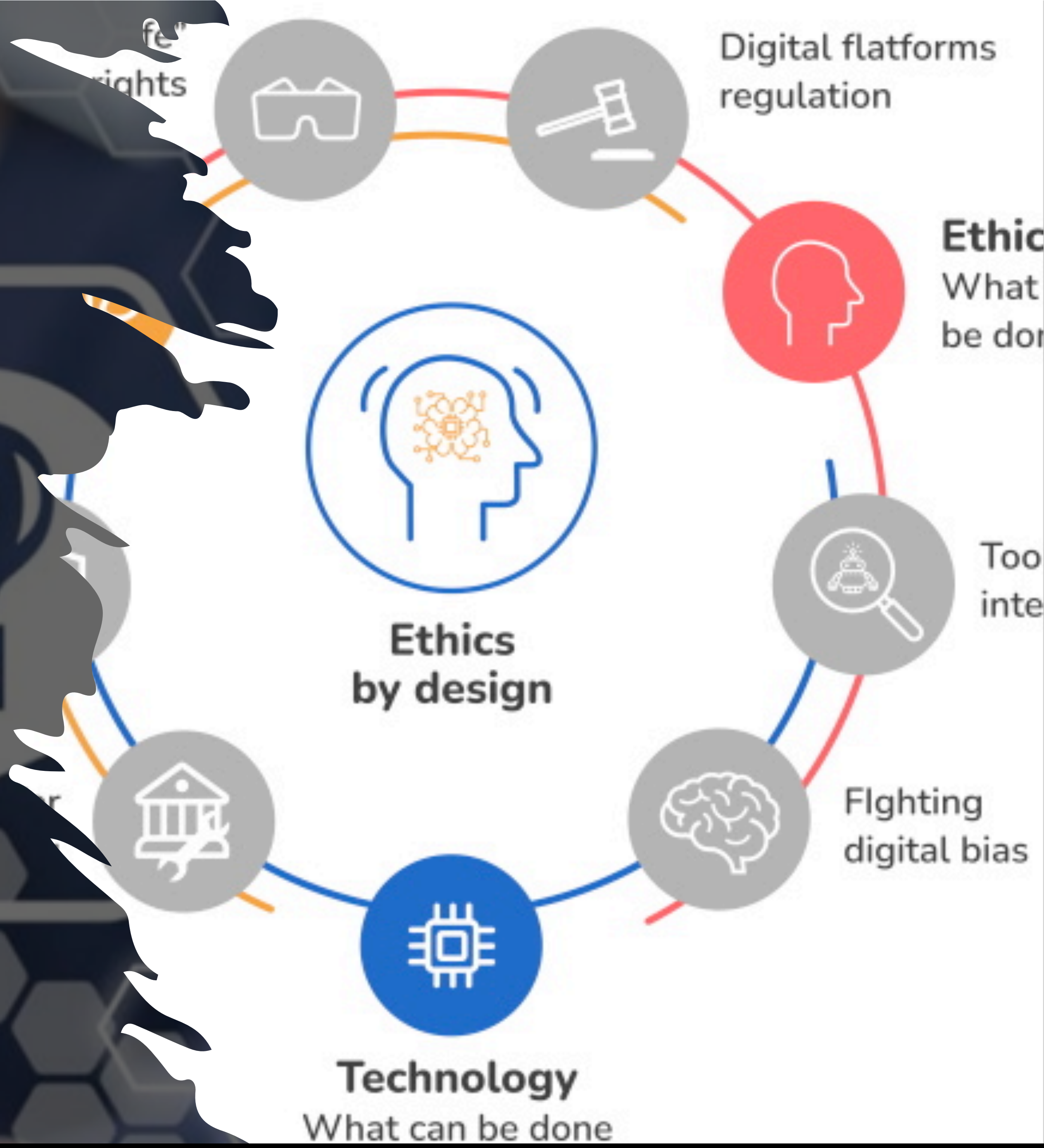
CT 1.0	CT 2.0
Reductionism	Emergence
Formal verification	Statistical measures
Black/glass box testing	Black box testing
No tinkering, toying, trial-and-error	Experimenting with data, parameters, hyperparameters
Prepare for worst-case complexity, optimize for average case	No time/space variance between passes of data through the network
Tedious to ensure portability	Straightforwardly portable

AI Ethics



https://www.weforum.org/agenda/2021/07/ai-machine-learning-bias-discrimination/

Ethics, bias, and critical examination of AI baked into all curricular experiences



Inclusive AI Literacy & Learning

Inclusive AI Literacy & Learning is a curriculum project that seeks to teach AI literacy while emphasizing accessibility, equity and adaptability for all.

DAILy Curriculum for Middle School

DAILy is a middle school AI curriculum focusing on on AI concepts, ethical issues in AI, creative expression using AI, and how AI relates to your future.

AI & Ethics for Middle School

The AI & Ethics Project seeks to develop an open source curriculum for middle school students on the topic of artificial intelligence and its ethical implications.

Personal Image Classifier: PICaboo

Students can create and train image classification models in App Inventor.

Supervised

Responsible AI for Social Empowerment and Education (raise.mit.edu)

Blacklifeai.com Home About Meditations on AI

Black Life In the Age of Artificial Intelligence (AI)

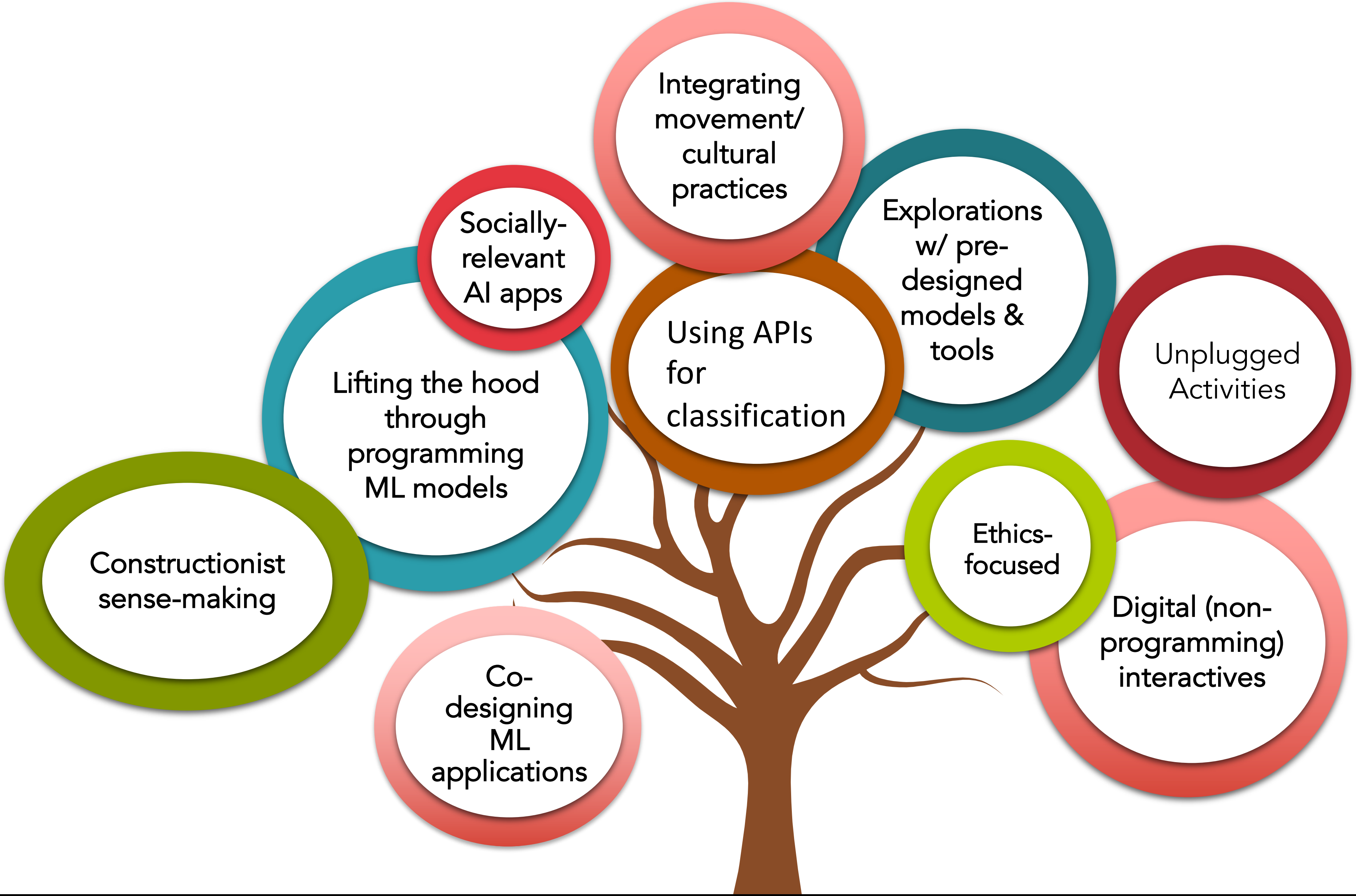
BLACK LIFE
IN THE AGE OF AI

Introduction:

This syllabus aims to bring learners of many backgrounds together to explore content related to Black Life and AI. The term Black Life refers to the varied experiences of Black folks including in terms of identity and experience. Thus we explore race, gender, sexuality, and ability alongside topics such as the internet, surveillance, and education. The syllabus can be used linearly, with a set of information explored per week, or at your own leisure. Over the course of engagement, learners will be exposed to a wide variety of topics that push you to 1) grapple with the ethics of technology , 2) communicate the implications of technology in multiple contexts and create visual media. Learners should leave the site with both tools for conversation with the public, and having had opportunities to reflect on the role of technology in their own lives.

Below you will find sections organized by topic with links to varying resources such as articles, reports, books, podcasts, and videos.

Plurality of Pedagogies for Teaching AI/ML



Two NSF-Funded R&D Efforts to Design AI learning for HS Students

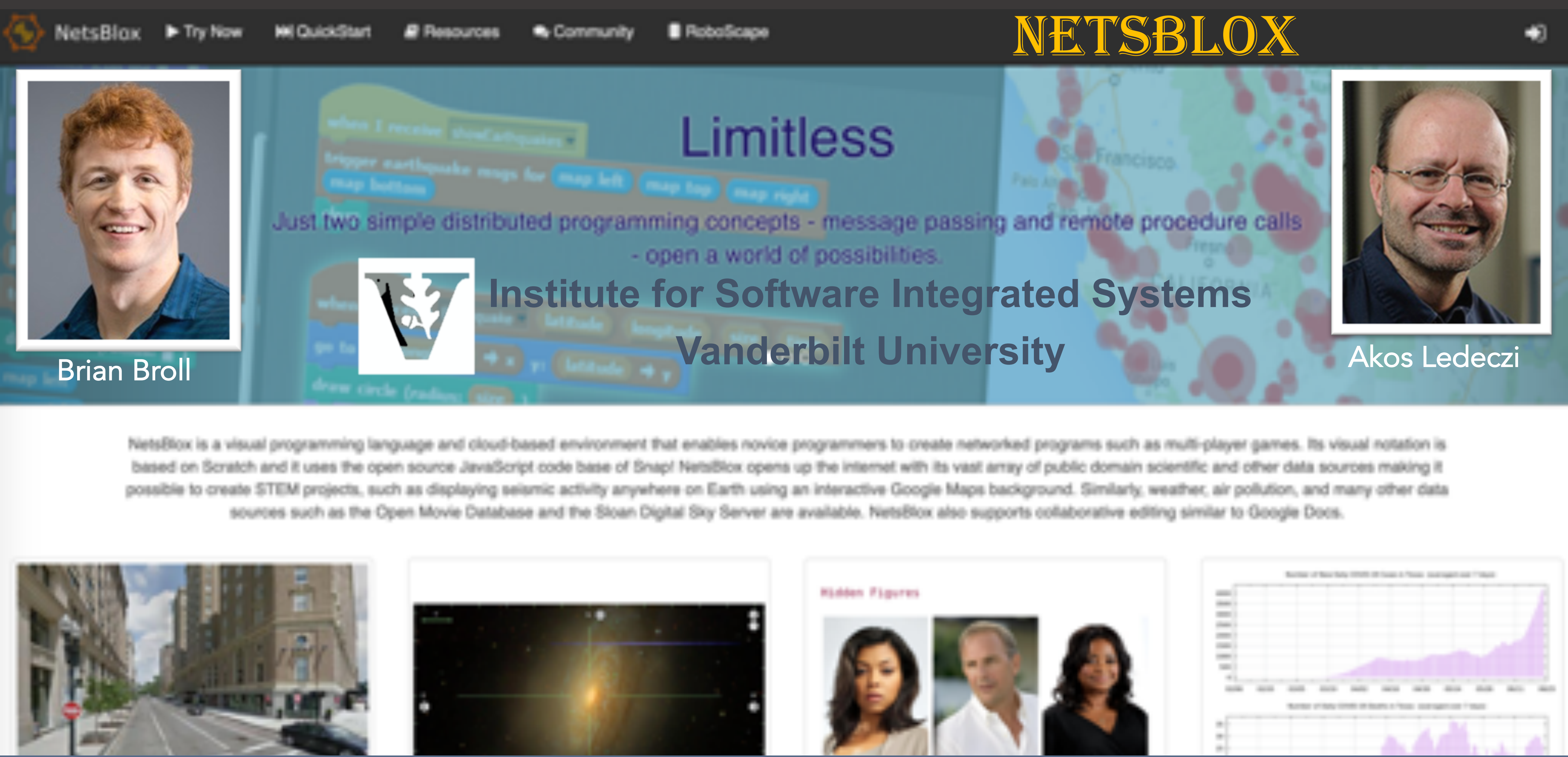
CS Frontiers (CSF)

- 4 year effort to design & test a year-long modular curriculum
    - Distributed Computing, AI/ML, Cybersecurity/Internet Of Things, Software Engineering (capstone)
- Focus on engaging HS girls in CS
- Interdisciplinary connections
- Team: Vanderbilt, NCSU, LGV

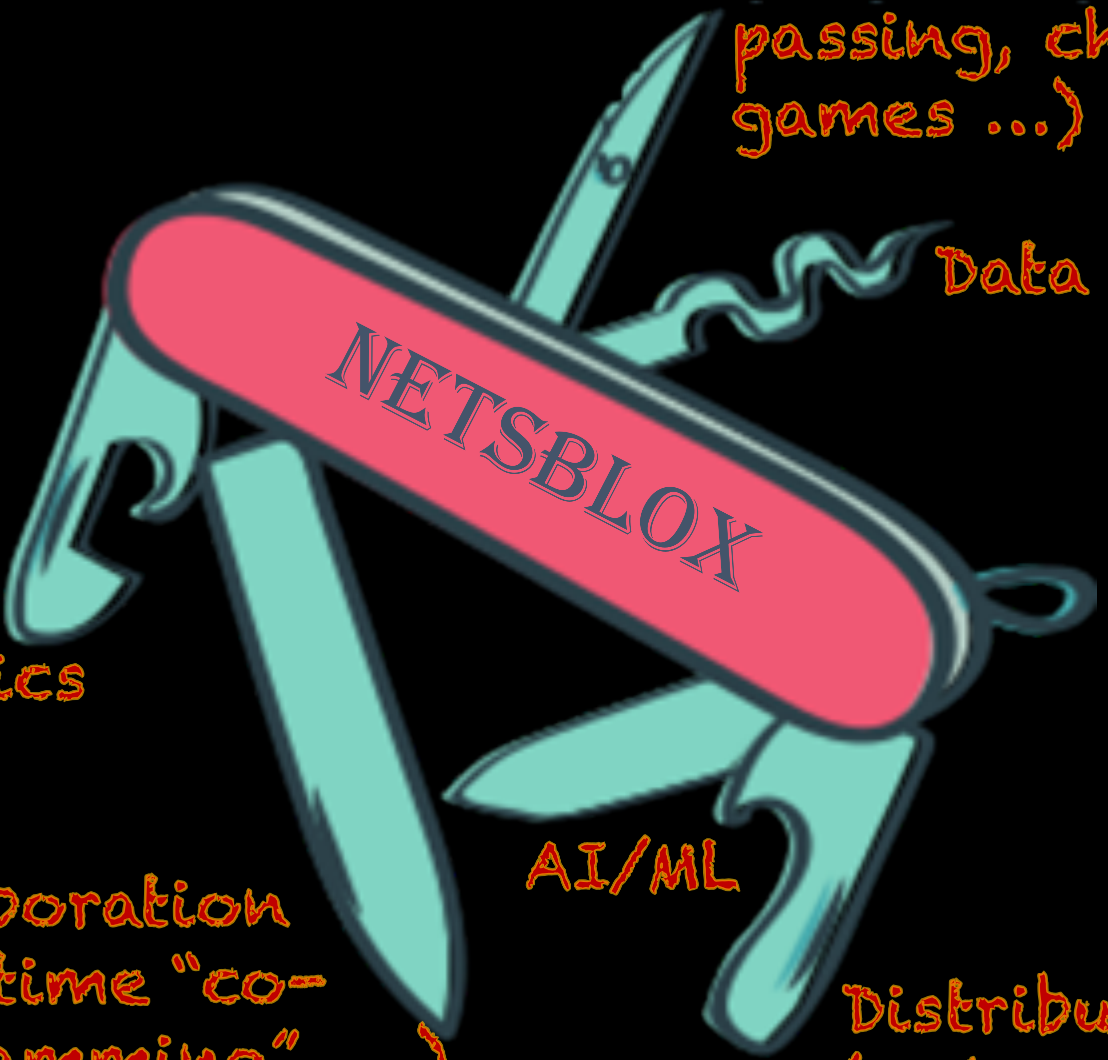
AI & Cybersecurity for Teens (ACT)

- 2 year exploratory effort
- Focus on (a) Integration of AI and Cybersecurity (NSF SaTC-Edu) ➔ Teaching AI in the context of real-world CyS issues (eg. bot detection, DDoS mitigation) (b) Lift the hood on how AI/ML works
- Team: LGV, Vanderbilt, UNO

Both rely on NetsBlox (an extension of Snap! with amazing capabilities)



Opening up Snap! to the web unleashes a world of possibilities

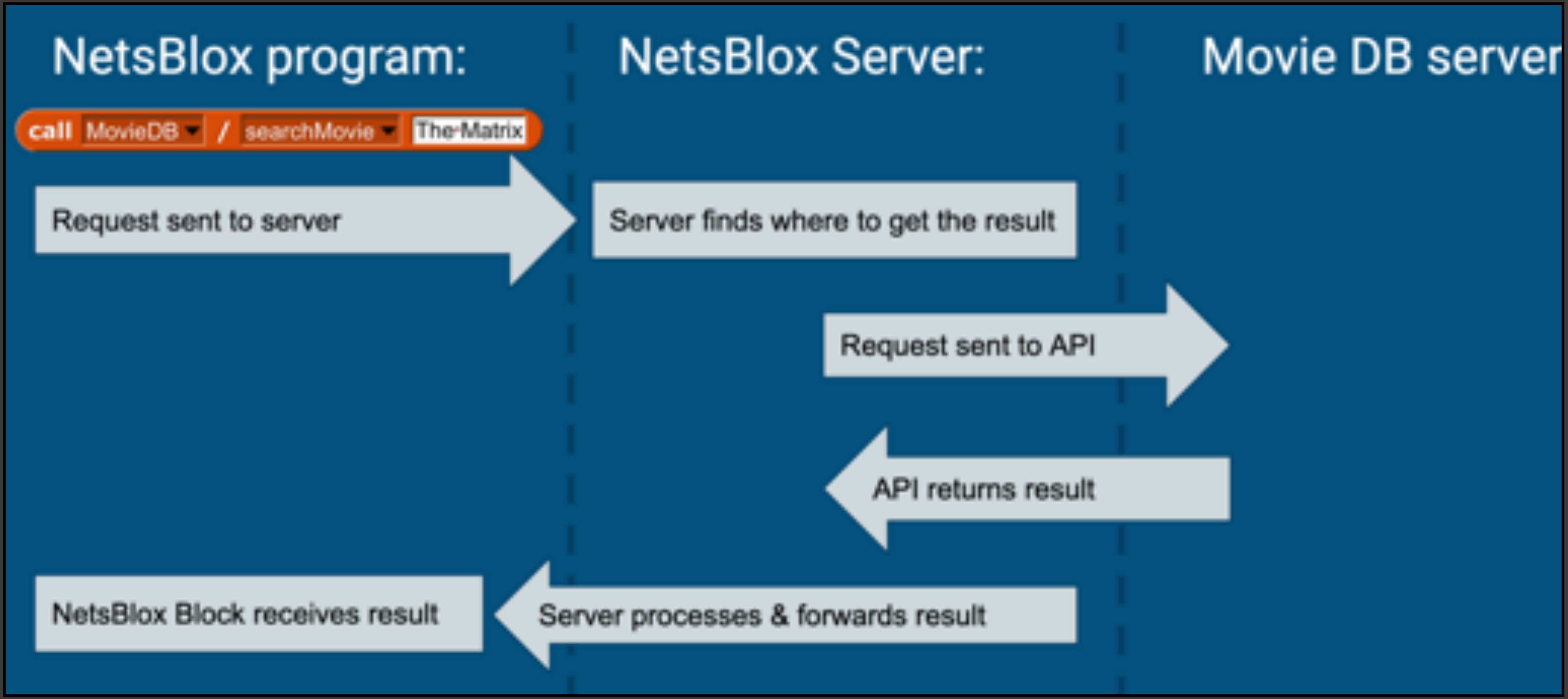

NETSBLOX
Communication (message passing, chatrooms, multiplayer games …)
Data Science / Data Viz
Cybersecurity
Robotics
AI/ML
Collaboration (real-time "co-programming", …)
Distributed computing (online web/data services)

TWO SIMPLE ABSTRACTIONS

Remote Procedure Calls

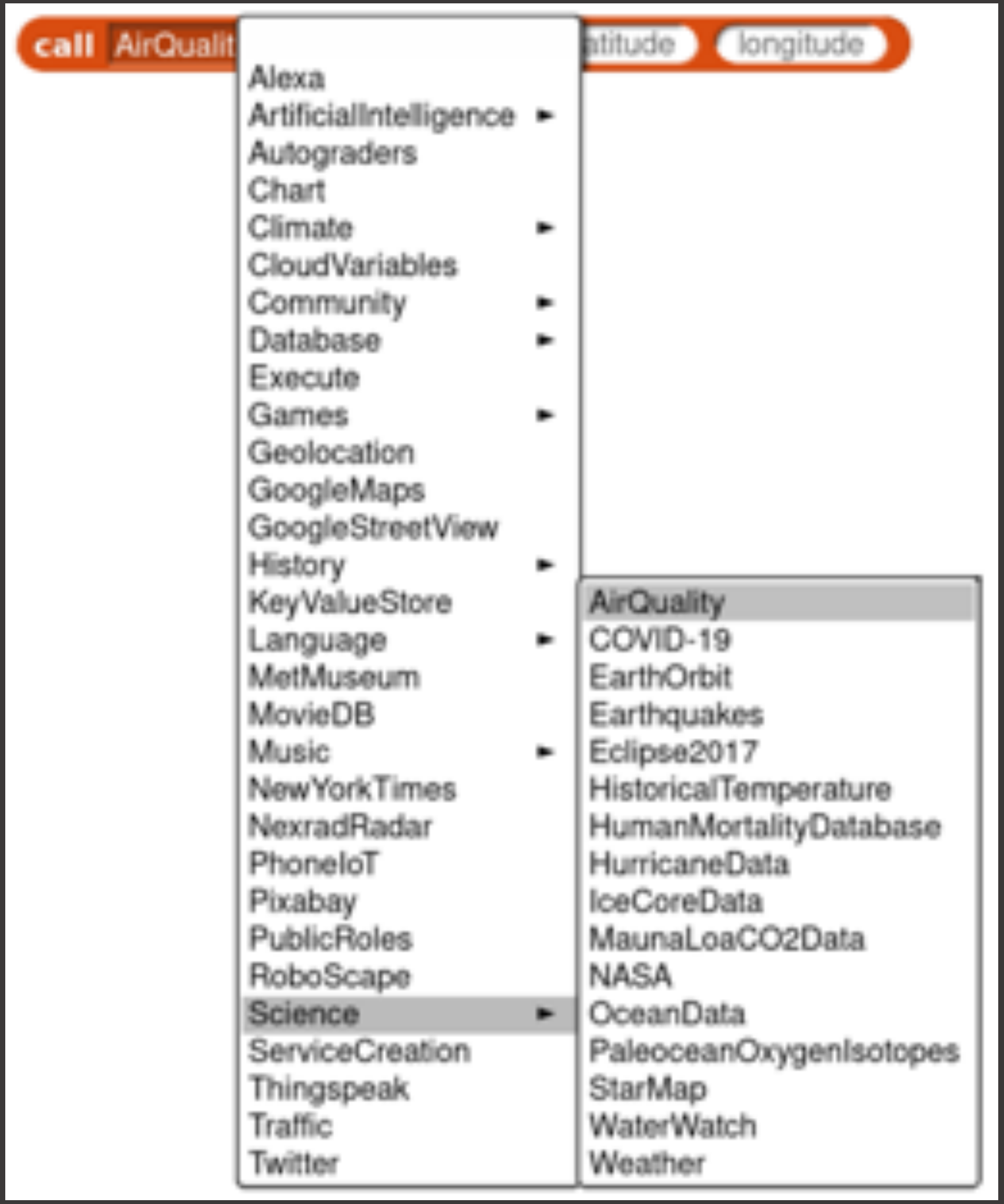
- RPC: call functions on the server
  - Multiple input arguments
  - One output argument
  - Blocking call (waits until it gets response)
  - Works like any other custom block

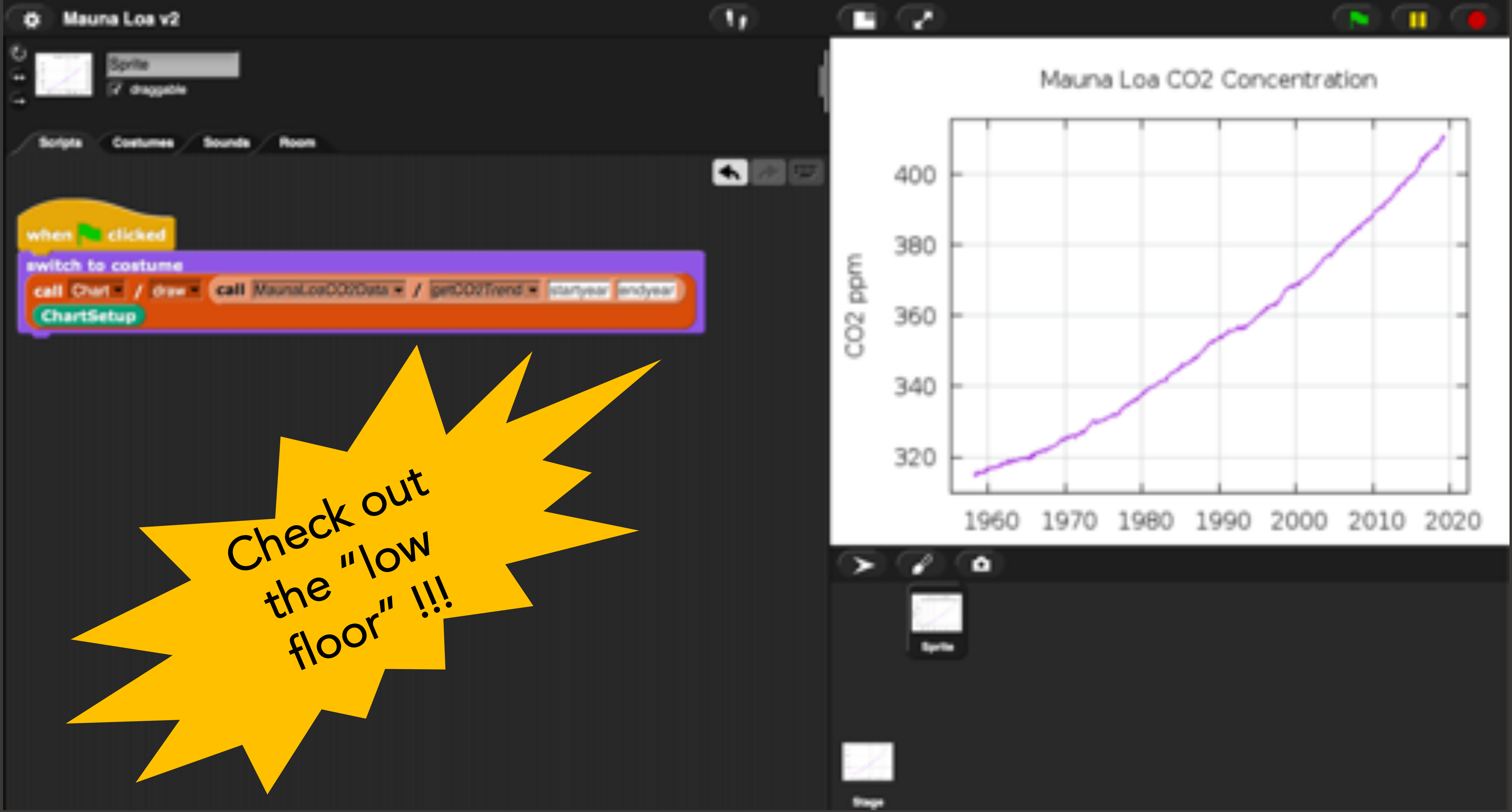
- Similar RPCs are grouped into a 'service'
  - Google Maps, weather, earthquake, museums, movies etc.



