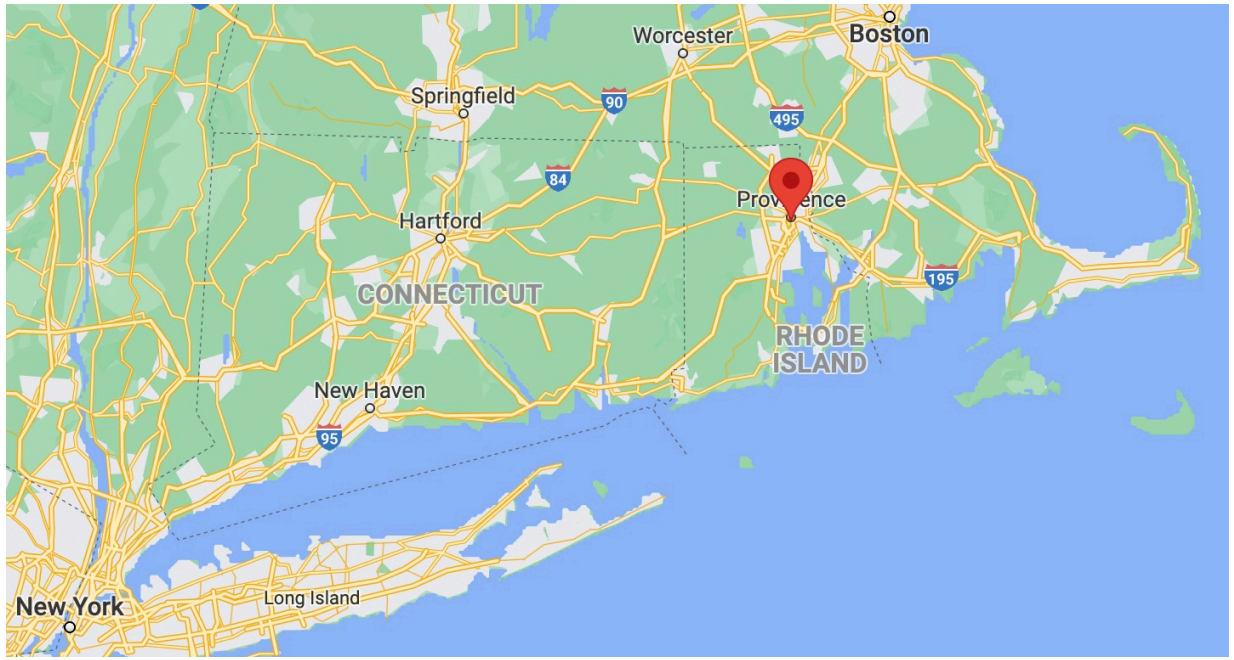
Data-Centricity: A Challenge and Opportunity for CS Education

Shriram Krishnamurthi, *Brown University*

Joint work with Kathi Fisler


Worcester
Boston
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Hartford
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RHODE
ISLAND
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New Haven
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