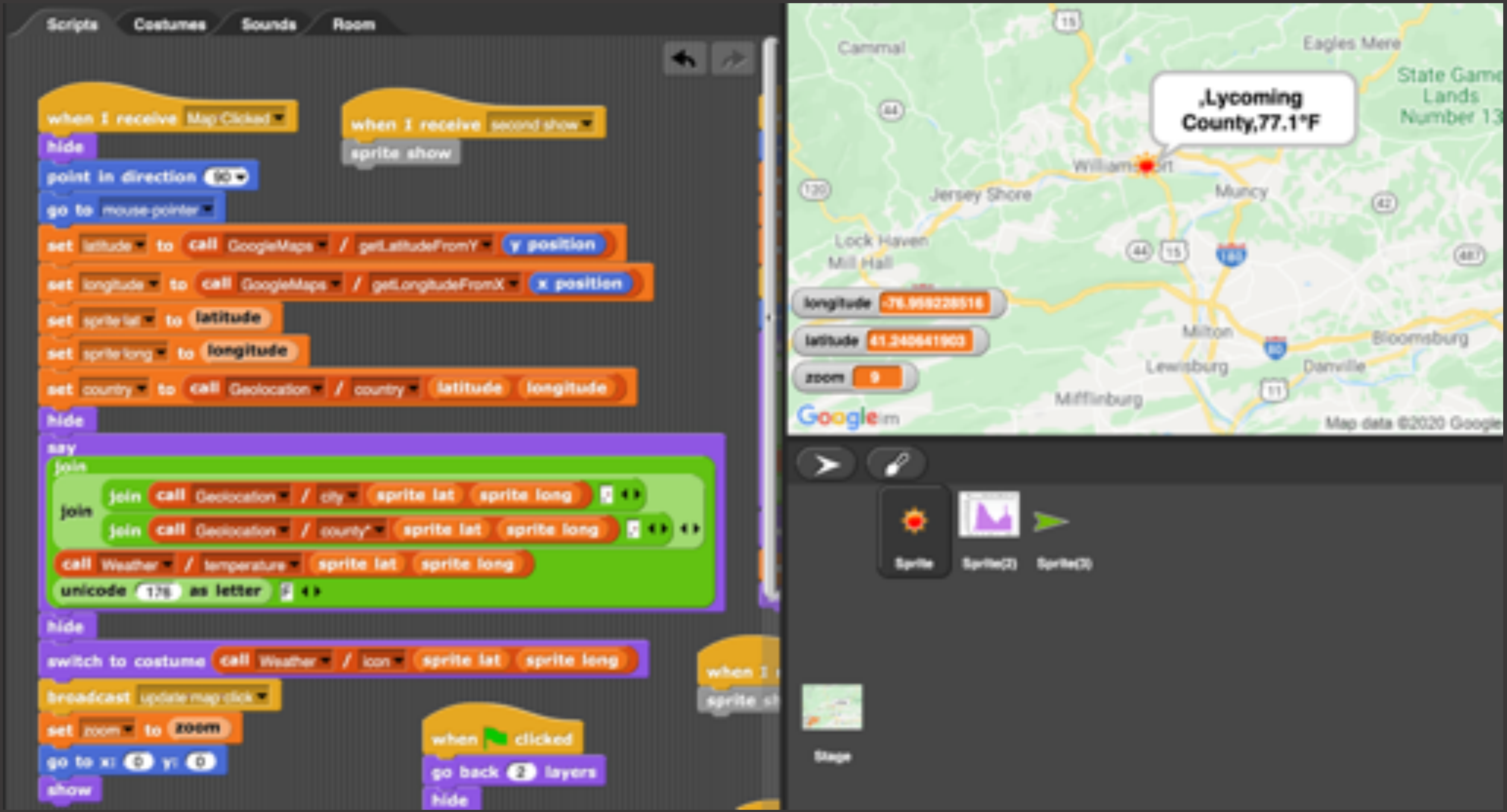
How a NetsBlox RPC works

ONLINE DATA AND WEB SERVICES

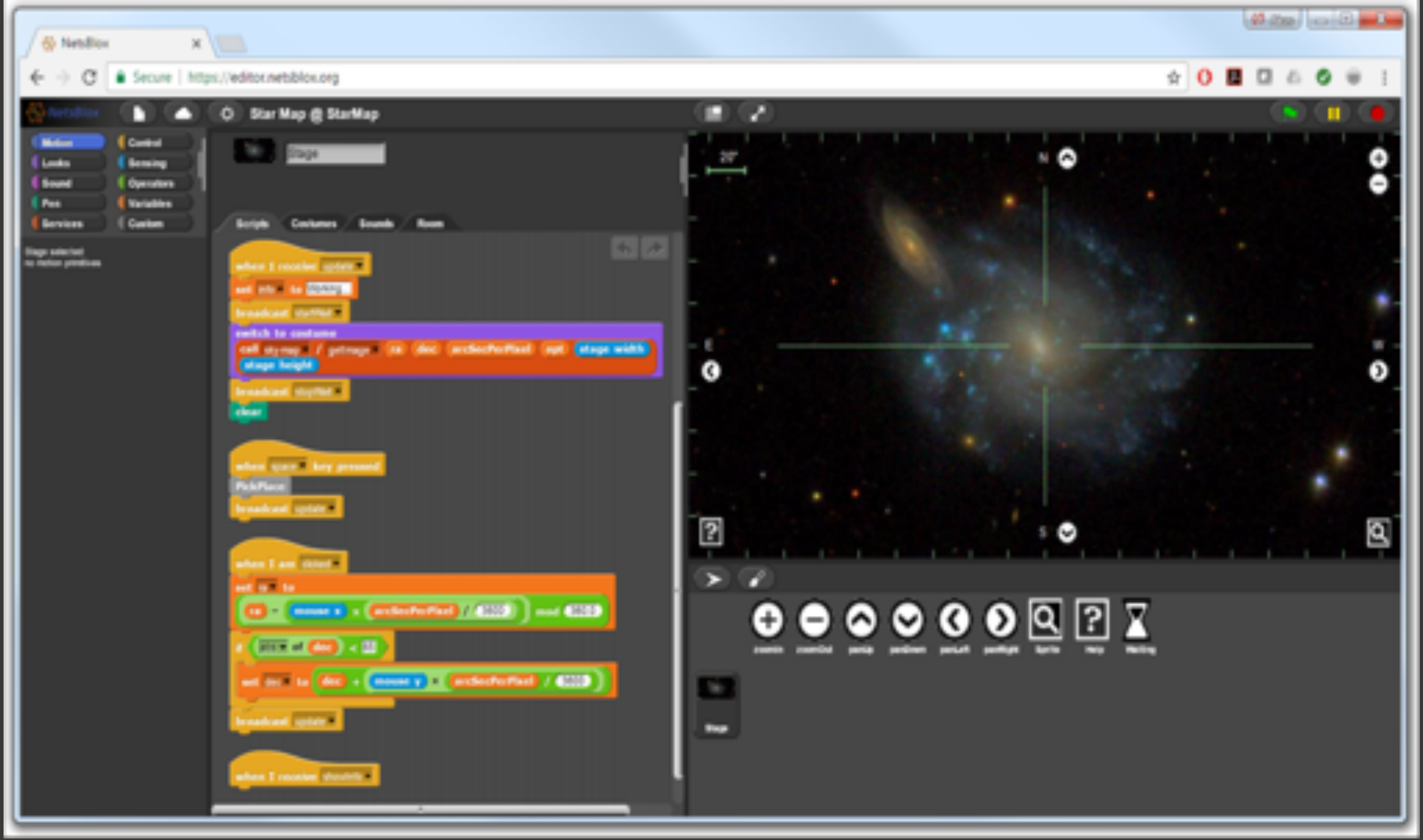




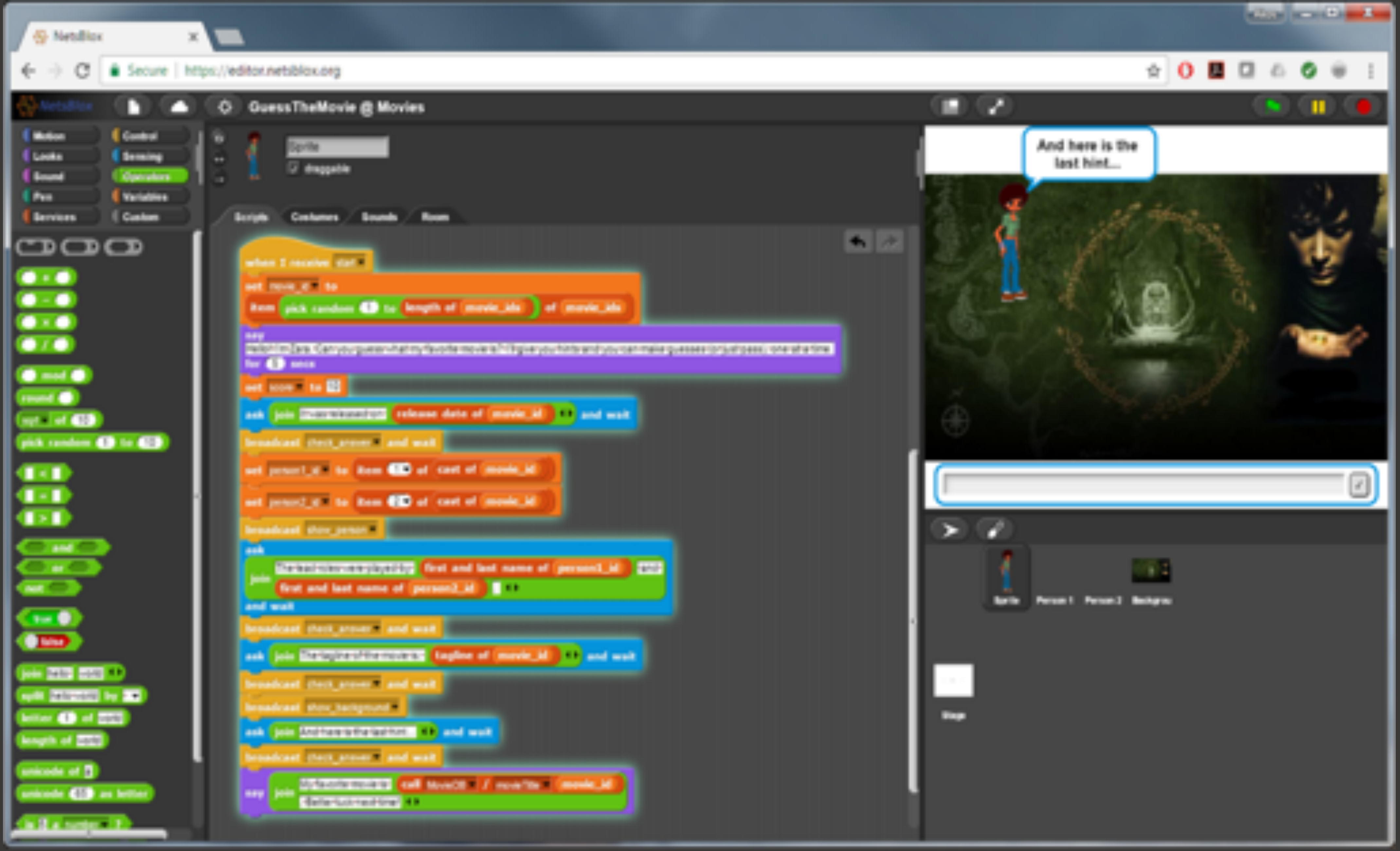
Charting climate data using Temp, CO2, Ice core, … data over time



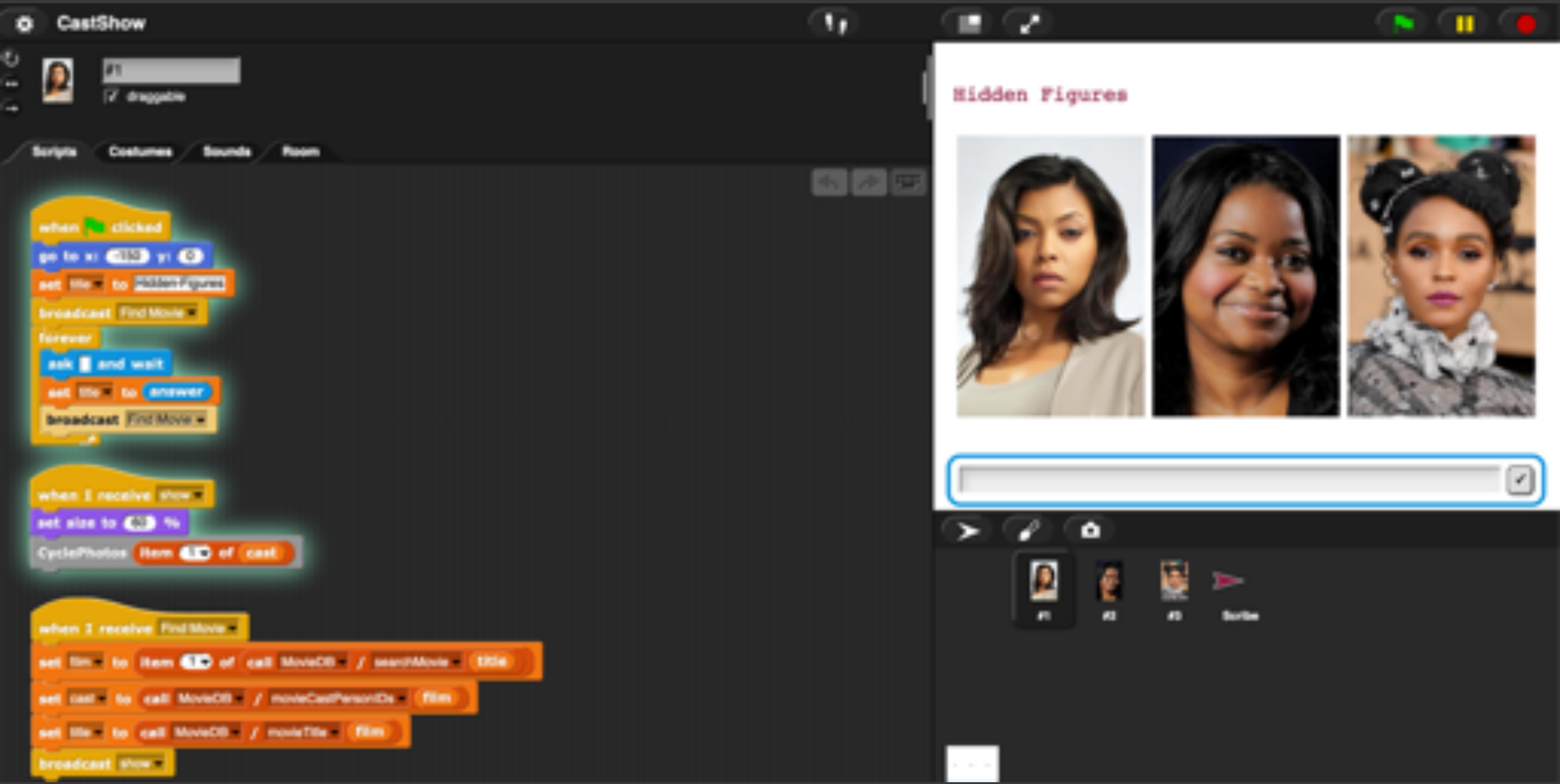
Weather/AQI/… using the Google Maps/Geolocation/Weather



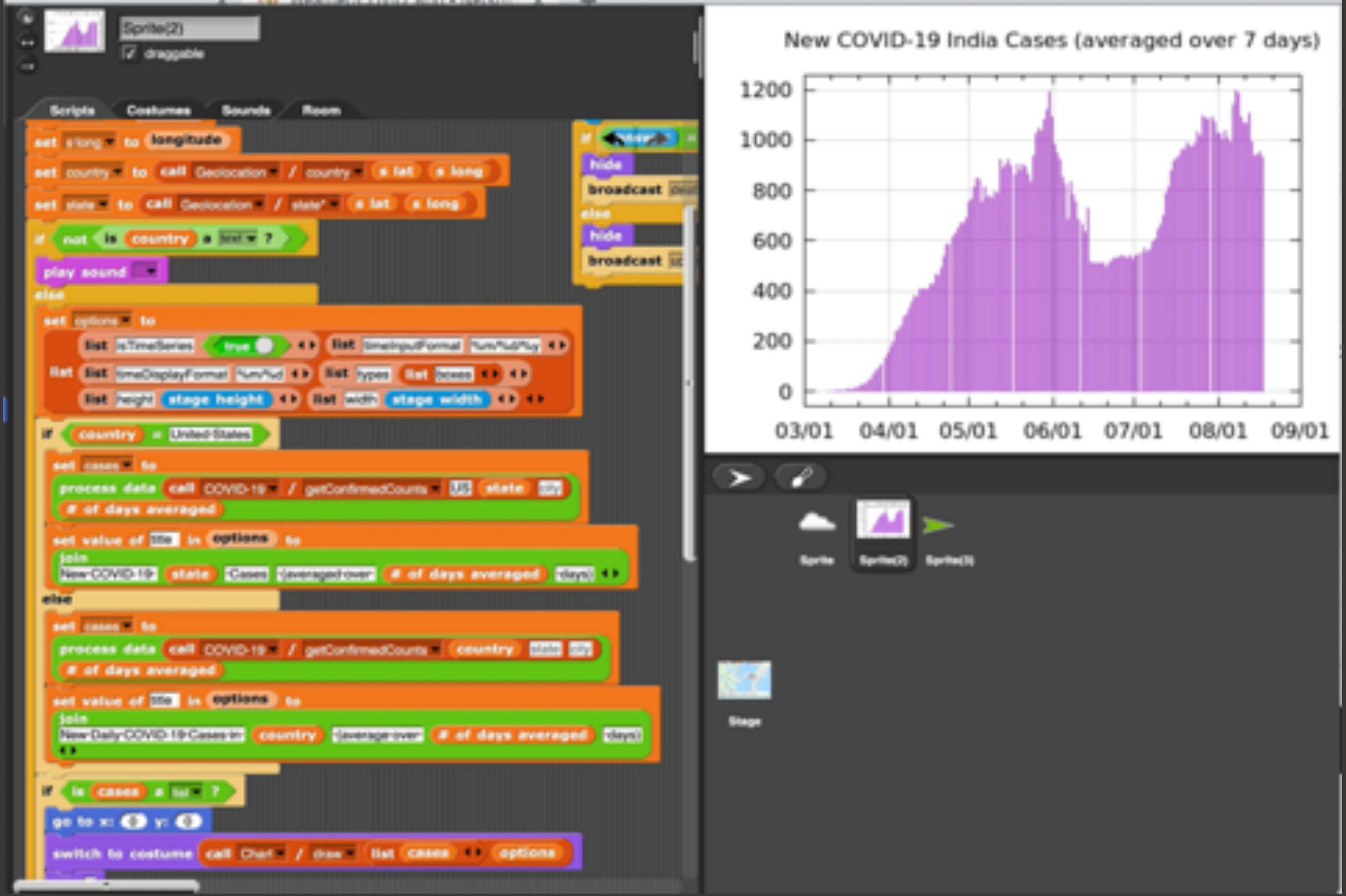
Sky navigator app using the Sloan Digital Sky Survey



Movie guessing game using The Movie Database (TMDB)



Hidden Figures Cast Show



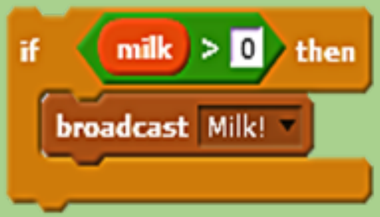
Covid-19 visualization by region using Google Maps/Geolocation/COVID-19/gnuplot

Data & Transdisciplinary Learning

TWO SIMPLE ABSTRACTIONS

Message Passing

- Events in Scratch:



- Messages in NetsBlox:

- Message type editor:

– CS Frontiers: Engaging Female High School Students in New Frontiers of Computing (CSFrontiers)

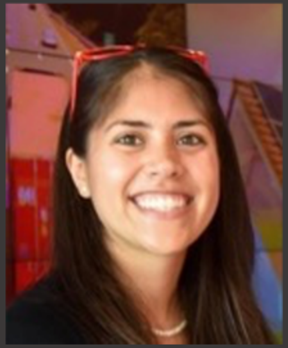
Research Team

Tiffany Barnes
(PI)
NCSU

Shuchi Grover
(PI)
LGV

Akos Ledeczi
(PI)
Vanderbilt

CS FRONTIERS
Powered by NetsBlox



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(AMSA Charter School)


Distributed
Computing


AI/ML


Cybersecurity


Software Engineering

Project Based Learning

Engage in Data Science

Engage non-dominant grps (esp. girls)

Collab. Activities

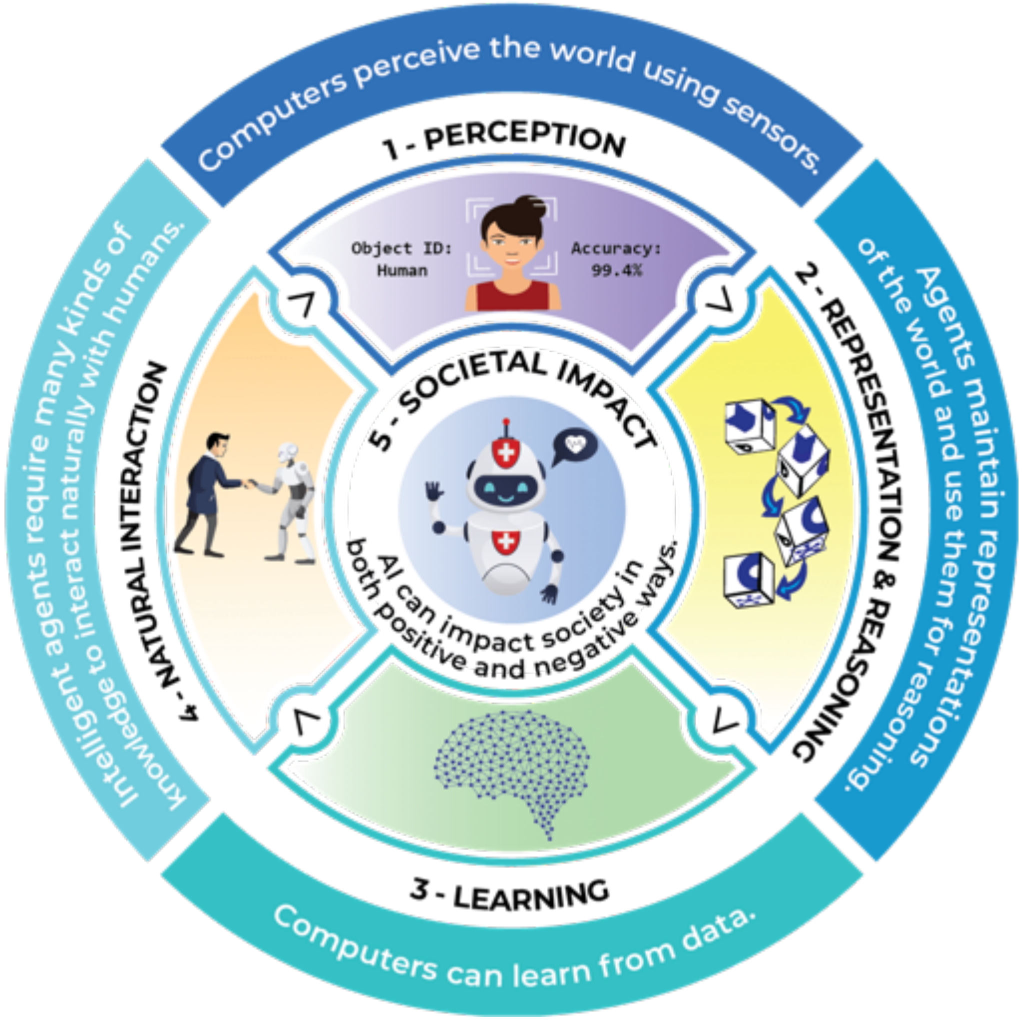
Integration & multi-disci. learning

AI/ML Curriculum Design/Curation

1. NetsBlox Activities

2. Open-source AI and ML materials for K-12 students:
   i. AI4All: AI Bytes Units
   ii. AI4K12
   iii. Ecraft2learn

3. Connected activities to the AI4K12 **learning objectives** in the **AI4K12 Big Ideas Progression chart**



CS Frontiers AI / ML Module Overview

Unit	Main Topic	Activities
Unit 0	Netsblox refresher	Introduction to Netsblox Activity
Unit 1	Introduction to AI	Google Quick, Draw!
Unit 2	Algorithms and Search	Map Breadth First Search
Unit 3	Introduction to Machine Learning	Twitter Bot Classification
Unit 4	Introduction to Natural Language Process and Sentiment Analysis	Music Sentiment Using Genius API
Unit 5	Sentiment Analysis	Students expand on above activity
Unit 6	Bias in Datasets, Ethics in AI/ML	Students create presentation on bias
Unit 7	Other ML Techniques	Imitation Learning Game
Unit 8	Deep Neural Networks	Square Root Predictions with Neural Networks
Unit 9	Real World Application of AI/ML	AI & Criminal Justice, AI & Environment

AI (Units 1–2)

ML (Units 3–5)

More ML and Other Topics (Units 7–9)

"Sentimental Writer" (NLP/Text Analysis)

"Classify" a text as positive, negative, or neutral sentiment using a publicly-available text classification API called "Parallel Dots" an AI powered NLP API https://apis.paralleldots.com/text_docs/index.html)

sentiment

3	A	B
1	negative	0.012
2	neutral	0.412
3	positive	0.575

Part 1 (Unplugged/Pseudocode)

Read through the following pseudocode and think about what this program is doing and how the program should be coded

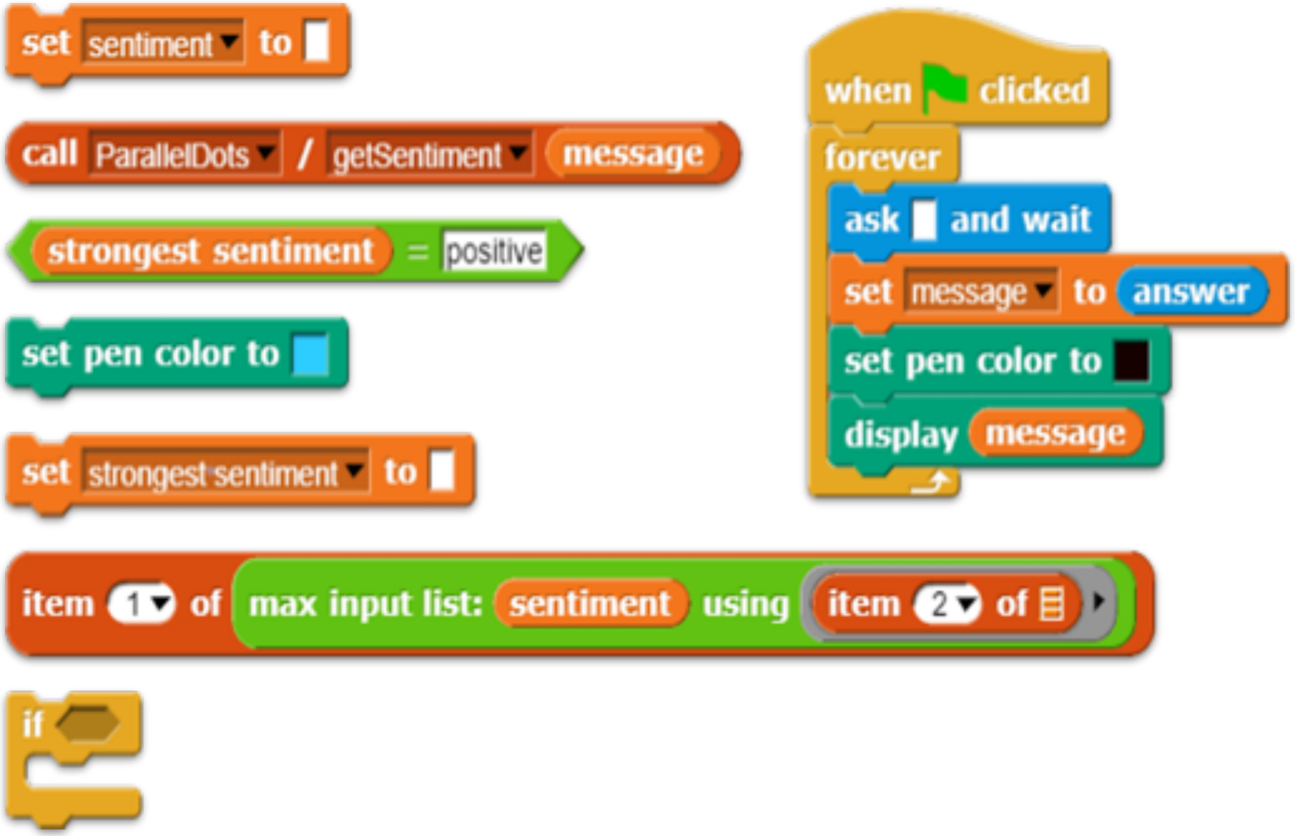
```
When ⚑ clicked
          Continue Forever
                    Ask a question and wait
                    Set message to the answer of the question
                    Set sentiment to a RPC that identifies the sentiment of message
                    Set strongest sentiment to the first item in a list of
sentiments
                    Set pen color to neutral color
                    If strongest sentiment is equal to positive
                              Then set pen color to positive sentiment
                    If sentiment sentiment is equal to negative
                              Then set pen color to negative sentiment
                    Display message to stage
          End Forever
```

Part 2 (NetsBlox Parson's Puzzle Activity)

Load up the Netsblox Activity :

Sentiment Writer [link]

Assemble the starter code provided to replicate the procedures in the pseudocode of Part 1.



Saturday, April 15, 2023
Today's Paper

The New York Times

World U.S. Politics N.Y. Business Opinion Science Health Sports Arts Books Style Food Travel Magazine Real Est

LIVE 4m ago

Rival Generals Duel for Power in Sudan, Dashing Hopes for Democracy

Mounting tensions broke into an open battle for control in Khartoum. At least 30 people were killed and about 400 were injured, U.N. officials said.

See more updates

Who is battling for control in Sudan? Here's what to know about the clashes.

3 MIN READ

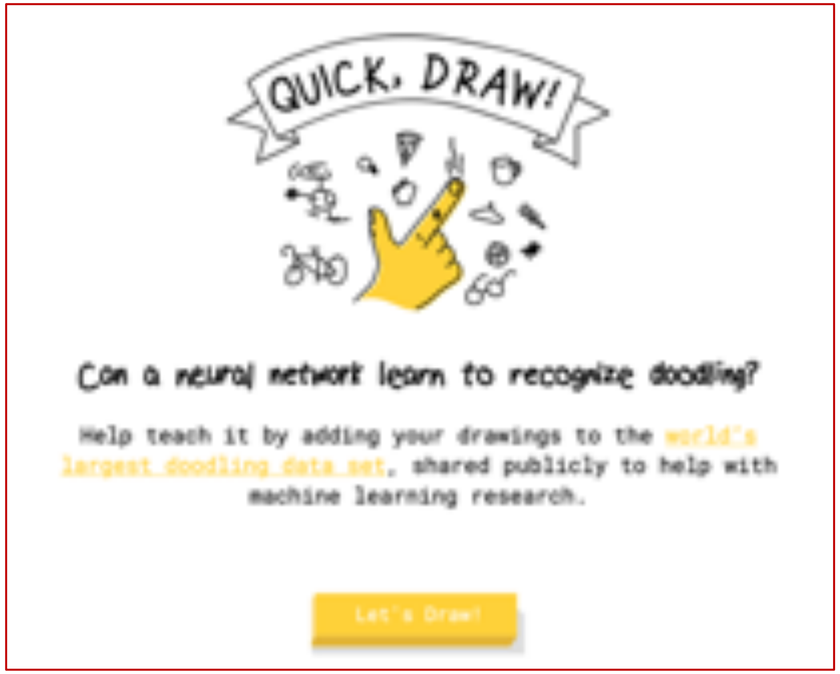
Leaked Pentagon Documents Who Is Jack Teixeira? What the Do

Analysis: The Pentagon Leaks Present New Twists in a Familiar Plot

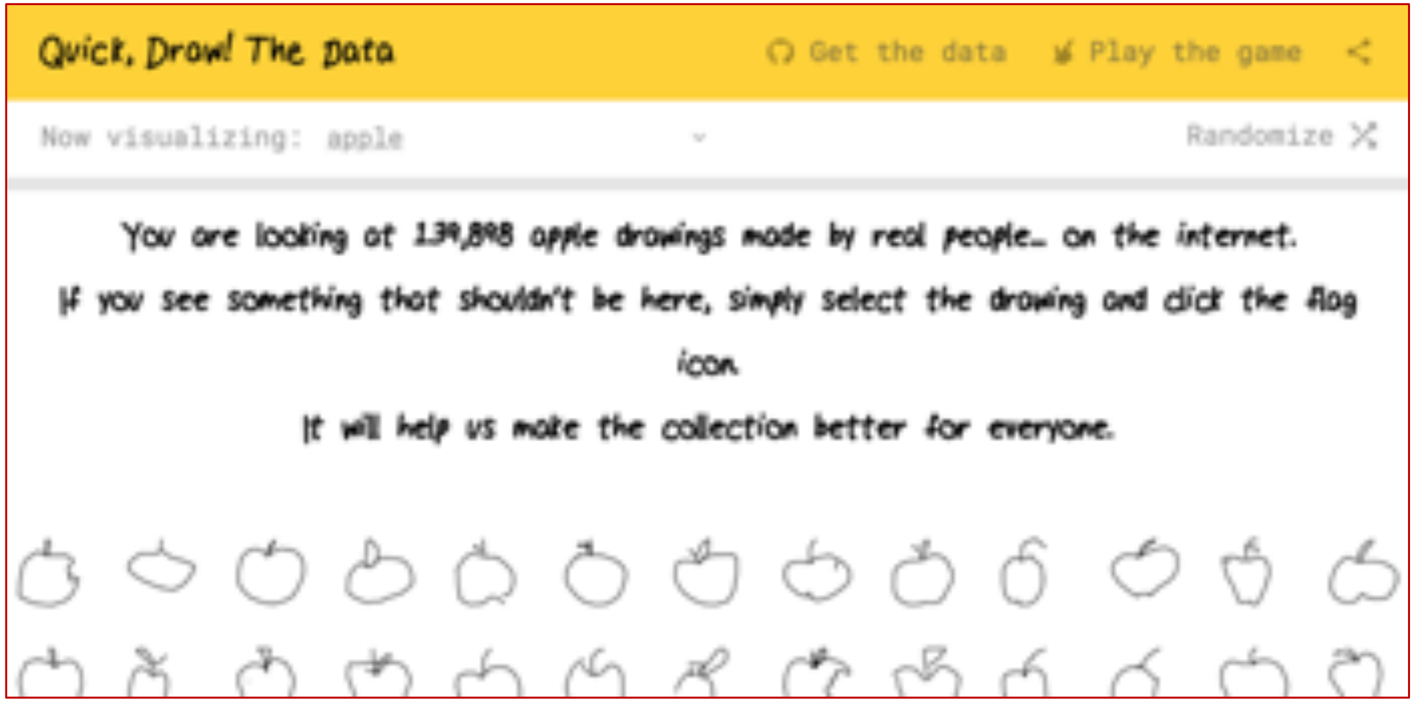
There was little palpable alarm in Ukraine over what the leaked documents said about the war. Some welcomed the confirmation of the country's dire situation.

6 MIN READ

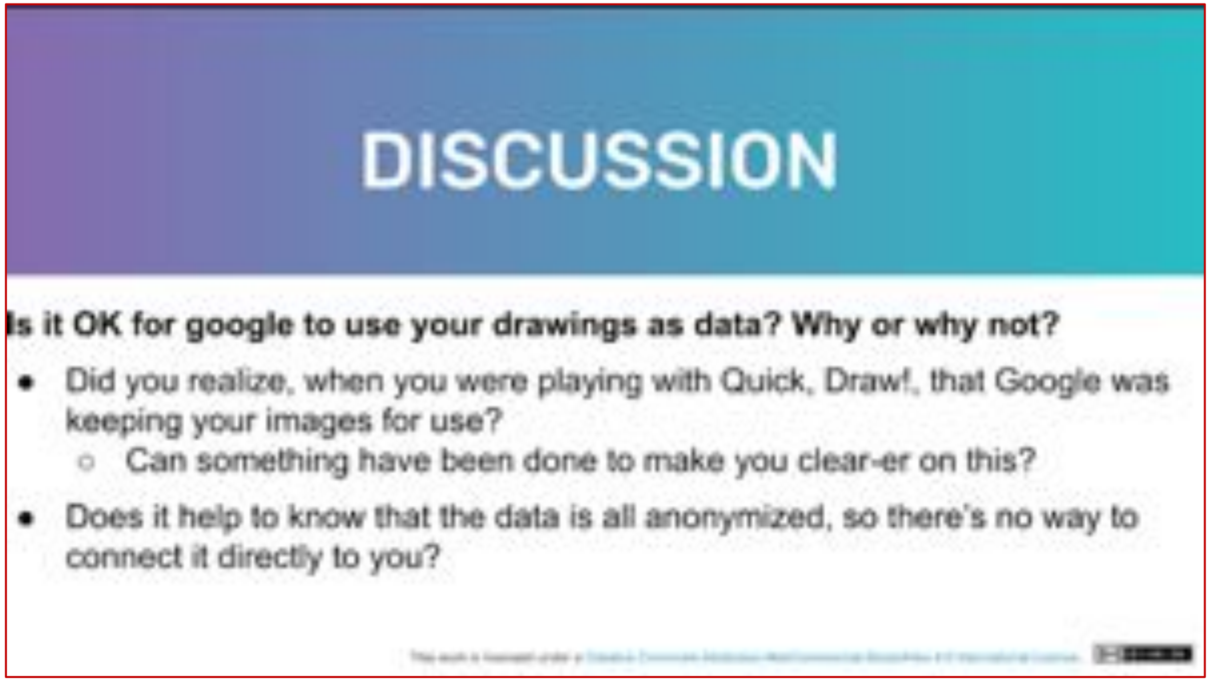
And all you're ever gonna be is mean
Why you gotta be so mean?
And I can see you years from now in a bar
Talking over a football game
With that same big loud opinion
But nobody's listening, washed up and ranting
About the same old bitter things
Drunk and grumbling on about how I can't sing
But all you are is mean
All you are is mean and a liar and pathetic



https://quickdraw.withgoogle.com/



Information	Description
Key_id	Unique identifier for each drawing
word	Category user was told to draw
recognized	If the game recognized it
timestamp	When it was drawn
country_code	Which country it was drawn in
drawing	How you drew the image (in what order)



A Socially Relevant Focused AI Curriculum Designed for Female High School Students
L Alvarez, I Gransbury, V Cateté, T Barnes… - … on **Artificial Intelligence**, 2022 - ojs.aaai.org
… For our **curriculum** framework, we wanted to implement an **AI** and ML module with the same goal. We believe introducing students to these **socially-relevant** topics early in their expo…
Save Cite Cited by 11 Related articles All 2 versions

EAAI "AI Education in K-12" Conference 2022

Student Attitudes During the Pilot of the Computer Science Frontiers Course
…, I **Gransbury**, V Cateté, T Barnes, S **Grover**… - Proceedings of the …, 2023 - dl.acm.org
Motivation. We have created a modular project-based learning curriculum, Computer Science Frontiers (CSF) [1, 8], for secondary students in attempts to increase the persistence of …

ACM SIGCSE 2023

ELSEVIER
Journal of Computer Languages
Volume 73, December 2022, 101156

Block-based abstractions and expansive services to make advanced computing concepts accessible to novices

Corey Brody [a], Brian Broll [a], Gordon Stein [a], Devin Jean [a], Shuchi Grover [b], Veronica Cateté [c], Tiffany Barnes [c], Ákos Lédeczi [a]

Journal paper on NetsBlox

Cybersecurity Education in the Age of AI:
Integrating AI Learning into Cybersecurity High School Curricula

Shuchi Grover
(PI - Looking Glass Ventures)

Brian Broll
(Co-PI - Vanderbilt)

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Derek Babb
(UN-Omaha)

Melissa Dark
(Advisor)


Since the start of the pandemic, the FBI has reported a
300%
Rise in Cybercrime
Data breaches in the healthcare sector have
Risen by 58%
In just April 2020, Google clogged
Over 18 Mil Malware
and phishing emails linked to coronavirus daily.

Why Integrate Cybersecurity & AI learning?

- Both are fast-growing and increasingly important CS-related topics

- Leads to better understanding of how these fields look in the real world
  - Authentic (AI in Cybersecurity)
  - Learning in context (Cybersecurity in AI)

- Practicalities of introducing new subjects is challenging
  - Already packed CS and school curriculum
  - Easier for HS students to get a flavor of multiple emergent fields in one course than trying to introduce 2 separate courses

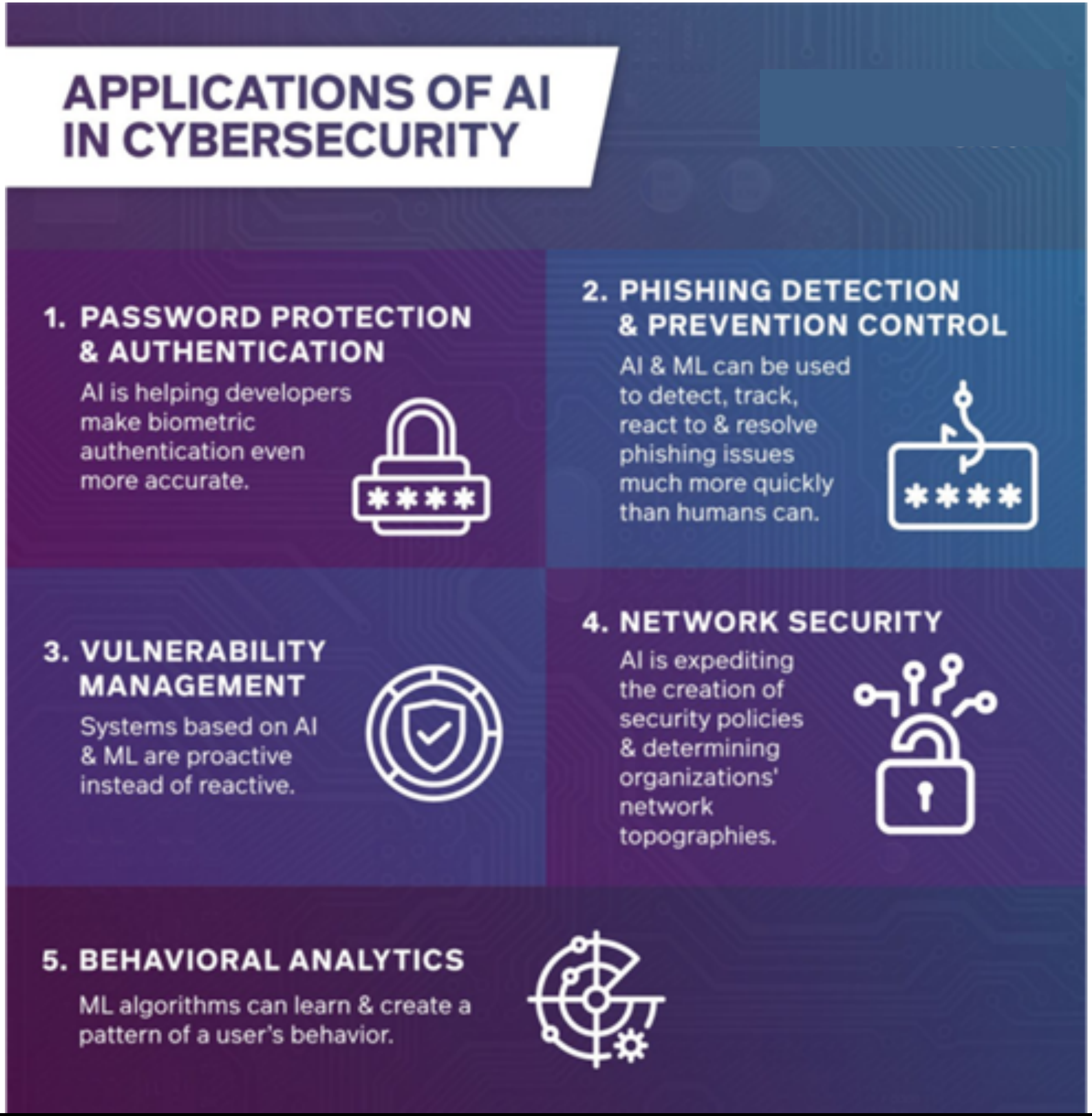
Cybersecurity & Artificial Intelligence

How & where do these 2 critical subfields of CS meet?

What does Cybersecurity look like in the age of AI?

How do AI models work to address issues of Cybersecurity?

How does AI raise (new) concerns related to Cybersecurity?



Learning Goals of ACT

Basics/Big Ideas of Cybersecurity

- Cybersecurity First Principles, The CIA Triad
  - Cryptography, passwords, and ciphers, hacking
  - Phishing, spamming
- Network security and vulnerabilities, DDOS attacks
- Misinformation campaigns, bullying, cyber warfare, bots

AI Ideas & ML Techniques

- Rule-based AI
- Decision Trees
- Classification & Prediction
- Supervised/ Unsupervised Learning
- Bias and Ethics
- Anomaly detection
- Adversarial examples
- Generative adversarial neural network (Deep fakes)

AI in context of Cybersecurity

- AI/ML concepts/techniques in Cybersecurity contexts
- Exploring various ML techniques & models in **NetsBlox** using code & (often actual) data
- Discuss use & implications for Cybersecurity and society
- Explore/play with pre-built games & examples

ACT Pedagogical Approach

- Learning in Context: Teaching AI *in context of* Cybersecurity
- Making Connections: Helping students see real-world connections through relatable examples/hooks and "cases"/"scenarios"
- Games and guided exploration for engagement and for building intuitions of ML techniques : Hands on unplugged, digital, and programming activities, e.g.,
  - https://kennysong.github.io/adversarial.js/, Google TensorFlow Playground, ThisXDoesNot Exist,
  - Pre-programmed games (Find the minimum, Registration Bot, …)
- Scaffolding: complex ideas through various techniques including
  - "Glass-boxing" / Levels of Abstraction: Increasing the transparency on how the model is programmed - idea/unplugged exploration, pseudocode, "sub-goal" blocks, Parson's problems, actual code
- Sense-making: Pre-activity topical news/issues; post-activity reflection/discussion
- Collaboration: All activities are designed to be completed in pairs/small groups

Big Ideas / Goals Related to AI/ML

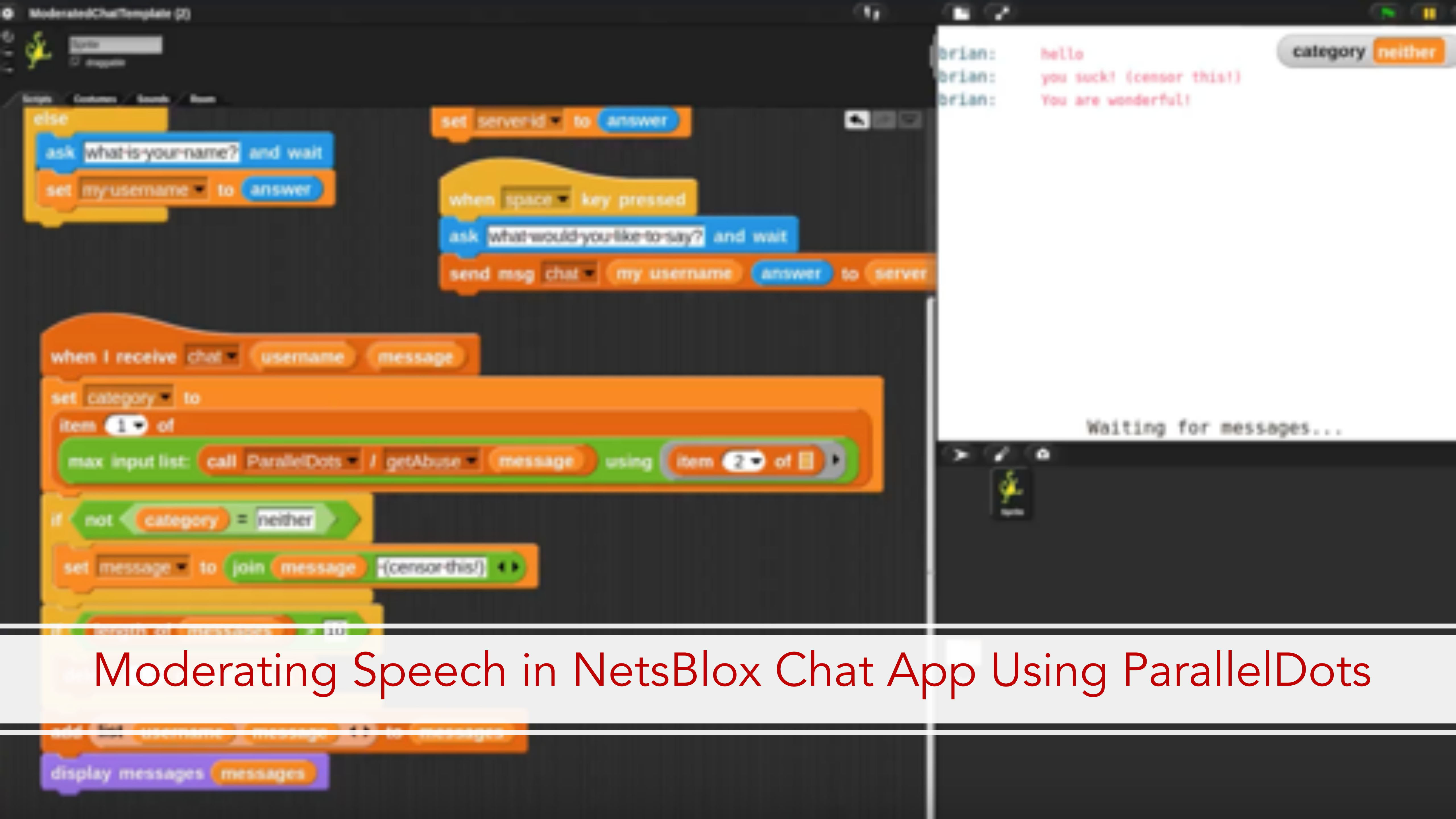
- Lift the hood on Machine Learning techniques
  - how the machine *learns*
  - how to examine/understand data and its features
- Optimization
- Generalization & Overfitting/Underfitting
- How bias can impact aspects (and phases) of machine learning
  a. Issues of Ethics
- Adversarial Thinking: Whenever we discuss solving a cyber detection issue using AI, also *think of how it can be fooled*

Curricular Activities & AI/ML Concepts/Big Ideas

- Curricular Coding Activities in NetsBlox:
  - Rule-Based AI to Mitigate Denial of Service Attacks (through a chat room kids code)
  - Text Classification and Cyberbullying (using the ParallelDots NLP API)
  - Twitter Bot Classification and Decision Tree Building
  - Optimization & Find the Minimum Game
  - Registration Bot Detection with Gradient Descent
  - Generative Adversarial Models

- Additional (Recurring) Topics:
  - Adversarial Thinking
  - Generalization and Over/Underfitting
  - Understanding Bias and Critical Interrogation of the Impacts of ML Models

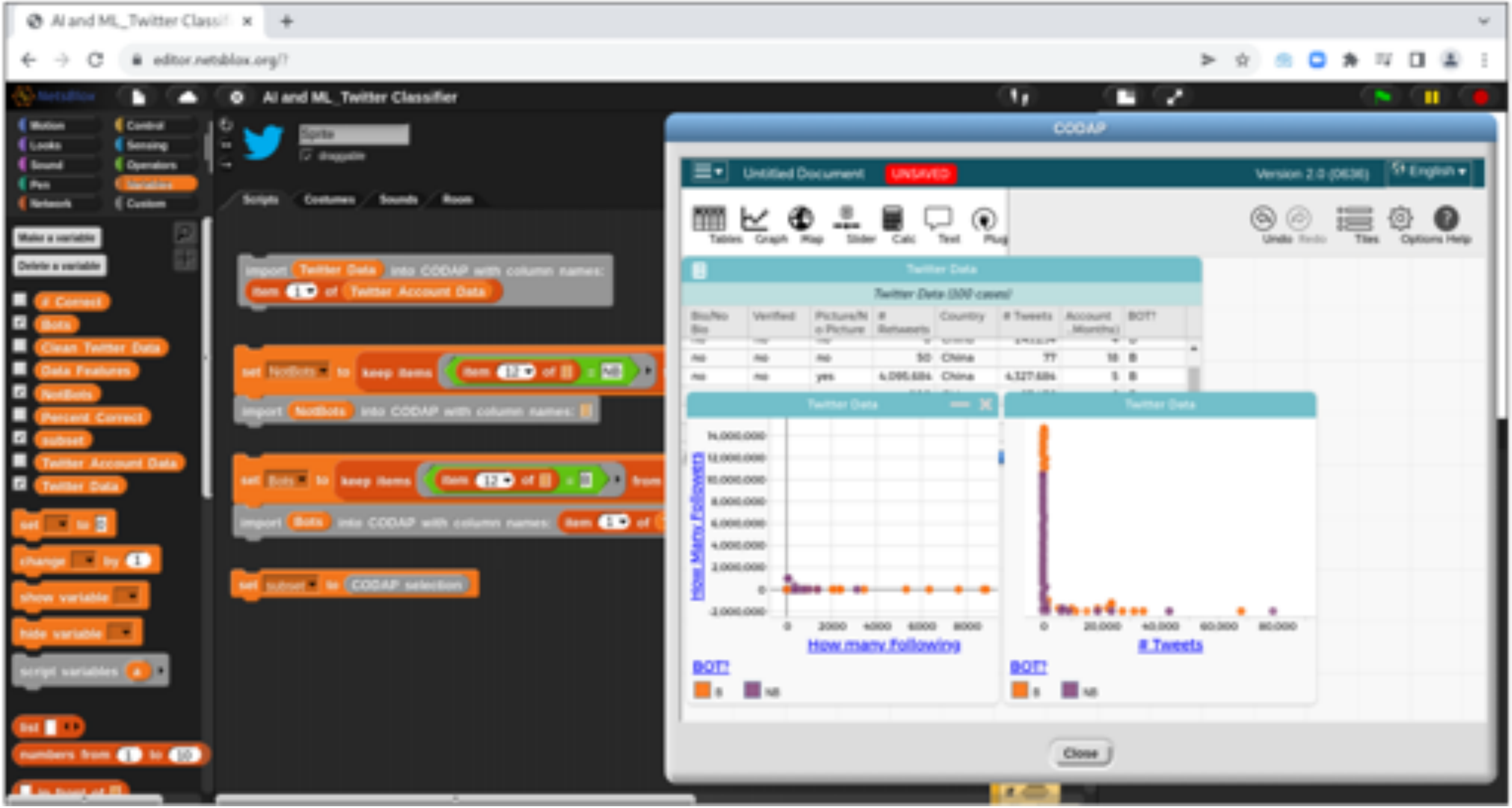
- Unplugged/Interactive (non-programming) activities before coding



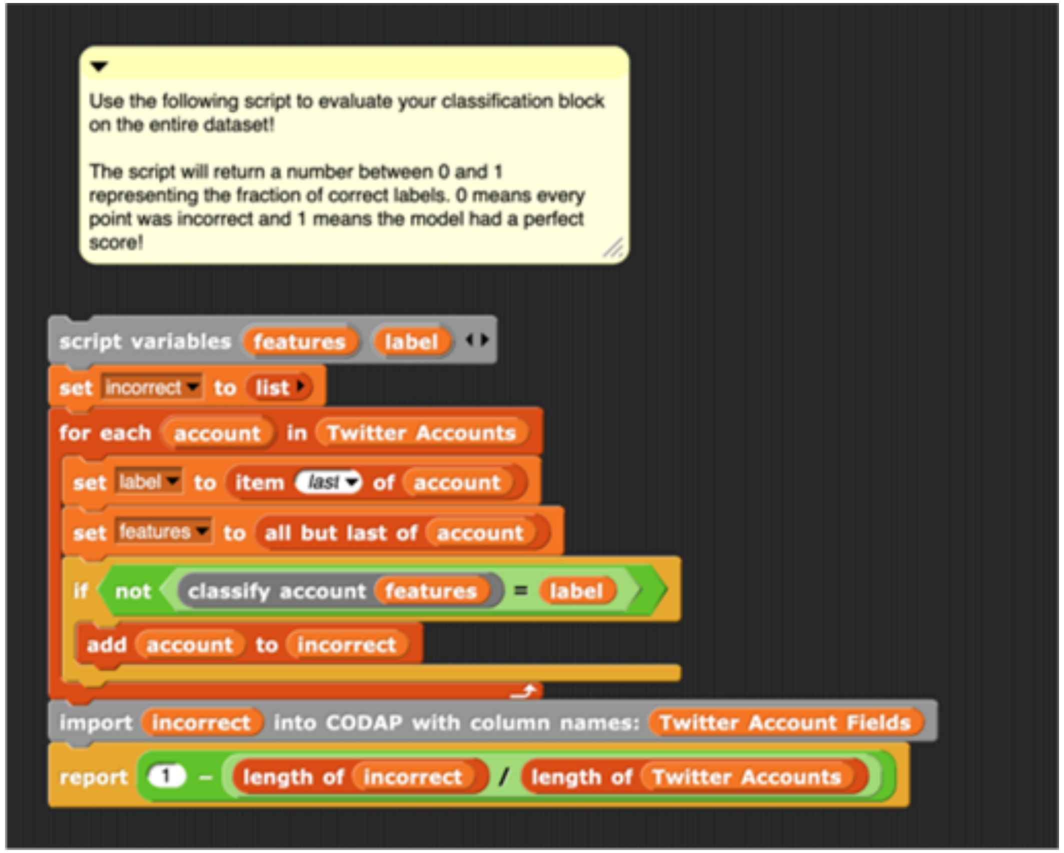
Moderating Speech in NetsBlox Chat App Using ParallelDots

Scaffolded Progression to Understand Decision Trees Through Twitter Bot Classification

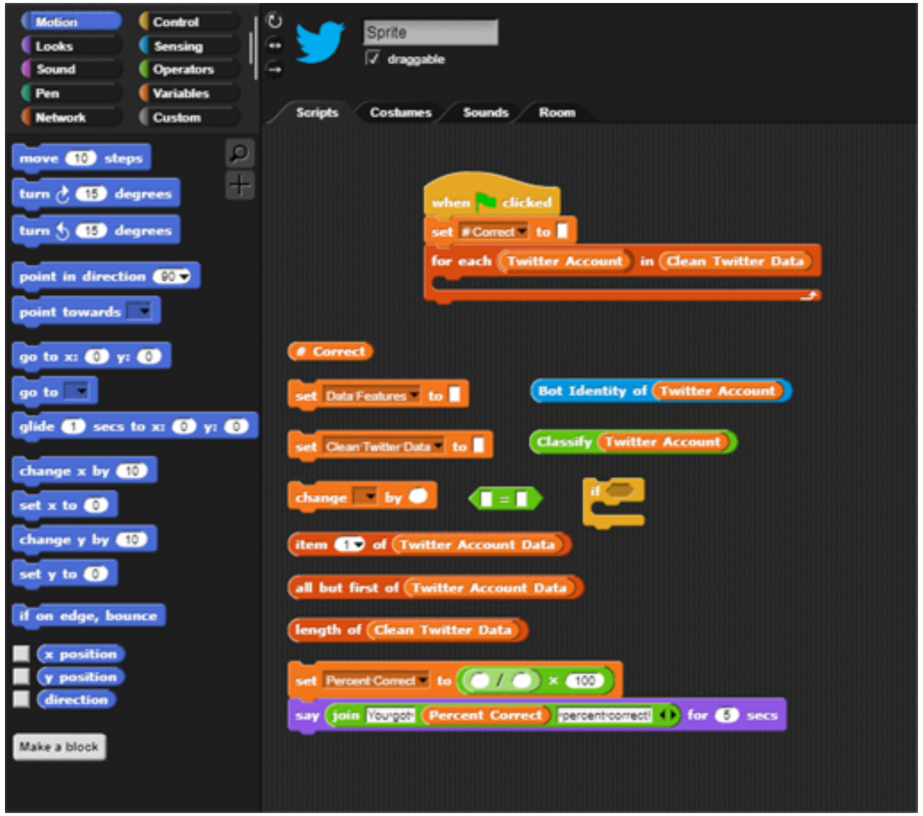
1. Data exploration in CODAP; Examine features; Ways to split the dataset
2. Scaffolded activity to manually build a rule-based classifier in NetsBlox & evaluate on the entire dataset
3. DT Classifier: Understand the algorithm for automating data for “best split” ie lowest entropy (Pseudocode)
4. DT Classifier: Explore the code for automating data for “best split” ie lowest entropy (Parson’s Puzzle)

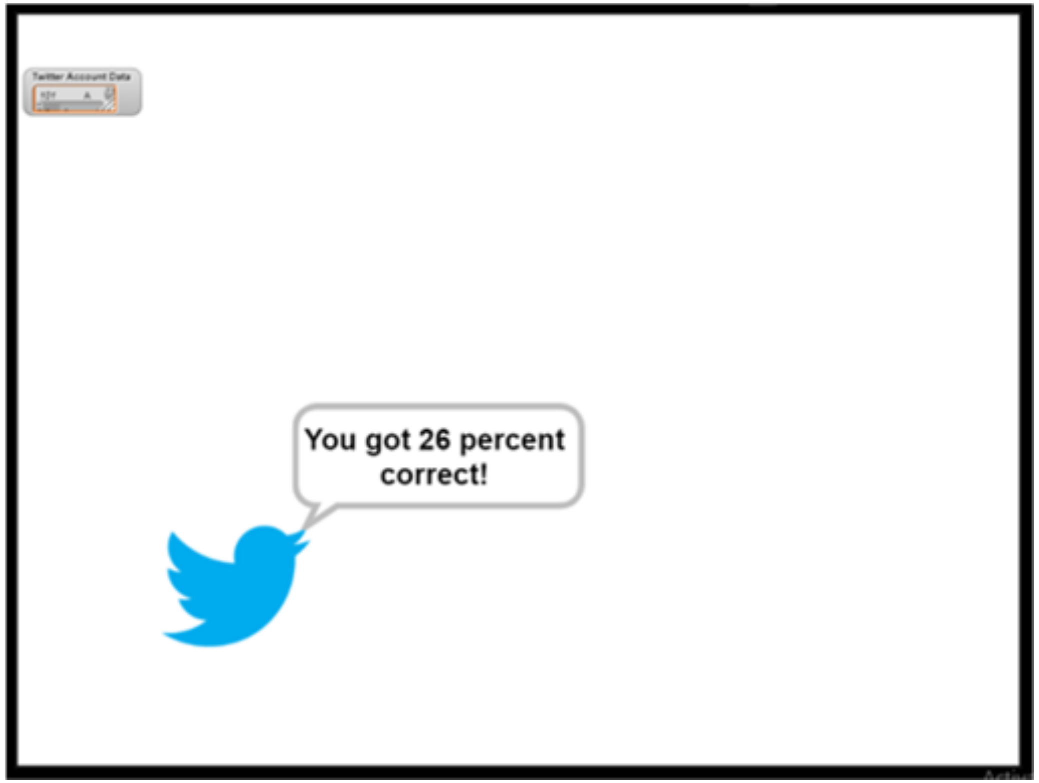

AI and ML_Twitter Classifier
CODAP
Untitled Document
UNSAVED
Twitter Data
How Many Followers
How many Following
Tweets
BOT?
Close


In this activity, we will be trying to classify Twitter accounts as bots or not using a synthetic dataset. First, we will create variables for the account features and labels from the original table.
set labels to map item last of over Twitter Accounts
set account features to map all but last of over Twitter Accounts
Next, we will import the data into CODAP so we can easily explore the dataset!
import Twitter Accounts into CODAP with column names: Twitter Account Fields
show CODAP
Can you write code that will classify the accounts correctly? Edit the "classify account" block below to give it a try!
This first data point should be classified as a bot.
classify account item 1 of account features
item 1 of labels


Use the following script to evaluate your classification block on the entire dataset!
The script will return a number between 0 and 1 representing the fraction of correct labels. 0 means every point was incorrect and 1 means the model had a perfect score!
script variables features label
set incorrect to list
for each account in Twitter Accounts
set label to item last of account
set features to all but last of account
if not classify account features = label
add account to incorrect
import incorrect into CODAP with column names: Twitter Account Fields
report 1 − length of incorrect / length of Twitter Accounts

Twitter Bot Detection Using a Rule-Based Classifier





Students create a classifier to classify twitter accounts as Bot or Not

Decision Tree Building Algorithm

set *possible branches* to all ways to split the data

for each *possible branch*:

set *improvement* to the decrease in entropy using this branch

if *improvement* > *best improvement* (seen so far):

Save the (best) *improvement*, *branch, data partitions*

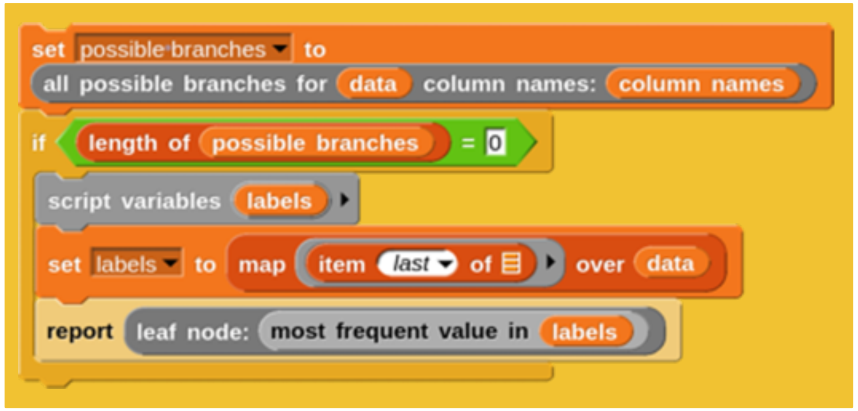
for each data partition created with the best branch:

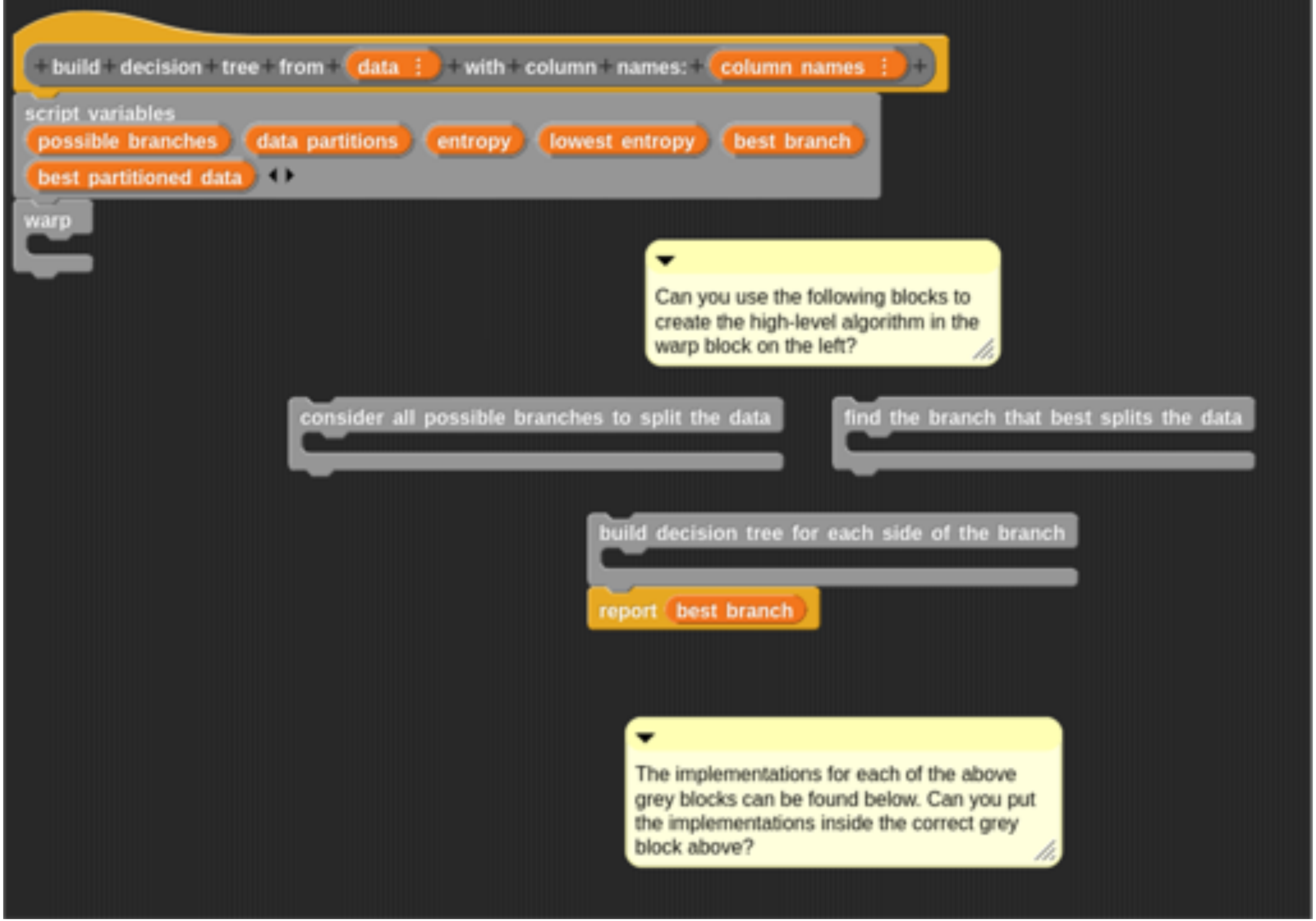
if the points have different labels:

create a new tree from the partition

else:

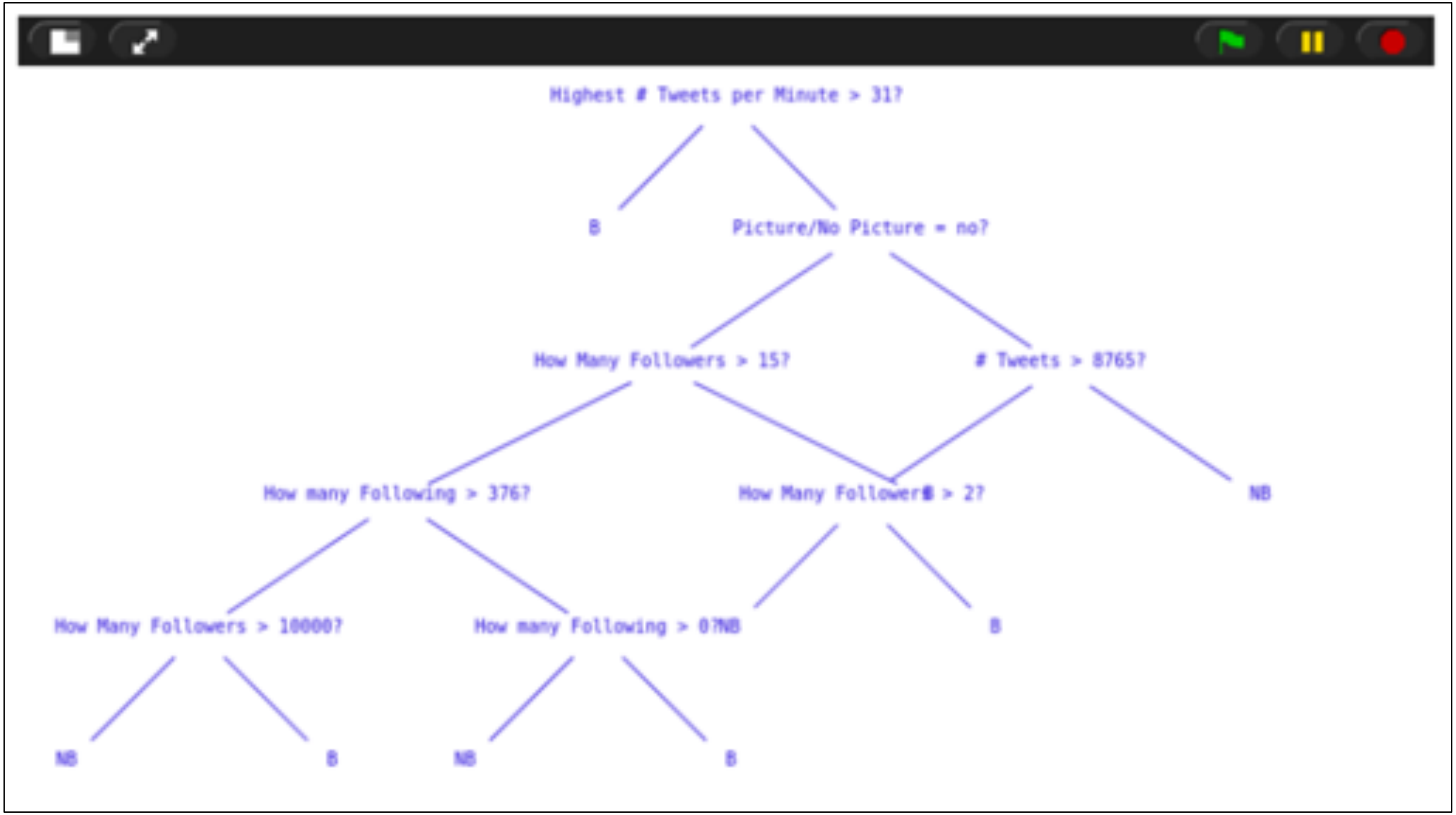
create a leaf node




build decision tree from data with column names: column names
script variables
possible branches
data partitions
entropy
lowest entropy
best branch
best partitioned data
warp
Can you use the following blocks to create the high-level algorithm in the warp block on the left?
consider all possible branches to split the data
find the branch that best splits the data
build decision tree for each side of the branch
report best branch
The implementations for each of the above grey blocks can be found below. Can you put the implementations inside the correct grey block above?

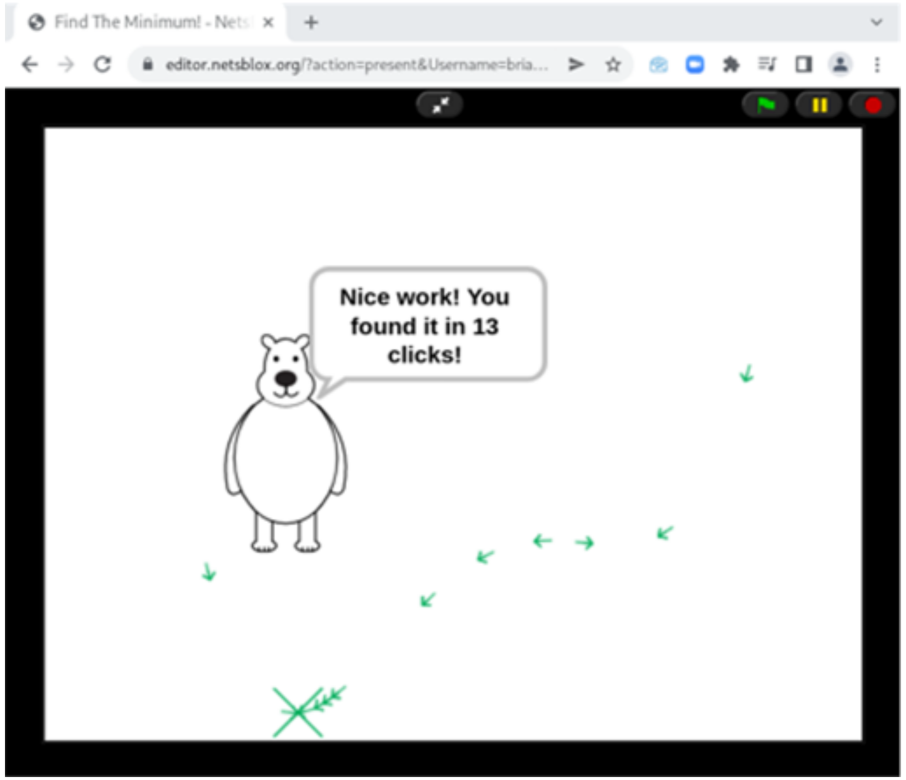

The implementations for each of the above grey blocks can be found below. Can you put the implementations inside the correct grey block above?
set lowest entropy to 1
for each branch in possible branches
set data partitions to split data with branch: branch
set entropy to average entropy input list: data partitions
if entropy < lowest entropy
set lowest entropy to entropy
set best branch to branch
set best partitioned data to data partitions
set possible branches to
all possible branches for data column names: column names
script variables branch sides
set branch sides to
do build decision tree from with column names: column names
best partitioned data
set sides of branch: best branch to branch sides
Nice work making it this far! There are two more

Adversarial Thinking: How Can The Model Be Fooled?



Example Sequence: **Optimization** using Gradient Descent & Registration Bot Classification

- Introduced using the "Find the Minimum" game
- The student is trying to find the minimum of an invisible function
- When the user clicks on the screen, the point of the function is shown to the user along with the gradient
- Functions increase in complexity as game progresses
- Discussion topics following the activity include:
  - What would the minimum represent if the function was concert ticket prices over time? Or something else?
  - What if it was the error of a machine learning model?



Example Sequence: Optimization + Bot Classification

- Given data collected from humans and bots while registering for a website, can we train a model to detect bots?
- Explore the data in CODAP
- Discuss a simple way we could try to predict if it is a bot (logistic regression)
- Can we “tweak” the unknowns (weights) of the model like in the “Find the Minimum” game?

Putting it all together!

Repeat many times:
- Determine what to tweak/optimize (enable gradients for them)
- For each data point:
  - make a prediction
    - multiply the features by their weights (and sum them)
    - compute the sigmoid of the above value
  - compute the error (loss) of the prediction
  - tweak the weights a small amount using the gradients

COMMUNICATIONS OF THE ACM

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Home / Blogs / BLOG@CACM / AI Education for Teens: Lifting the Hood on Data and... / Full Text

BLOG@CACM

AI Education for Teens: Lifting the Hood on Data and Machine Learning

By Shuchi Grover and Brian Broll
November 23, 2021
Comments

MORE NEWS & OPINIONS
Is A.I. the Future of Test Prep?

https://cacm.acm.org/blogs/blog-cacm/256999-ai-education-for-teens-lifting-the-hood-on-data-and-machine-learning/

Beyond Black-Boxes: Teaching Complex Machine Learning Ideas through Scaffolded Interactive Activities

Brian Broll[1] and Shuchi Grover[2]
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EAAI "AI Education in K-12" Conference 2023

Cybersecurity Education in the Age of AI: Integrating AI Learning into Cybersecurity High School Curricula

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ACM SIGCSE 2023

CS Frontiers

- Website: csfrontiers.org
- Curriculum: csfrontiers.org/curriculum
- Intro to CSF & Distributed Computing video
- AI/ML Module

AI & Cybersecurity for Teens (ACT)

- Website: cyberai4k12.org
- Curriculum: https://cyberai4k12.github.io/curriculum/
- Resources: https://github.com/cyberai4k12/awesome-cyberai4k12

Key Emergent Themes & Outcomes

What we should be teaching in schools about AI

Data Primacy/Agency & 'CT 2.0'

Importance of ethics, bias, and critical examination of AI

Pedagogies & instructional approaches

Ways to integrate AI into other subjects

Curricular co-design processes & teacher preparation

+ A plethora of free curricular resources

Plethora of freely available activities, interactives, tools, curricula,…
(See the growing resource list on AI4k12.org)

Challenges & Tensions

My Recommendations for K-12 AI Ed

Build on lessons from K-12 CS Education (pedagogies, equity, teacher prep, …)

Integrate into/with core school subjects

Dovetail CS Education & AI Education

Focus on building an empirical base for age-appropriate progressions and pedagogies.

Why K-12 AI Ed? (aka AI & the coming tsunami!)

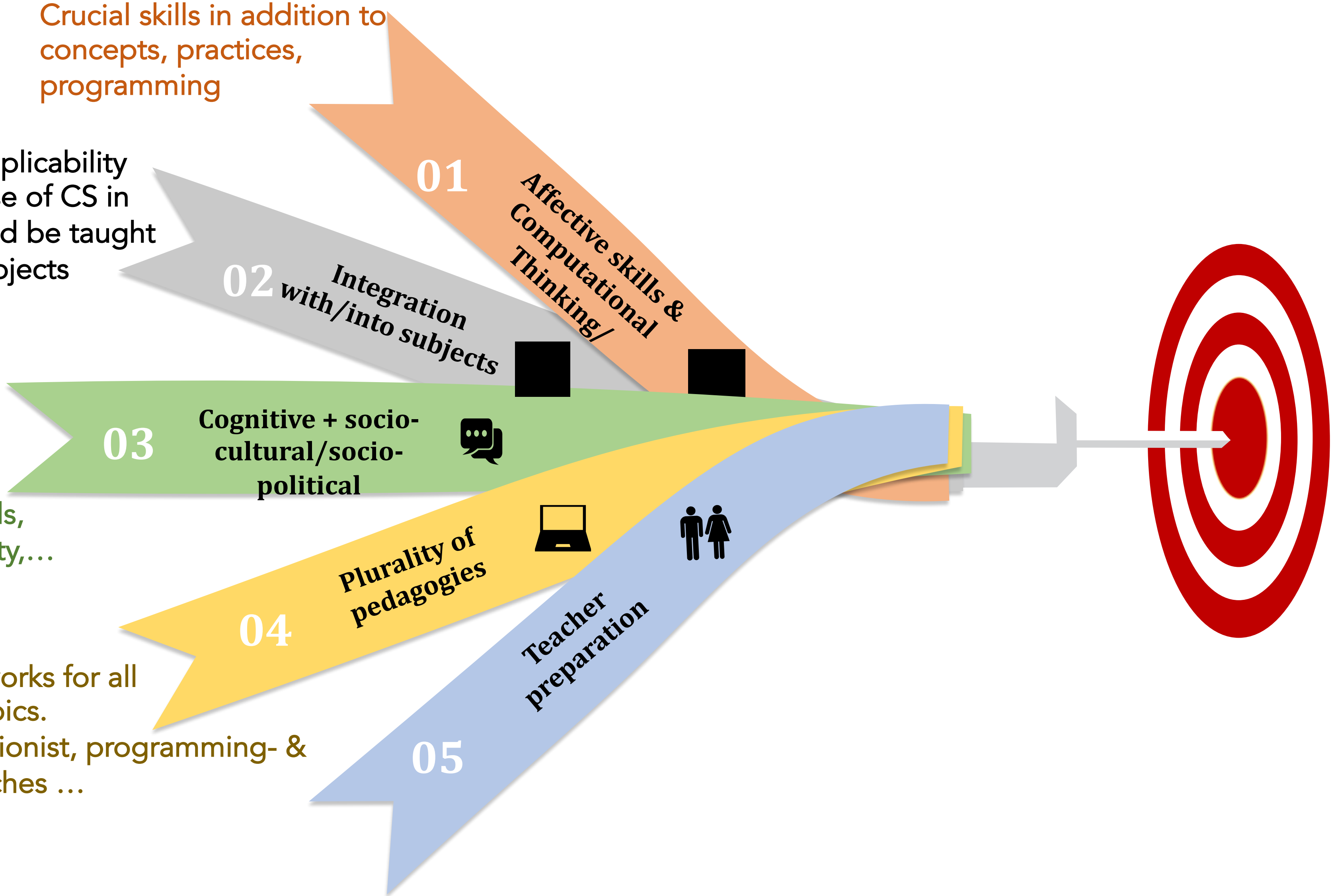
State of AI education in K-12

Lessons from K-12 CS Ed

Challenges, open issues,& recommendations

Crucial skills in addition to concepts, practices, programming

For students to see applicability and understand the use of CS in the real-world, it should be taught in conjunction with subjects



COMPUTER SCIENCE FOR ALL

Attend to conceptual learning through the cognitive & affective-- leveraging backgrounds, connections, community,…

No single approach works for all contexts, learners, topics. Unplugged, constructionist, programming- & game-based, approaches …

No effort to introduce CS can succeed without preparing teachers; co-designing; building on their teaching experiences

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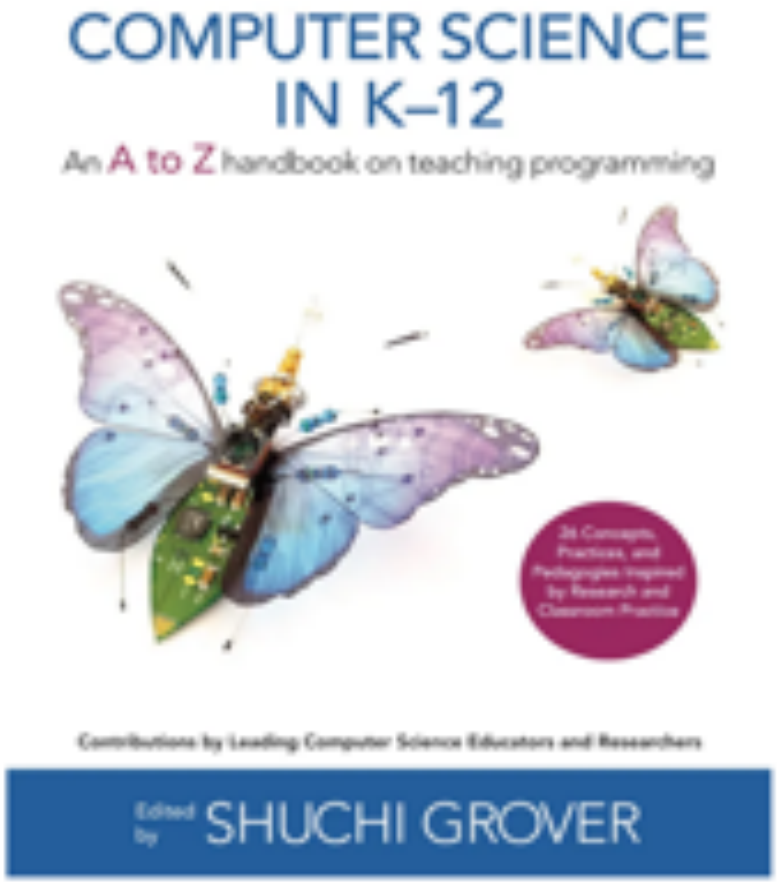
Computer Science in K-12
An A to Z Handbook on teaching programming

Home | Book | Resources | Testimonials | Contact | BUY NOW

csa2z.com



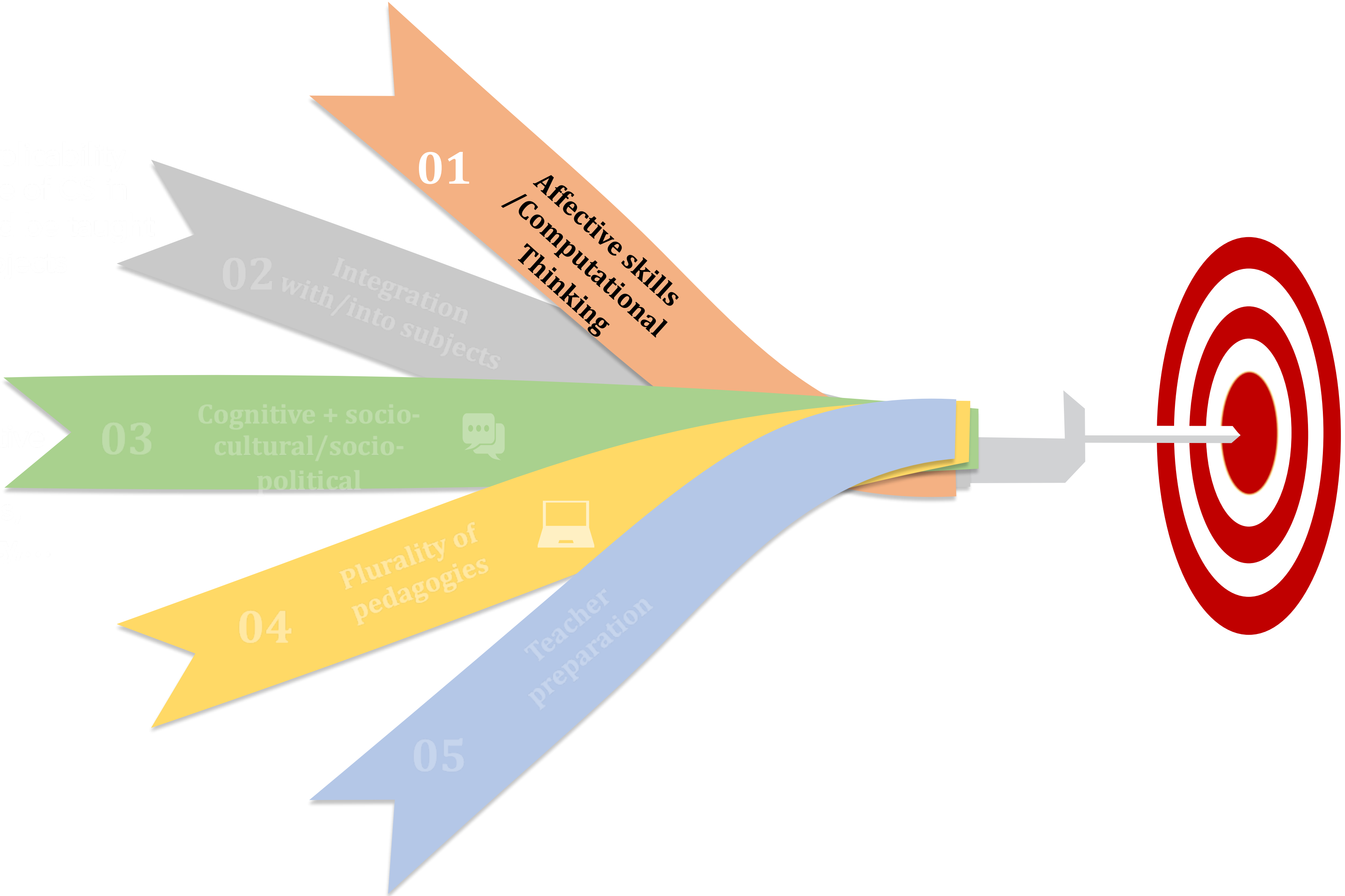
Computer Science in K-12

An A to Z handbook on teaching programming

Coding teaches our students the essence of logical thinking and problem solving while also preparing them for a world in which computing is becoming increasingly pervasive. While there's excitement and enthusiasm about programming becoming an intrinsic part of K-12 curricula the world over, there's also growing anxiety about preparing teachers to teach effectively at all grade levels.

This book strives to be an enduring, practical guide for every K-12 CS teacher anywhere who is either teaching or planning to teach programming at any level. To this end, readers will discover:

- An A-to-Z organization that affords comprehensive insight into teaching introductory programming
- 26 chapters that cover foundational concepts, practices and well-researched pedagogies related to teaching introductory programming as an integral part of K-12 computer science. Cumulatively these chapters address the two alient building blocks of effective teaching of introductory programming – ***what content to teach (concepts and practices)*** *and* ***how to teach (pedagogy)***
- Concrete ideas and rich grade-appropriate examples inspired by practice and research for classroom use.
- Perspectives and experiences shared by educators and scholars who are actively practicing and/or examining the teaching of computer science and programming in K-12 classrooms.


01
Affective skills
/Computational
Thinking
02
Integration
with/into subjects
03
Cognitive + socio-
cultural/socio-
political
04
Plurality of
pedagogies
05
Teacher
preparation

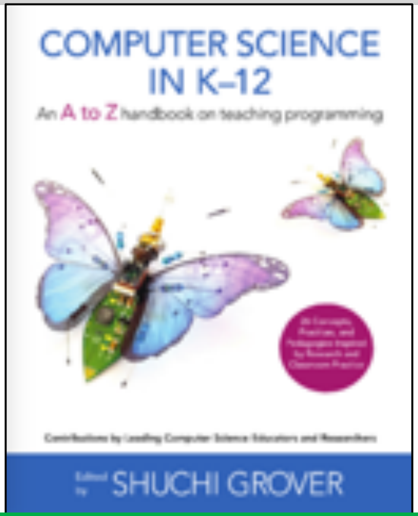
The Concepts and Practices of the K–12 Computer Science Framework

Core Concepts

1. Computing Systems
2. Networks and the Internet
3. Data and Analysis
4. Algorithms and Programming
5. Impacts of Computing

Core Practices

1. Fostering an Inclusive Computing Culture
2. Collaborating Around Computing
3. Recognizing and Defining Computational Problems
4. Developing and Using Abstractions
5. Creating Computational Artifacts
6. Testing and Refining Computational Artifacts
7. Communicating About Computing



Knowledge, Skills, Attitudes, and Beliefs: Learning Goals for Introductory Programming

CHAPTER 11

Rebecca Vivian, Shuchi Grover & Katrina Falkner

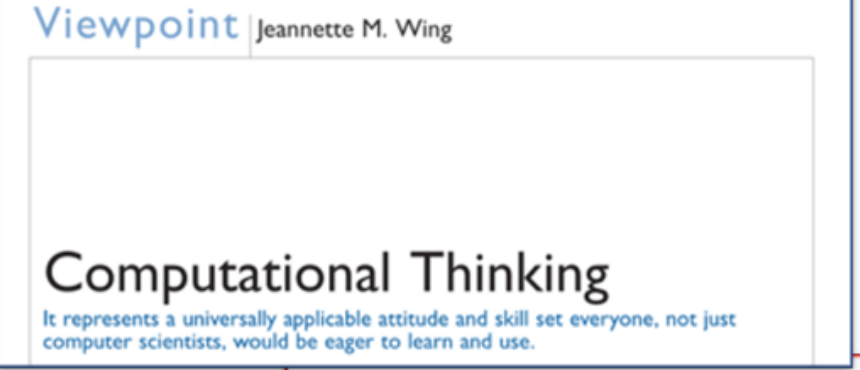
Educating the mind without educating the heart is no education at all
- Aristotle

INTRODUCTION

Learning computer programming can be a nuanced experience. It can empower learners as much as it can challenge their self-beliefs and their perceptions of computing. A key goal of 21st century education is to help learners build not just knowledge about new concepts, skills, and practices but also ways of thinking, interests and identities, and beliefs and skills to succeed in this connected, technology-infused world. This is true of teaching computing as well.

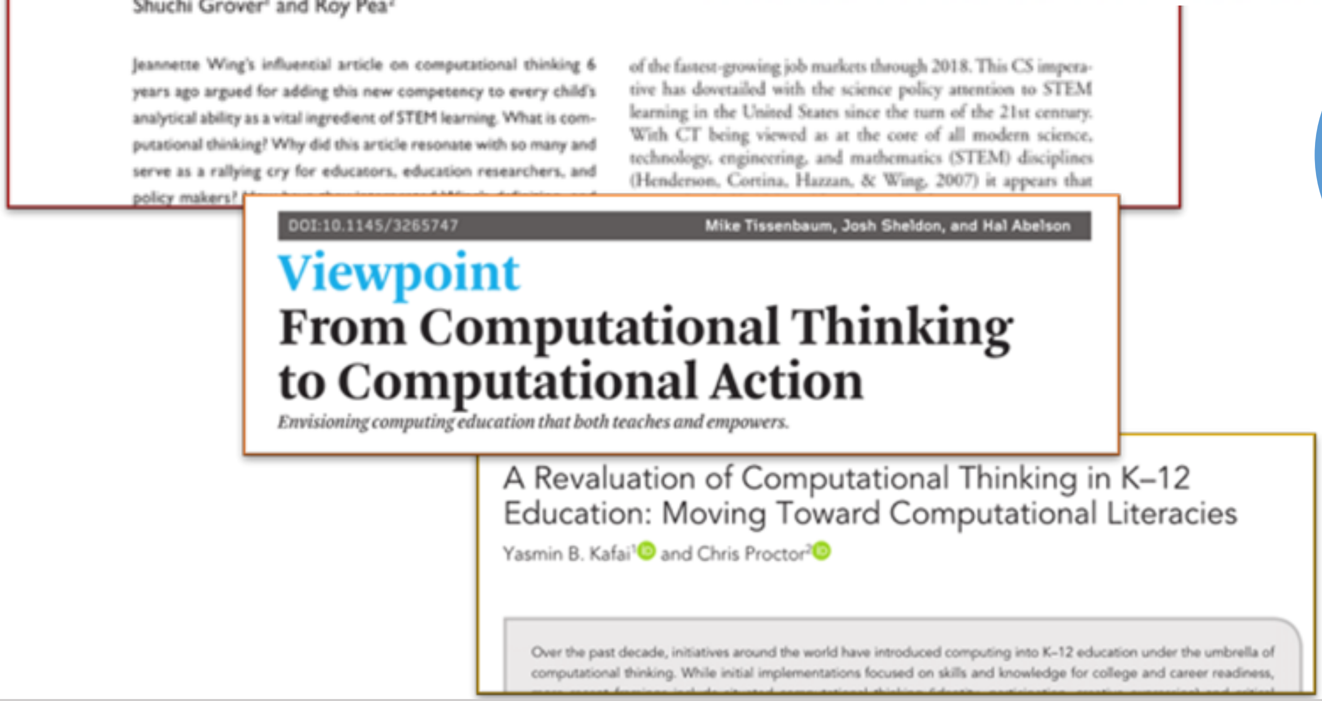
This chapter outlines key knowledge and skills as well as positive attitudes, beliefs, and mindsets related to learning programming. We also unpack practical learning and teaching strategies. The overarching goal is to build teacher capacity and confidence that can support students in flourishing as confident learners with increased interest and agency in the learning process. Ensuring students have the necessary problem-solving and self-regulatory learning skills to design, build, and test programming solutions supports the development of resilient learners who also recognize that taking

Figure 1. Deeper learning calls for attending to cognitive, interpersonal, and intrapersonal skills to prepare K-12 students for college and beyond.


Viewpoint | Jeannette M. Wing

Computational Thinking

It represents a universally applicable attitude and skill set everyone, not just computer scientists, would be eager to learn and use.


Computational Thinking in K–12:
A Review of the State of the Fiel

Shuchi Grover[1] and Roy Pea[2]

Jeannette Wing's influential article on computational thinking 6 years ago argued for adding this new competency to every child's analytical ability as a vital ingredient of STEM learning. What is computational thinking? Why did this article resonate with so many and serve as a rallying cry for educators, education researchers, and policy makers?

of the fastest-growing job markets through 2018. This CS imperative has dovetailed with the science policy attention to STEM learning in the United States since the turn of the 21st century. With CT being viewed as at the core of all modern science, technology, engineering, and mathematics (STEM) disciplines (Henderson, Cortina, Hazzan, & Wing, 2007) it appears that

DOI:10.1145/3265747 Mike Tissenbaum, Josh Sheldon, and Hal Abelson

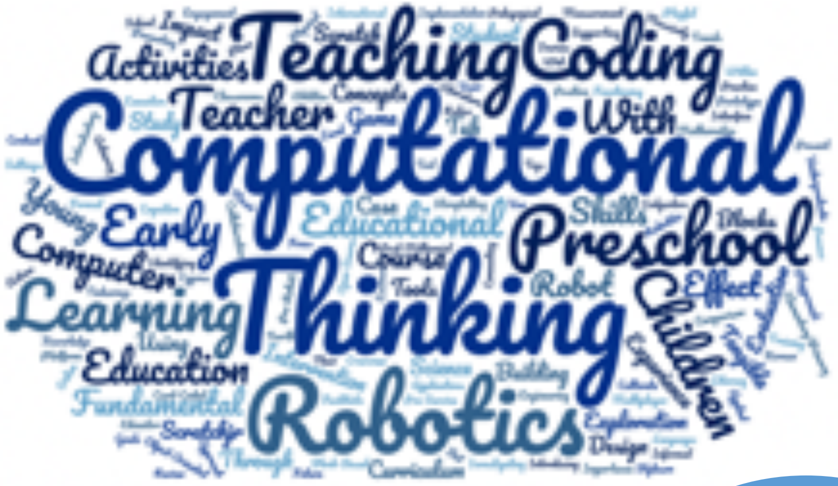
Viewpoint
From Computational Thinking to Computational Action

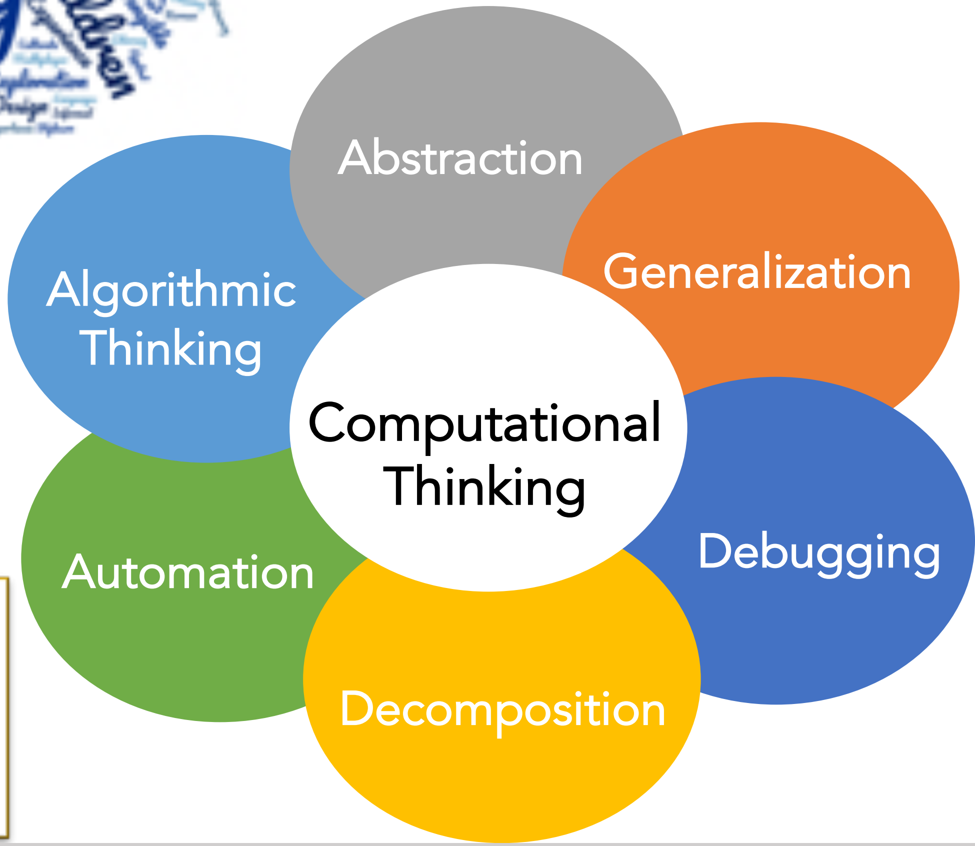
Envisioning computing education that both teaches and empowers.

A Revaluation of Computational Thinking in K–12 Education: Moving Toward Computational Literacies

Yasmin B. Kafai[1] and Chris Proctor[2]

Over the past decade, initiatives around the world have introduced computing into K-12 education under the umbrella of computational thinking. While initial implementations focused on skills and knowledge for college and career readiness,



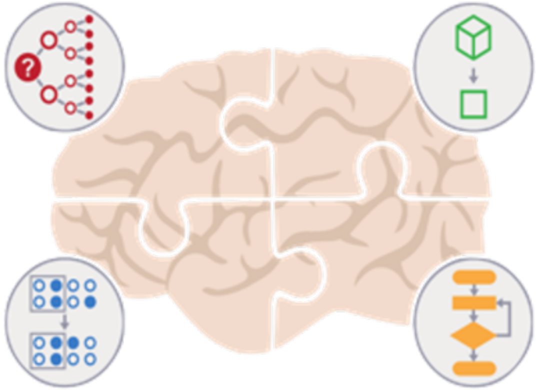


The practice of CS involves learning of problem-solving skills (in addition to core disciplinary topics comprising CS) that transcend programming languages and help learners engage with and apply computing in multiple subjects, domains, and situations

BLOG@CACM

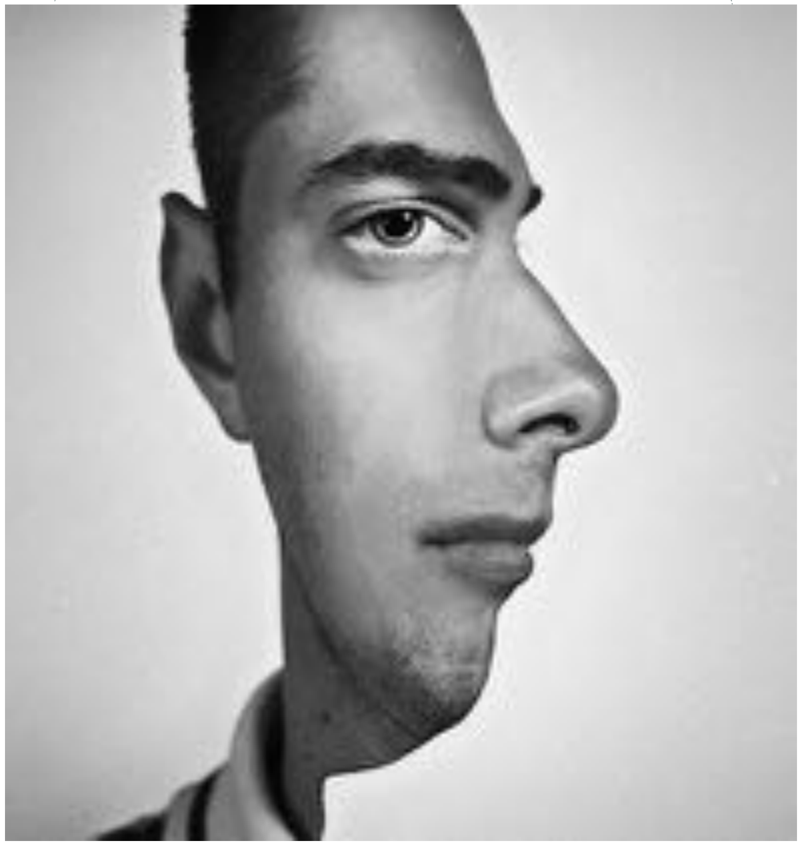
A Tale of Two CTs (and a Revised Timeline for Computational Thinking)

By Shuchi Grover
November 5, 2018



CT for CS

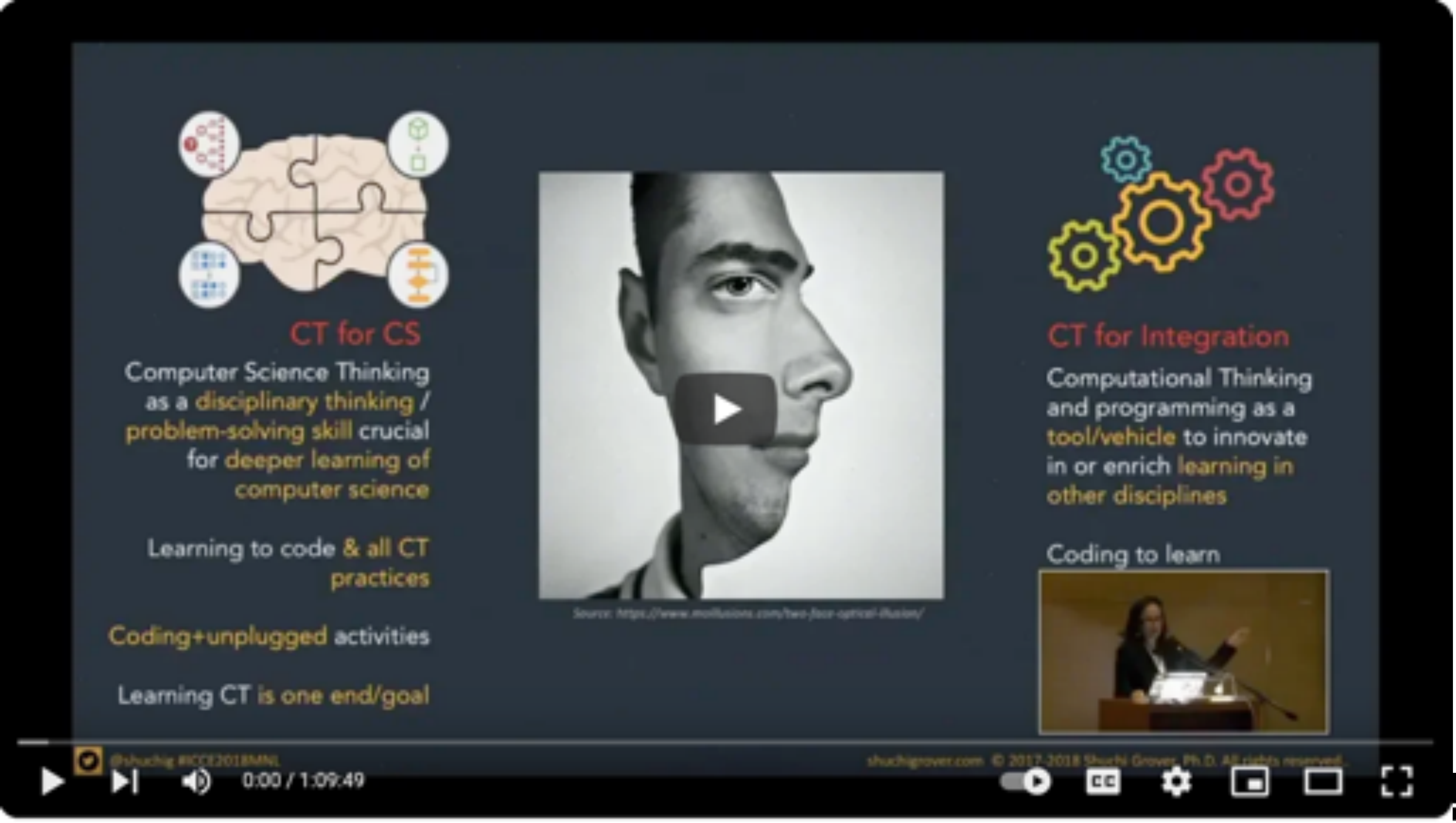
Computational Thinking (or CS Thinking) as a disciplinary thinking / problem-solving skill crucial for deeper learning of computer science



Source: https://www.moillusions.com/two-face-optical-illusion/

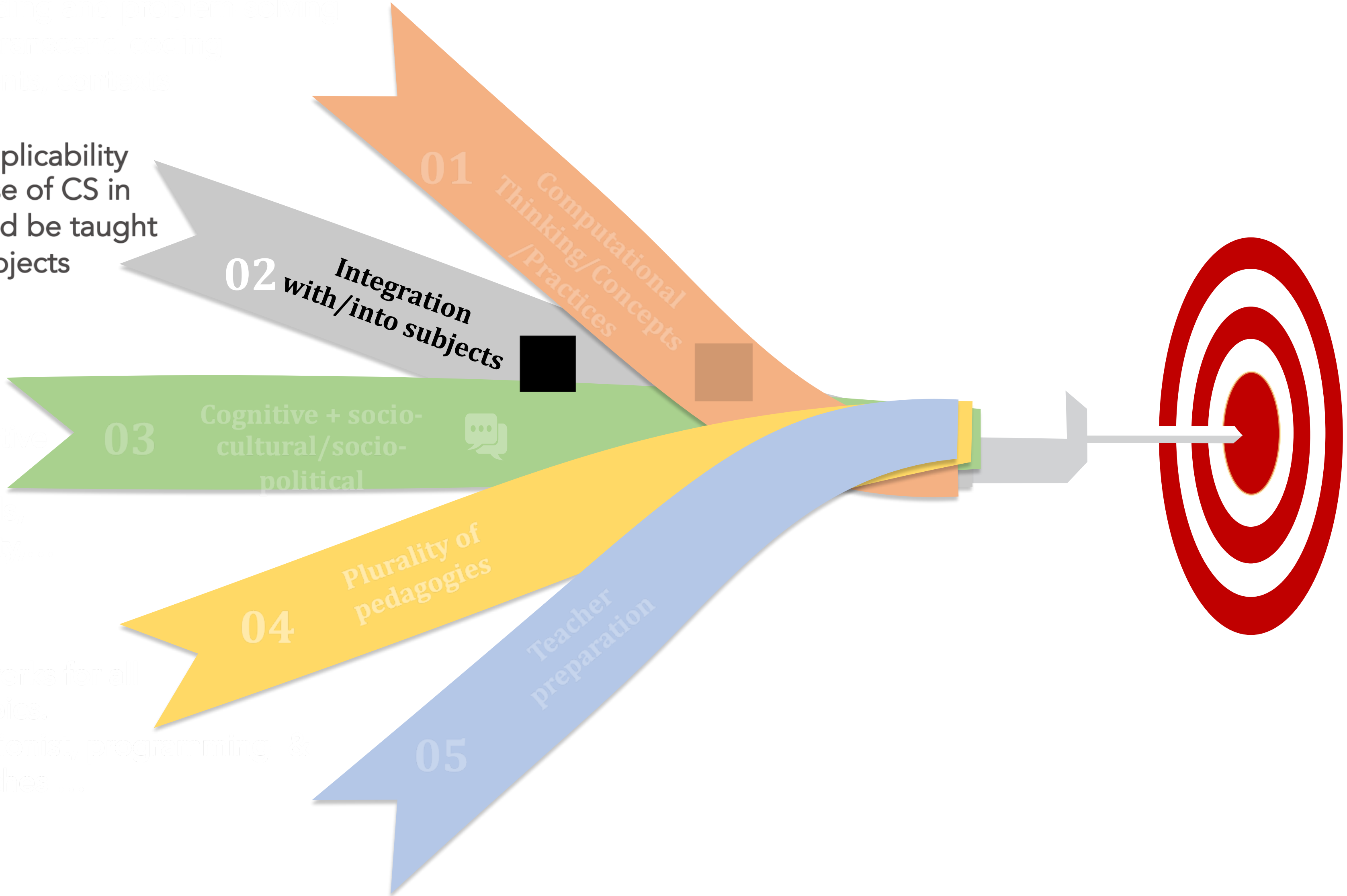
CT for Integration

Computational Thinking and programming as a tool or means to innovate in or enrich learning in other disciplines



Thinking About Computational Thinking - Dr. Shuchi Grover Keynote, ICCE 2018

For students to see applicability and understand the use of CS in the real-world, it should be taught in conjunction with subjects



Computational Thinking from K-12 Disciplinary Perspectives - 2 Workshop series (NSF)

ICLS2020 Symposium: Integrating STEM and Computing in PK-12: Operationalizing Computational Thinking for STEM Learning and Assessment (Grover et al., 2020)

Special Issue of Journal of Science and Technology Education focused on integration of CT In STEM Disciplines
(Lee, Grover, Martin, Pillai, & Malyn-Smith, 2020)

PISA 2021 Mathematics Framework Expert Group (inclusion of some CT items)

VELA: Exploratory Activities for Computational Concepts in Intro Programming

Synergistic Learning of Physics/Biology & CT through computational model building in C2STEM

Integrating CT into Science & Math activities for pre-K learners in formal/informal settings

CSFrontiers: Engaging Female High School Students in New Frontiers of Computing

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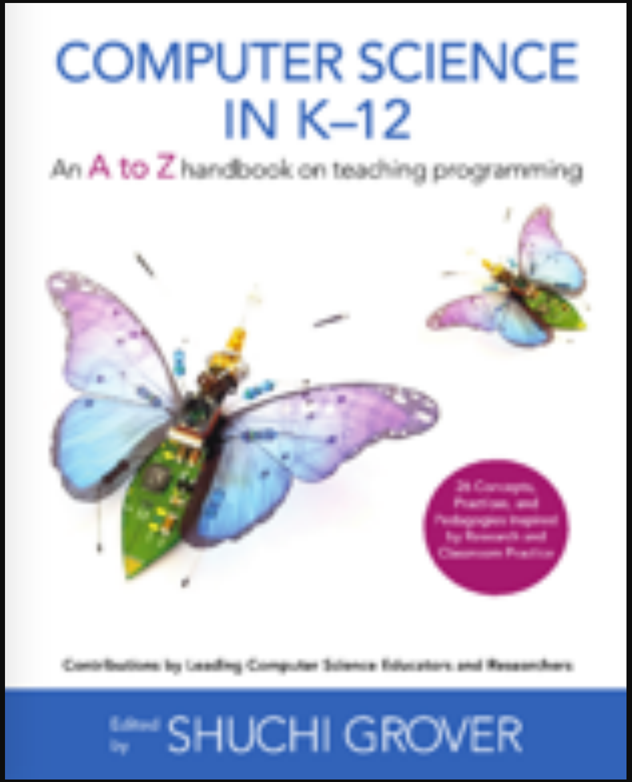
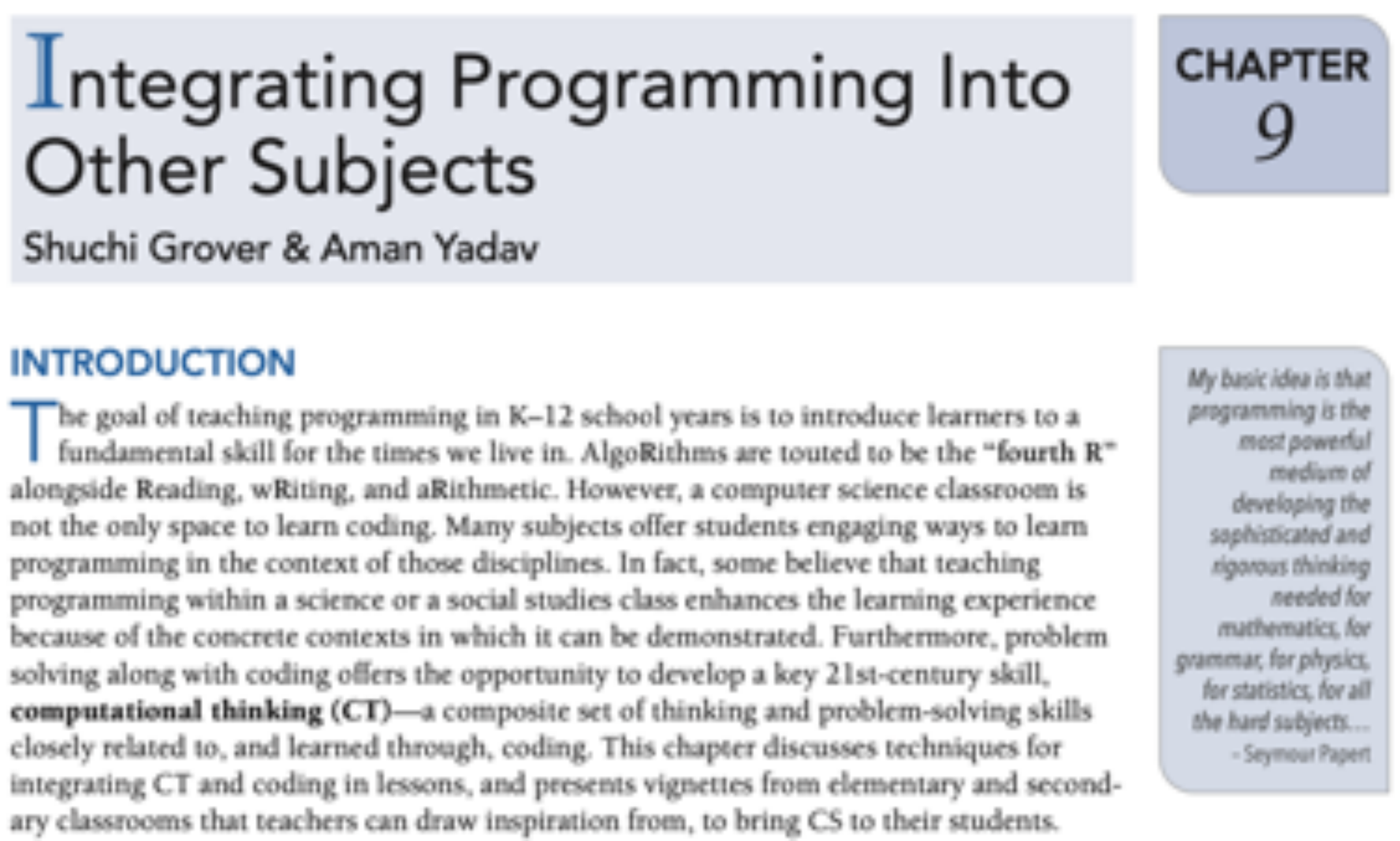


https://csa2z.com/



Integrating Programming Into Other Subjects

CHAPTER 9

Shuchi Grover & Aman Yadav

INTRODUCTION

The goal of teaching programming in K–12 school years is to introduce learners to a fundamental skill for the times we live in. AlgoRithms are touted to be the "**fourth R**" alongside Reading, wRiting, and aRithmetic. However, a computer science classroom is not the only space to learn coding. Many subjects offer students engaging ways to learn programming in the context of those disciplines. In fact, some believe that teaching programming within a science or a social studies class enhances the learning experience because of the concrete contexts in which it can be demonstrated. Furthermore, problem solving along with coding offers the opportunity to develop a key 21st-century skill, **computational thinking** (CT)—a composite set of thinking and problem-solving skills closely related to, and learned through, coding. This chapter discusses techniques for integrating CT and coding in lessons, and presents vignettes from elementary and secondary classrooms that teachers can draw inspiration from, to bring CS to their students.

My basic idea is that programming is the most powerful medium of developing the sophisticated and rigorous thinking needed for mathematics, for grammar, for physics, for statistics, for all the hard subjects....
- Seymour Papert

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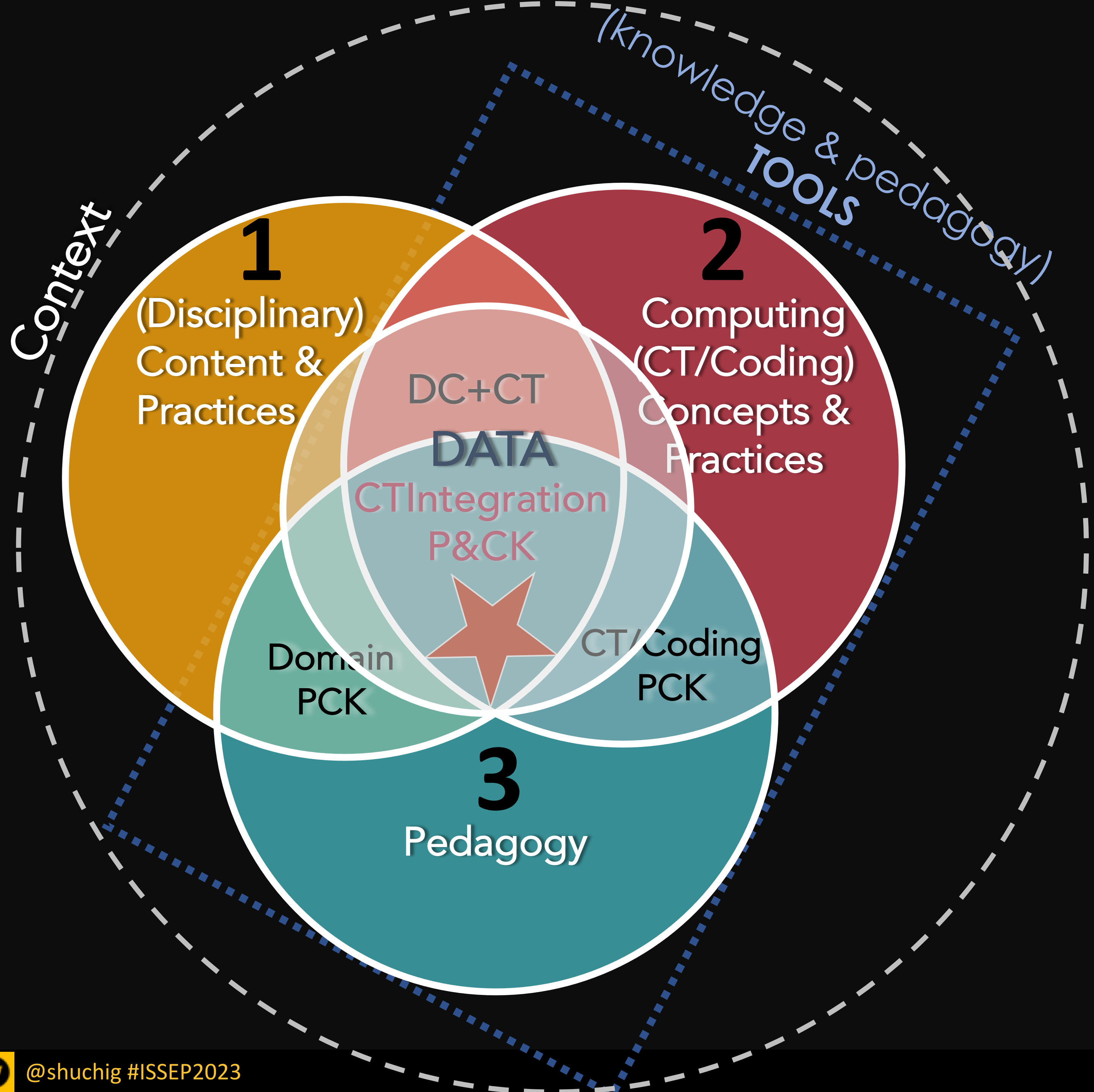
WHY INTEGRATE PROGRAMMING IN OTHER SUBJECTS?

Seymour Papert's pioneering work on using programming in mathematics classrooms in the 1980s laid the foundation for integrating programming into other subjects. Just as meaningful and authentic use of technology tools help enrich learning in the classroom, coding enriches the learning of the host domain. But the benefits of integrating coding in other subjects are bidirectional—integration also helps students learn computing "in context." This is especially true of STEM subjects.

> *Computing and STEM share a deeply symbiotic relationship, and as such, mathematics and science classrooms provide perhaps the most intuitive and easy non-CS contexts for integrating computing. . . . STEM contexts can enrich computational learning while also providing valuable opportunities to embed coding and CT in established and accessible (as well as required) STEM courses.* —Grover and Pea (2018).

Although there has been much focus on teachers' understanding of computational thinking and programming constructs as well as their attitude toward computational thinking ideas, Yadav and colleagues have concluded through their research that CT can also change teachers' disciplinary teaching practice. Foregrounding CT provides teachers with tools and practices they can use to deepen disciplinary learning by providing students with an opportunity to engage in "thinking skills" that are not always explicitly focused on, especially at the elementary level. For example, in the mathematics example discussed later in this chapter, as teachers ask students to draw a triangle in Scratch, they are drawn into thinking about interior and exterior angles. This is because rotating the Scratch sprite requires the use of the exterior angle, even though one might intuitively use the interior angle. It provides an opportunity for the students to dive deeper into geometrical ideas that



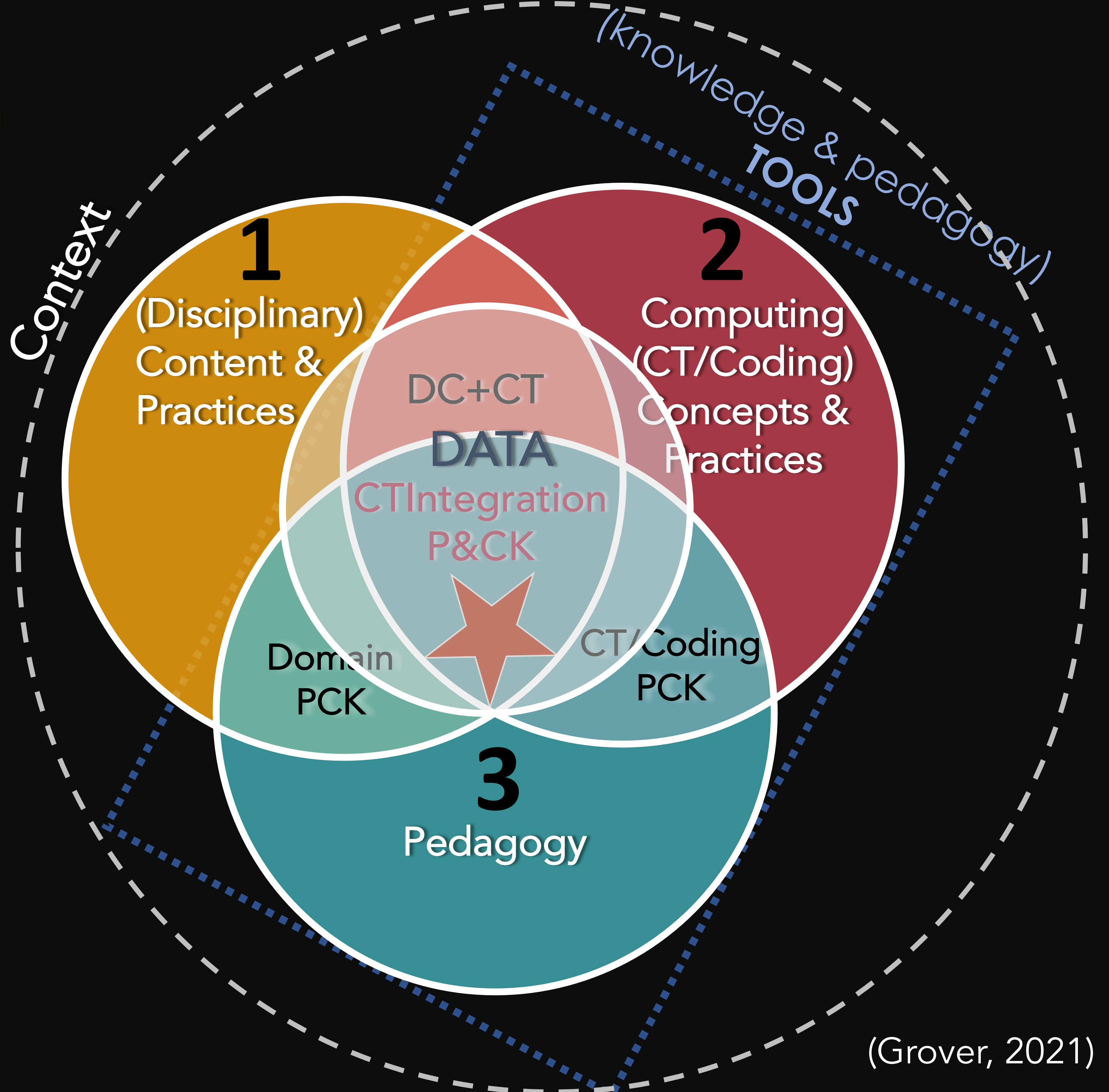
CTIntegration:

A FRAMEWORK FOR DESIGNING FOR AND ANALYZING THE INTERCONNECTED ELEMENTS OF CT INTEGRATION INTO OTHER DOMAINS

Grover, S. (2021). 'CTIntegration': A Conceptual Framework Guiding Design and Analysis of Integration of Computing and Computational Thinking Into School Subjects. https://doi.org/10.35542/osf.io/eg8n5

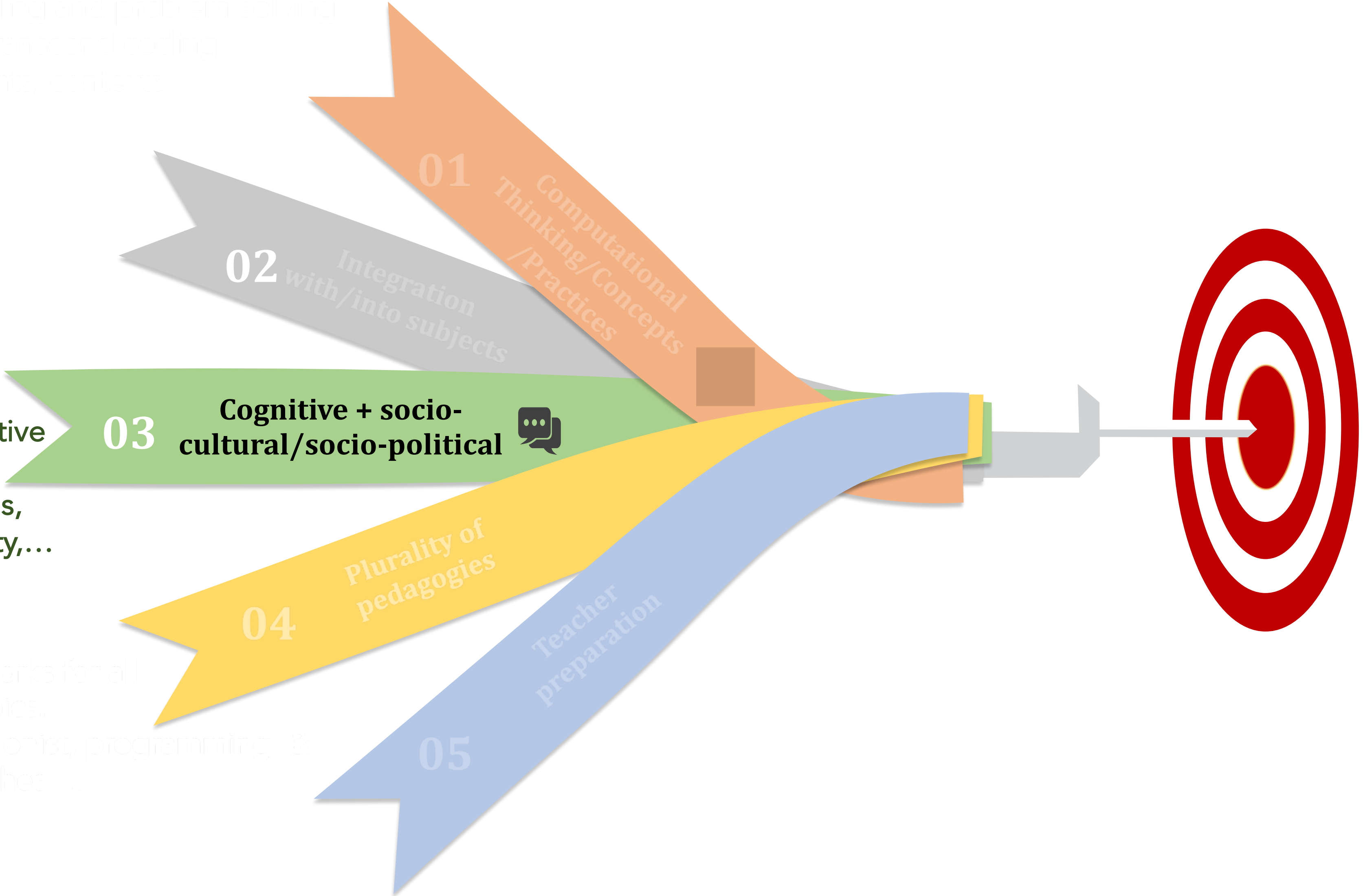
DATA as the linchpin for integrating STEM (& non-STEM) and Computing

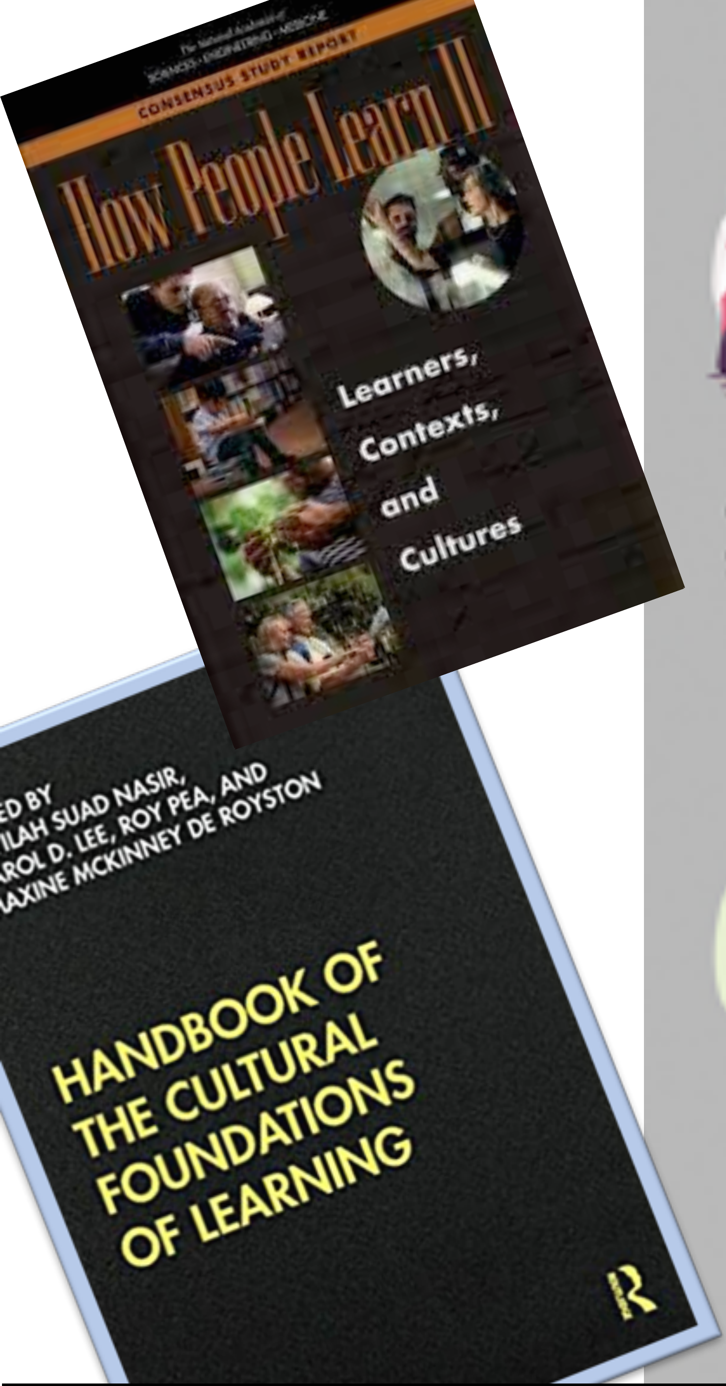
- Data from (or relevant to) the domain and communities
- Answer questions from the domain
  - Critically examine social & scientific phenomena
  - Evidence-based reasoning
  - Recognizing patterns
  - Make predictions
  - Support argumentation
- Data practices
- Data representations & abstractions
- Data analysis tools (spreadsheets, databases, …)

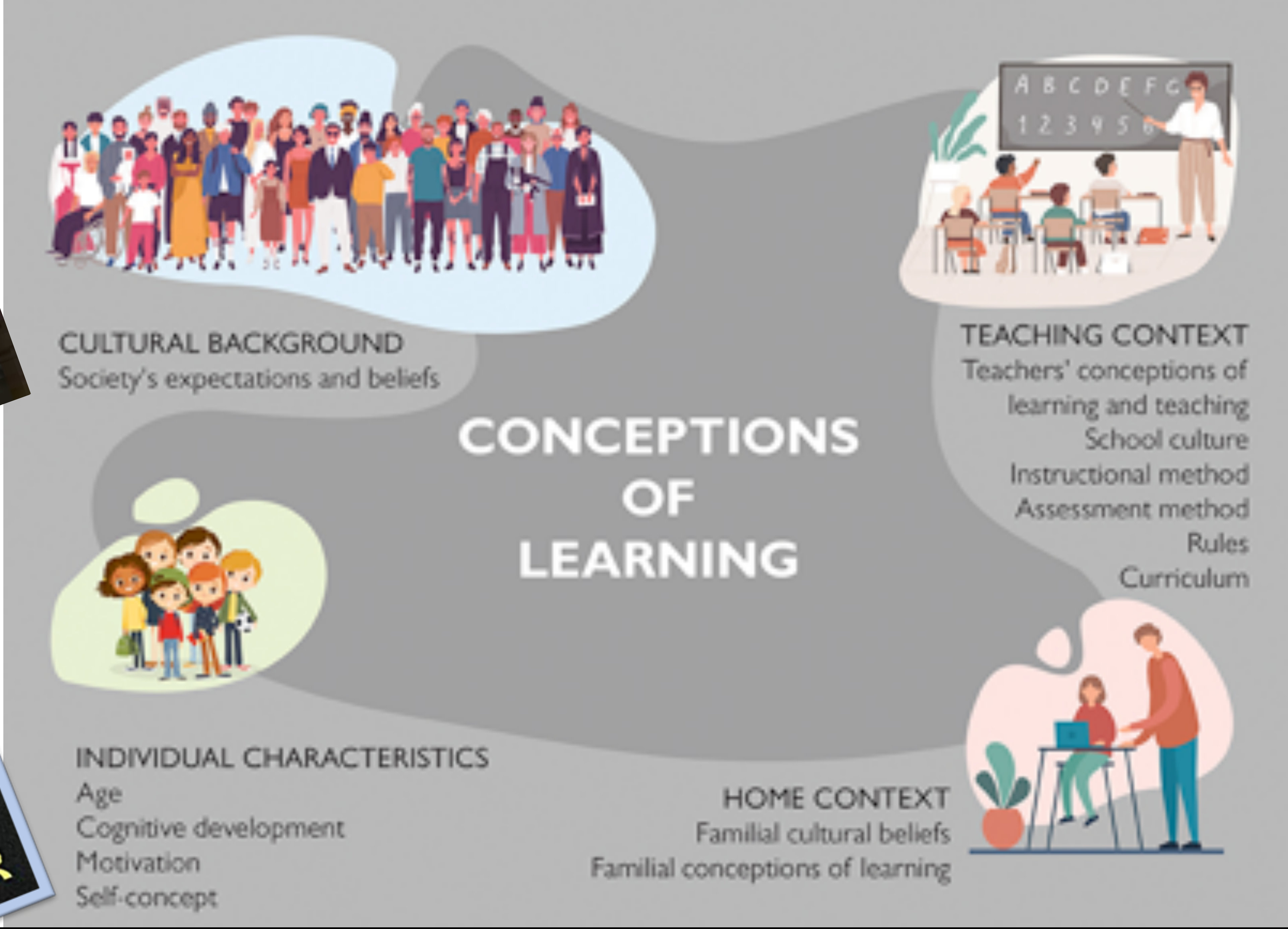


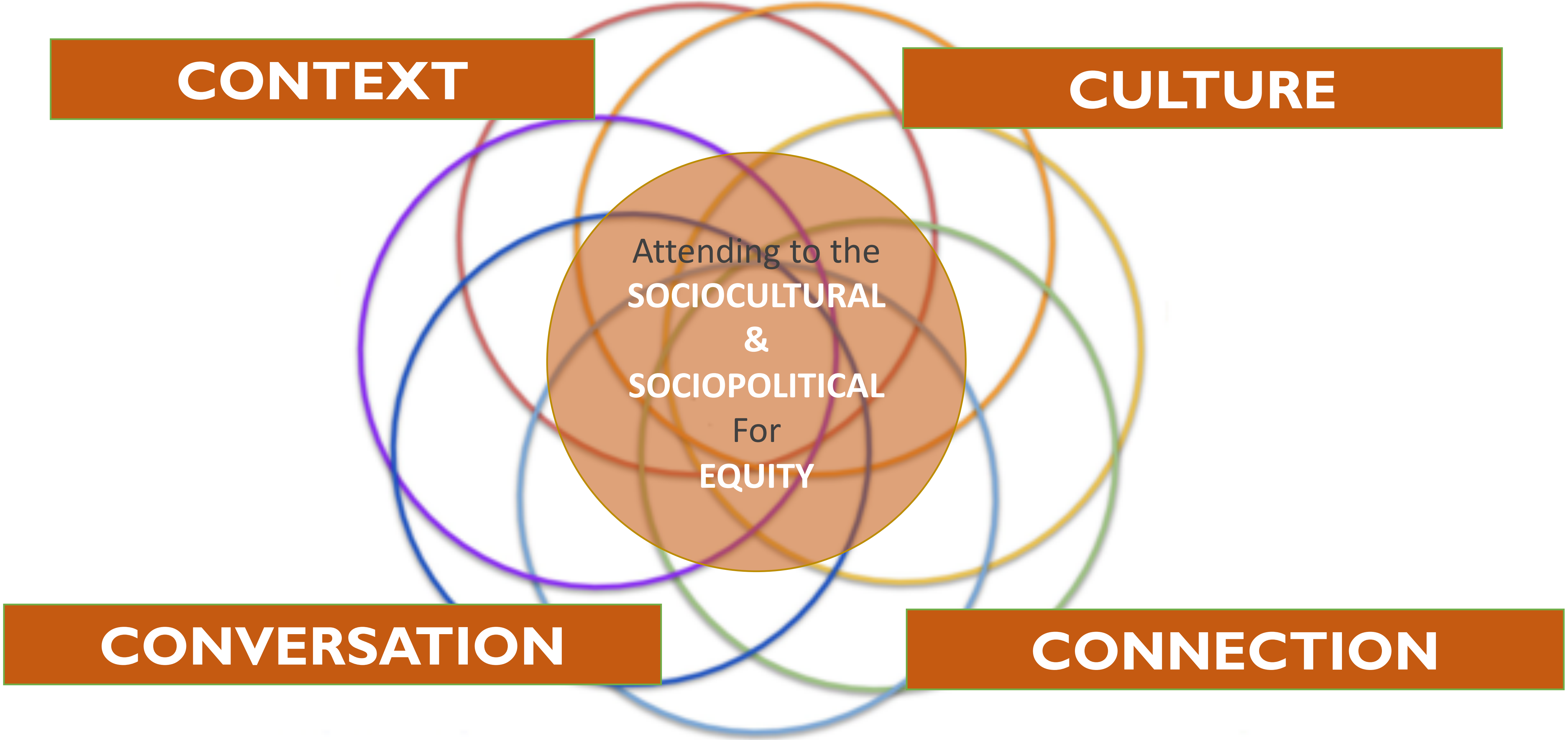
(Grover, 2021)

Attend to conceptual learning through cognitive & non-cognitive-- leveraging backgrounds, connections, community,…




CONSENSUS STUDY REPORT
How People Learn II
Learners, Contexts, and Cultures
HANDBOOK OF THE CULTURAL FOUNDATIONS OF LEARNING


CULTURAL BACKGROUND
Society's expectations and beliefs
TEACHING CONTEXT
Teachers' conceptions of learning and teaching
School culture
Instructional method
Assessment method
Rules
Curriculum
CONCEPTIONS OF LEARNING
INDIVIDUAL CHARACTERISTICS
Age
Cognitive development
Motivation
Self-concept
HOME CONTEXT
Familial cultural beliefs
Familial conceptions of learning


CONTEXT
CULTURE
Attending to the
SOCIOCULTURAL
&
SOCIOPOLITICAL
For
EQUITY
CONVERSATION
CONNECTION

Learner-Centered and Culturally Relevant Pedagogy

CHAPTER 12

Tia C. Madkins, Jakita O. Thomas, Jessica Solyom,
Joanna Goode, and Frieda McAlear

INTRODUCTION: CULTURALLY RELEVANT PEDAGOGY

Underrepresented minority students (for example, Black, Latinx, Native American/Alaskan, Hawaiian / Pacific Islander in the United States) have historically experienced racial bias and structural inequities both inside and outside of school settings. Educational inequities appear at all levels, from low funding for schools with high proportions of underrepresented students of color to diminished teacher and counselor expectations, tracking students into remedial and special needs programs, and over-referring students to school disciplinary officials. For underrepresented students of color, these practices are an extension of colonial and assimilative educational practices, have led to the development of school-perpetuated (historical) trauma, and contribute to experiencing an education environment that feels irrelevant, hostile, and unwelcoming.

Culturally relevant pedagogy (CRP) was first proposed by Ladson-Billings as well as Allen and Boykin in the 1990s. CRP is founded on the idea that learning grounded in a familiar cultural context can potentially increase equitable outcomes. This framework outlines three tenets for academic success: (1) implementing academic rigor, (2) honoring students' cultural and linguistic backgrounds, and (3) helping students to understand, recognize, and critique social inequities. This mode of teaching also emphasizes an authentically caring rapport between teacher and student and connecting curriculum to students' home cultures and everyday lived experiences.

Promote “computational discourse” and discussions around computing concepts

Encourage conversations about contexts, cultures, connections as they relate to computing (even if it involves confronting uncomfortable truths).

Contextualize CS/programming examples and activities in students’ lives and communities

(e.g., creating the best transportation route for afterschool activities in their community as a way of learning about efficient algorithms).

Make programming accessible by connecting learning to students’ interests, social identities, perspectives, & everyday lives

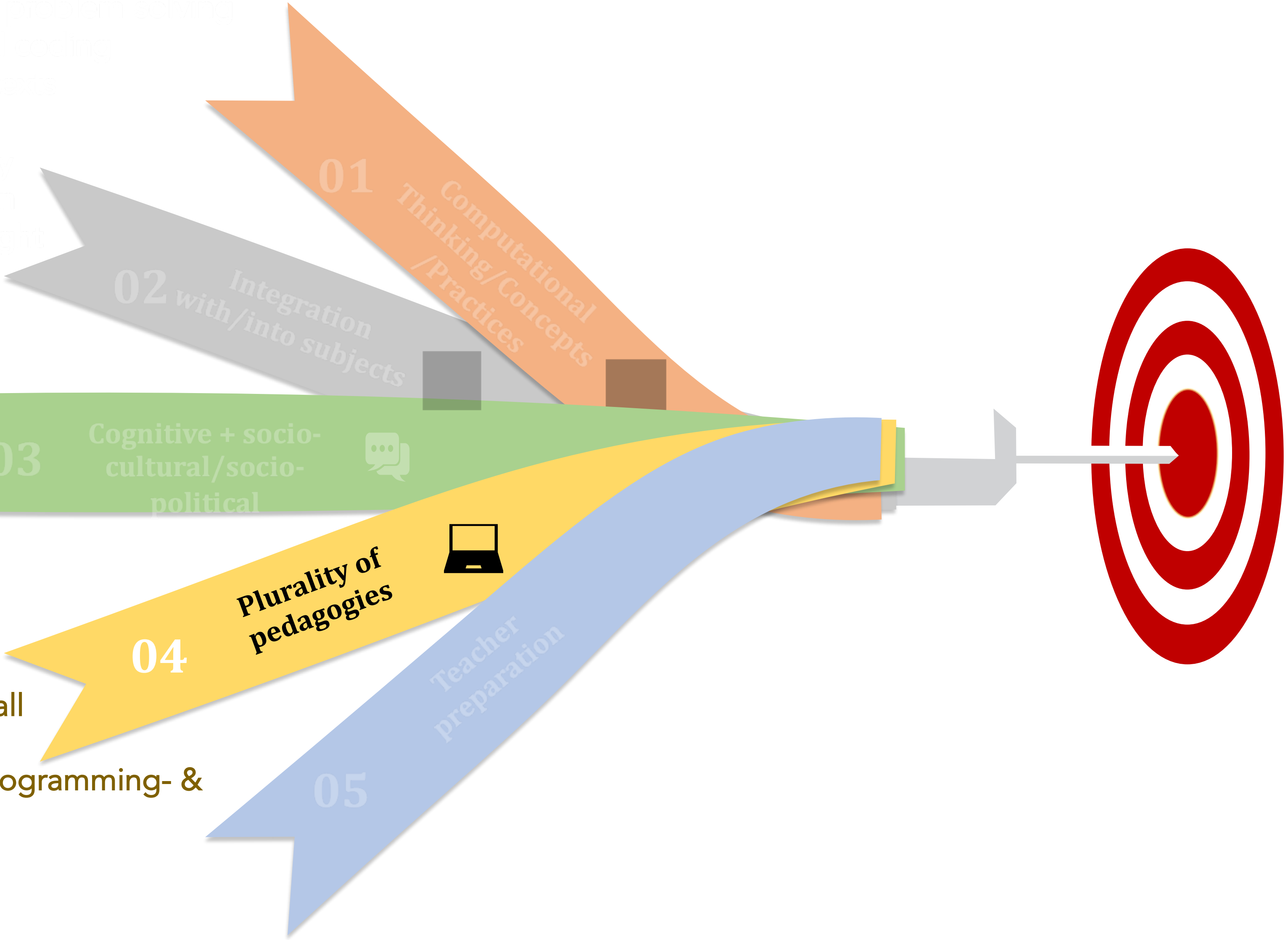
(e.g., inviting a student who skateboards to help introduce a culturally situated design tool about the culture & math of skateboarding)

Draw from students’ cultural assets and knowledge to use as building blocks for examining programming topics

(e.g., using popular music to discuss programming paradigms such as loops and linked lists, or using family recipes to discuss how the same algorithm can be represented in different ways)

Through attention to context, culture and connections, we demonstrate what matters when you teach computing (or AI, or whatever the next new tech is)...

It's always the humans in the equation that matter above all else.



No single approach works for all contexts, learners, topics.
Unplugged, constructionist, programming- & game-based, approaches …

Universal Design for Learning: Reaching All Students
CHAPTER 21
Maya Israel and Todd Lash
INTRODUCTION
UDL: Maximizing Student
Instructional Barriers
Learner-Centered and Culturally Relevant Pedagogy
CHAPTER 12
Tia C. Madkins, Jakita O. Thomas, Jessica Solyom, Joanna Goode, and Frieda McAlear
INTRODUCTION: CULTURALLY RELEVANT PEDAGOGY
CHAPTER 6
Feedback Through Formative Check-ins
Shuchi Grover, Vicky Sedgwick, & Kelly Powers
INTRODUCTION: WHAT AND WHY OF FORMATIVE FEEDBACK?
Integrating Programming Into Other Subjects
CHAPTER 9
Shuchi Grover & Aman Yadav
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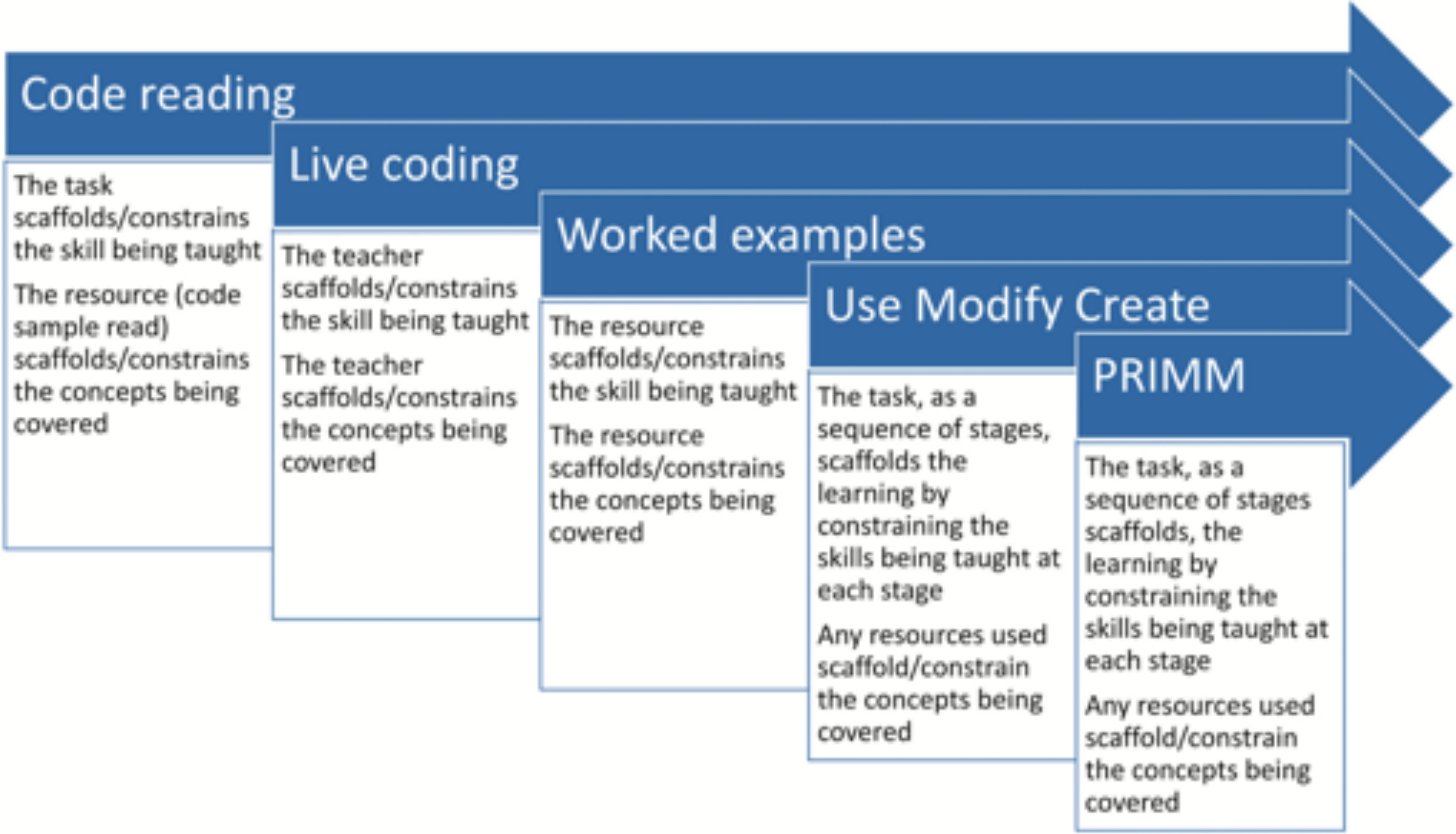
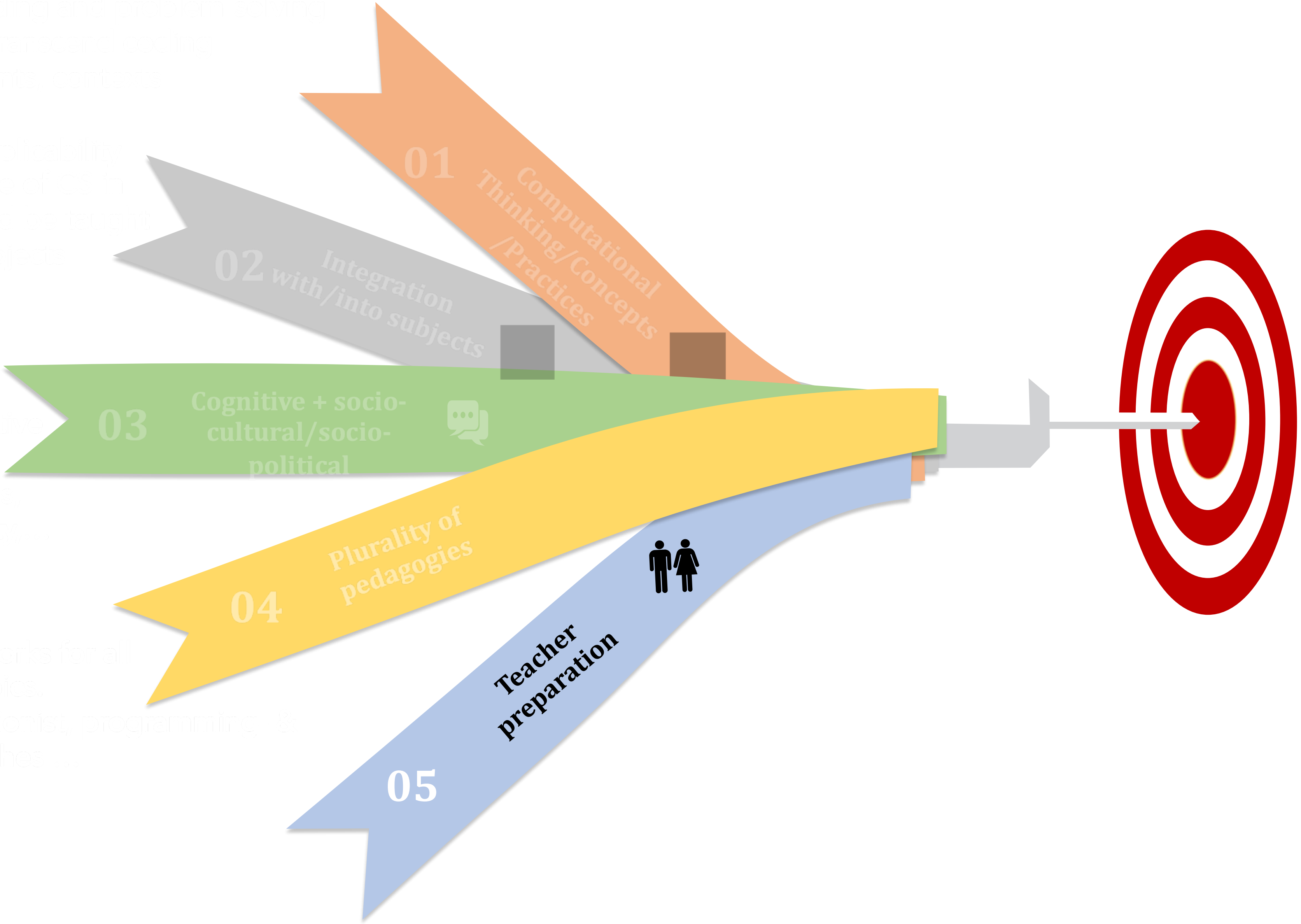
WHY INTEGRATE PROGRAMMING IN OTHER SU
CHAPTER 24
X-ing Boundaries With Physical Computing
Sue Sentance and Katharine Childs
WHAT IS PHYSICAL COMPUTING?
Hard Fun With Hands-On Constructionist Project-Based Learning
CHAPTER 8
Deborah A. Fields and Yasmin B. Kafai
INTRODUCTIO
Guided Exploration Through Unplugged Activities
CHAPTER 7
Paul Curzon & Shuchi Grover
WHAT IS GUIDED EXPLORATION?
CHAPTER 3
Creative Coding
Miles Berry
INTRODUCTION: WHAT IS CREATIVE CODING?
Zestful Learning
CHAPTER 26
Bryan Twarek
INTRODUCTION
CHAPTER 23
Worked Examples & Other Scaffolding Strategies
Jane Waite & Shuchi Grover
INTRODUCTION: THE WHY AND WHAT OF SCAFFOLDING
Why Scaffolding?
Peer Collaboration and Pair Programming
CHAPTER 16
Shannon Campe & Jill Denner
INTRODUCTION
CHAPTER 17
Questions and Inquiry


Code reading
The task scaffolds/constrains the skill being taught
The resource (code sample read) scaffolds/constrains the concepts being covered
Live coding
The teacher scaffolds/constrains the skill being taught
The teacher scaffolds/constrains the concepts being covered
Worked examples
The resource scaffolds/constrains the skill being taught
The resource scaffolds/constrains the concepts being covered
Use Modify Create
The task, as a sequence of stages, scaffolds the learning by constraining the skills being taught at each stage
Any resources used scaffold/constrain the concepts being covered
PRIMM
The task, as a sequence of stages scaffolds, the learning by constraining the skills being taught at each stage
Any resources used scaffold/constrain the concepts being covered


01
Computational Thinking/Concepts /Practices
02
Integration with/into subjects
03
Cognitive + socio-cultural/socio-political
04
Plurality of pedagogies
05
Teacher preparation

CS Education for K-12 students = CS Education for Teachers

Teachers as key stakeholders

Nothing can be accomplished without adequately preparing teachers and addressing their needs

Co-design

The benefits of co-designing curriculum extend to teacher preparation

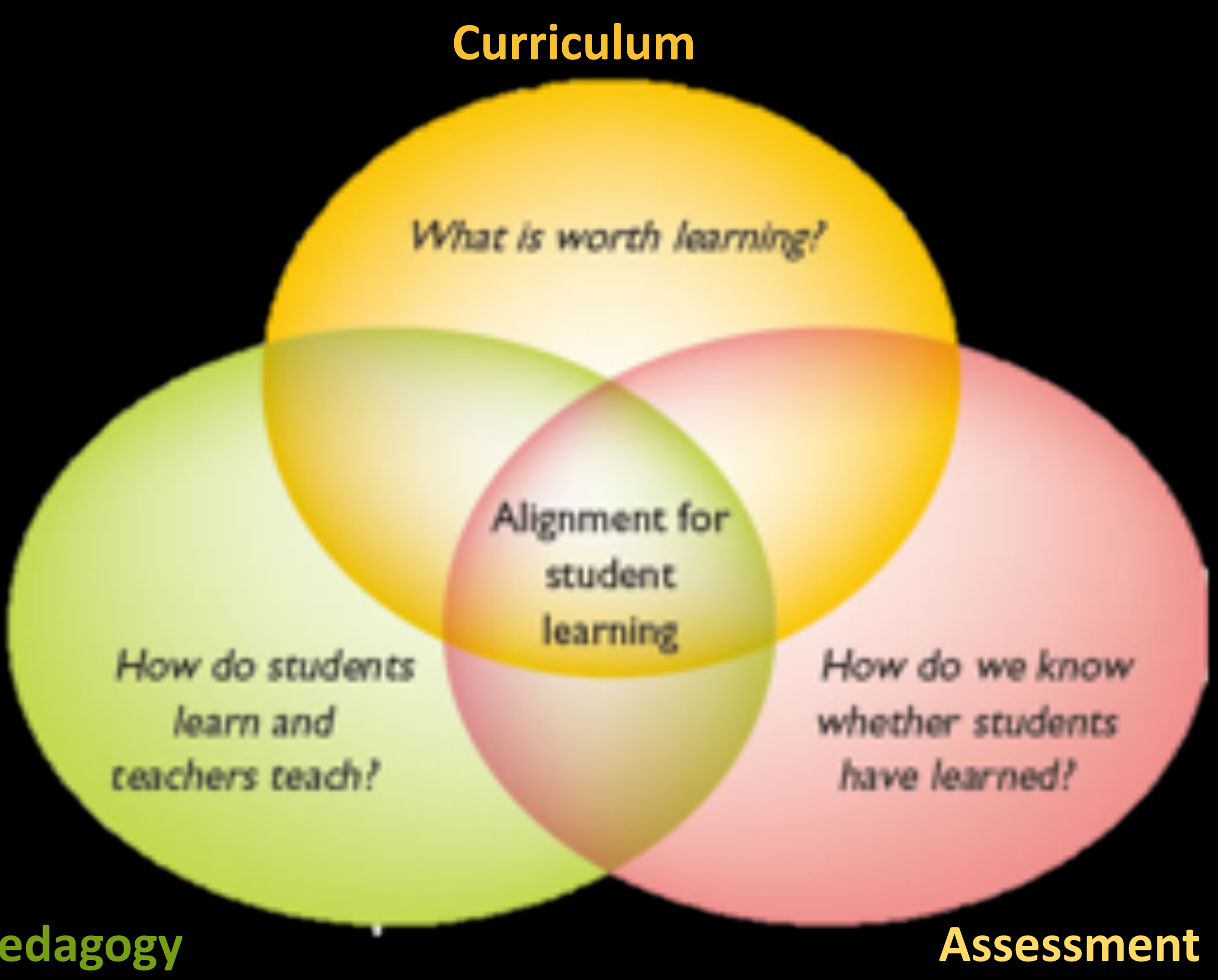
Build Teachers' PCK & Build on on Teacher Prior Expertise

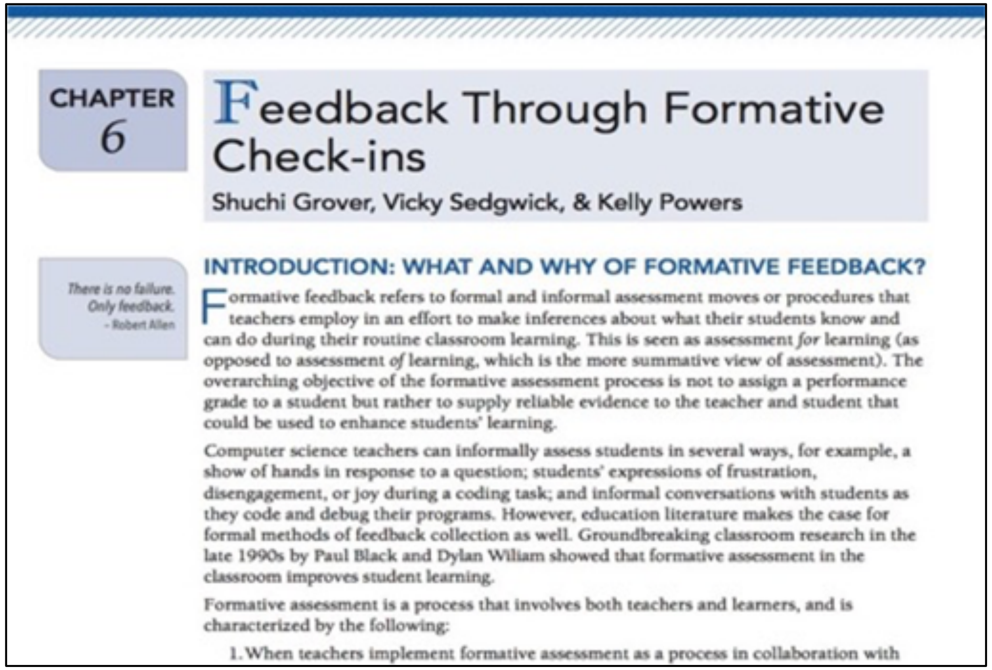
Knowing the what of teaching CS is incomplete without knowing the how; build on pre-existing peda. & content expertise of teachers.

Teacher Communities & Resources

Sustaining CoPs is hard but very worthwhile, for sharing experiences and resources

Curriculum → Pedagogy → Assessment




CHAPTER 6

Feedback Through Formative Check-ins

Shuchi Grover, Vicky Sedgwick, & Kelly Powers

There is no failure. Only feedback. - Robert Allen

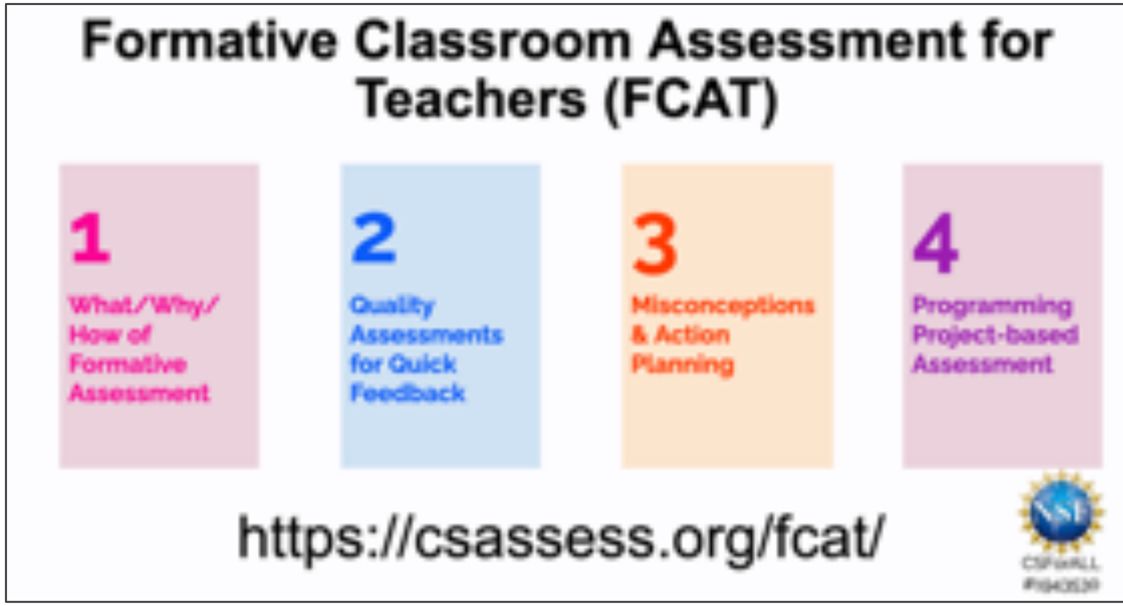
INTRODUCTION: WHAT AND WHY OF FORMATIVE FEEDBACK?

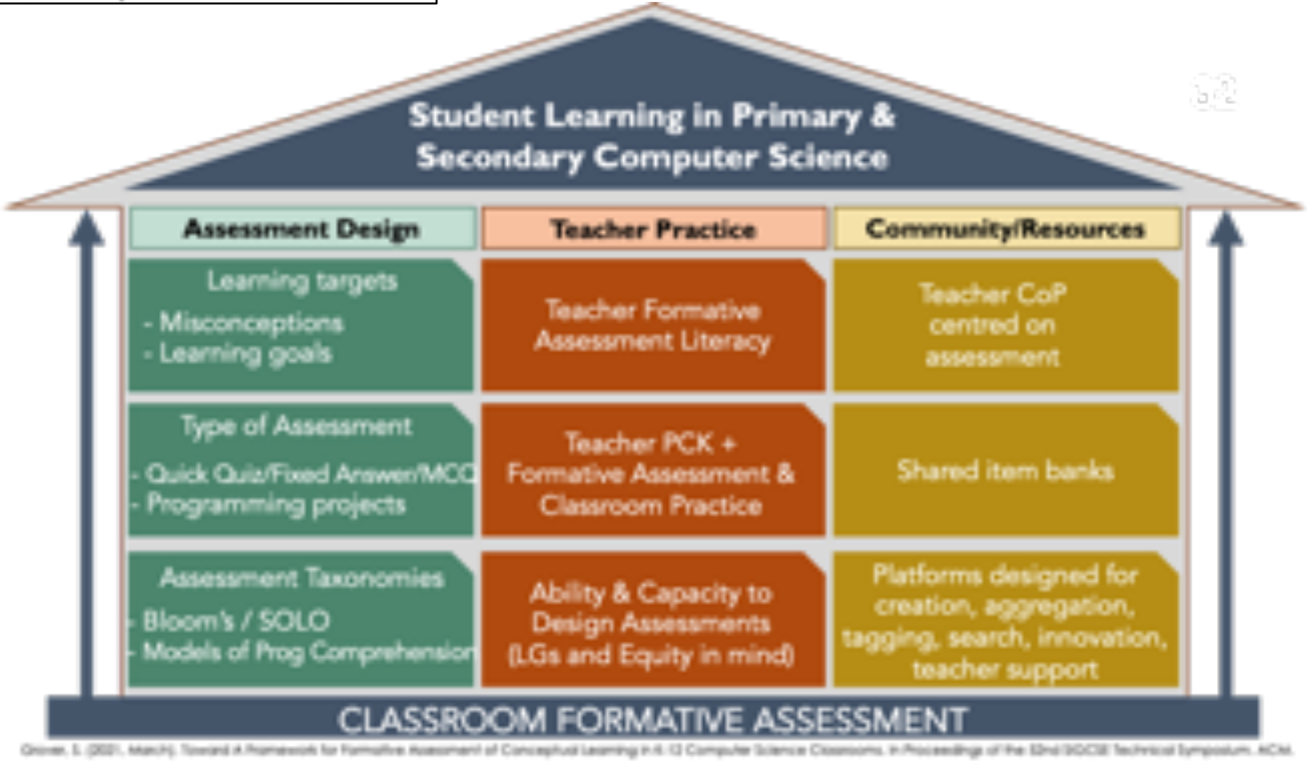
Formative feedback refers to formal and informal assessment moves or procedures that teachers employ in an effort to make inferences about what their students know and can do during their routine classroom learning. This is seen as assessment *for* learning (as opposed to assessment *of* learning, which is the more summative view of assessment). The overarching objective of the formative assessment process is not to assign a performance grade to a student but rather to supply reliable evidence to the teacher and student that could be used to enhance students' learning.

Computer science teachers can informally assess students in several ways, for example, a show of hands in response to a question; students' expressions of frustration, disengagement, or joy during a coding task; and informal conversations with students as they code and debug their programs. However, education literature makes the case for formal methods of feedback collection as well. Groundbreaking classroom research in the late 1990s by Paul Black and Dylan Wiliam showed that formative assessment in the classroom improves student learning.

Formative assessment is a process that involves both teachers and learners, and is characterized by the following:

1. When teachers implement formative assessment as a process in collaboration with





Why K-12 AI Ed? (aka AI & the coming tsunami!)

State of AI education in K-12

Lessons from K-12 CS Ed for K-12 AI Ed

Challenges, open issues, & recommendations

Challenges & Tensions

- Rapidly Changing Landscape
- Misperceptions About AI in the Broader Discourse
- A Crowded Curriculum & AI's curricular relationship to CS and other core subjects
- Building Teacher Capacity
- How Deep Can/Should We Go? (What will "AI for All" mean?)
- Need for a robust evidence base
- Lack of clarity around terminology & learning goals

Teach AI

AI Literacy

The knowledge, skills, and attitudes associated with how artificial intelligence works, including its principles, concepts, and limitations, as well as how to use artificial intelligence, such as its applications, implications, and ethical considerations.

How to Use + How it Works

AI Literacy + Computer Science

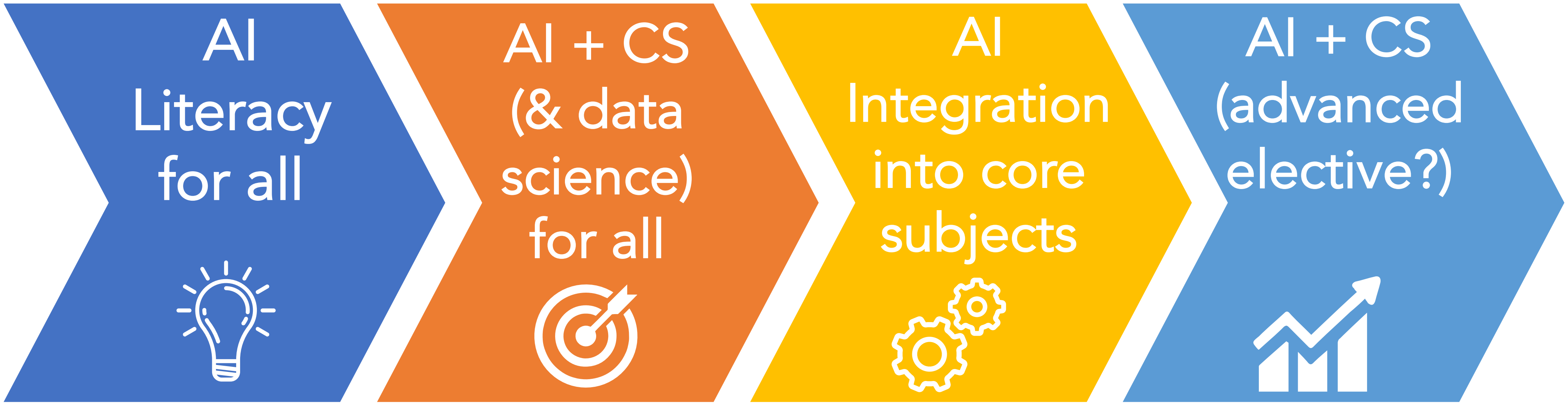
With **AI Literacy**, I CAN:

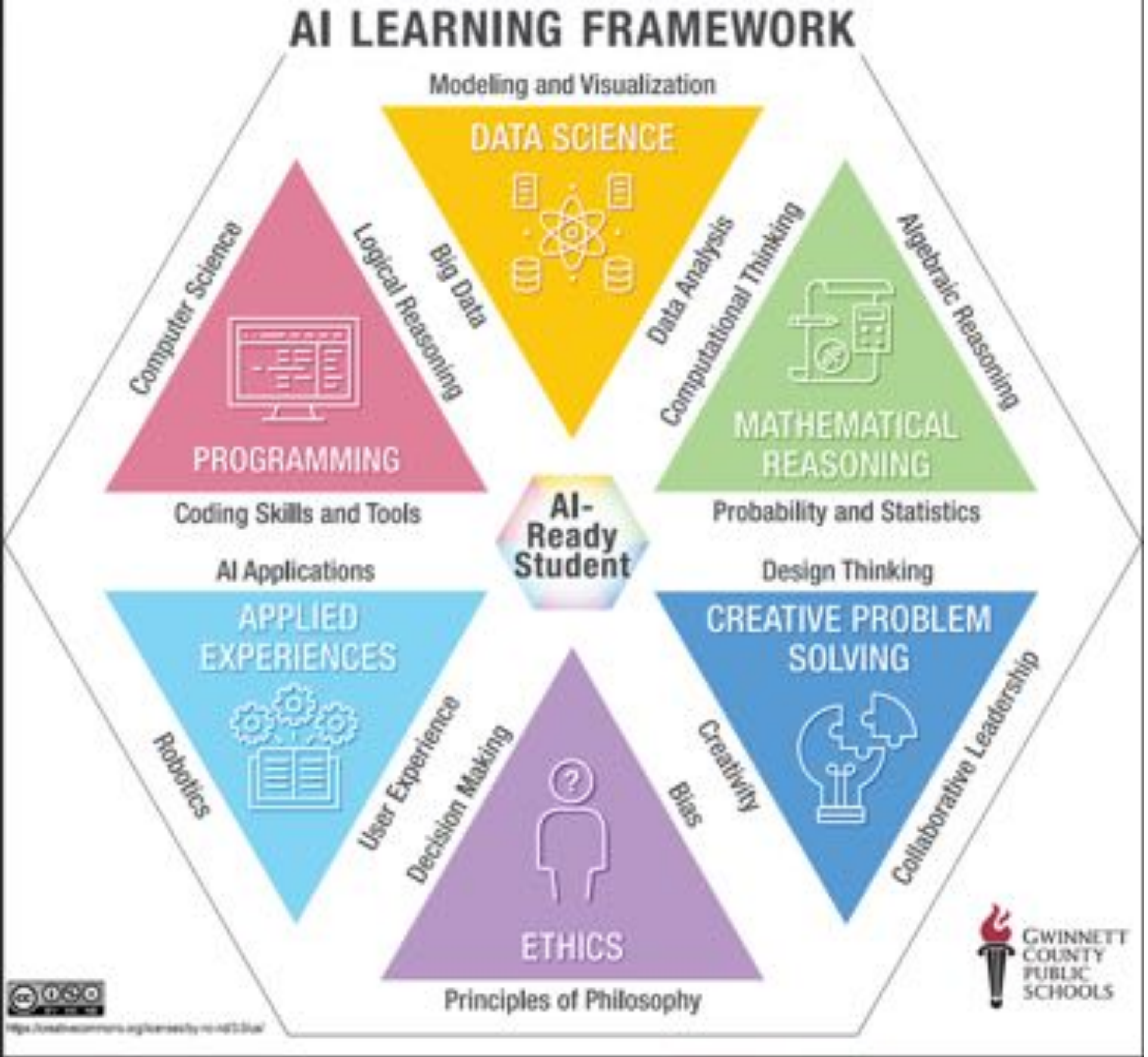
- Personalize my learning
- Assess safety and privacy with apps and data sharing
- Properly cite AI usage when writing or creating
- Prepare for the future of work
- Act as an informed citizen

With **AI/CS integration**, I CAN:

- Collect data responsibly
- Break down complex problems
- Analyze data critically
- Identify patterns and trends
- Evaluate the effectiveness of solutions
- Ethically evaluate AI systems to minimize bias

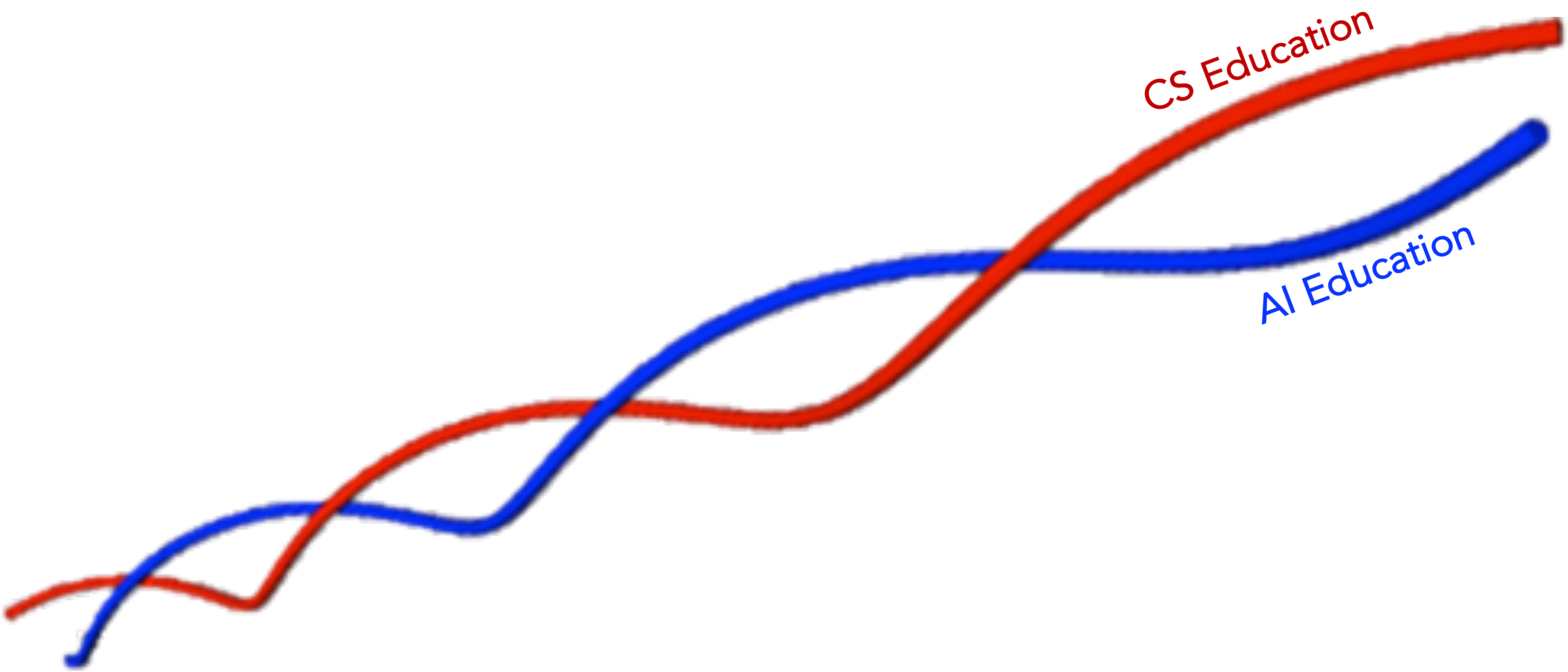
K-12 AI Ed Progression





Integration is the only answer!

- Multi- & inter-disciplinary projects that integrate CS & AI, or CS, AI, & Data Science
- Easily situated in contexts drawn from domains/subjects e.g. science, math, health, earth/climate science, politics, sports, entertainment, culture, digital literacy/cybersecurity,...
- Examination of ethics/biases intertwined throughout


CS Education
AI Education

K-12 CS Standards Revision

Fall 2023	Begin research
Spring 2024	Select advisory board(s) and writing team
Fall 2024	**<u>Kick off standards writing</u>**
Fall 2025	Finish draft standards, collect feedback
Winter 2026	Finalize content of standards
Spring 2026	Develop exemplary lesson resources, teacher PD
Summer 2026	**<u>Publish revised standards</u>**
Winter 2027	Complete supplementary resource development
2026-27	Disseminate Standards and support implementation


BRAVE NEW WORLD

@shuchig / shuchigrover.com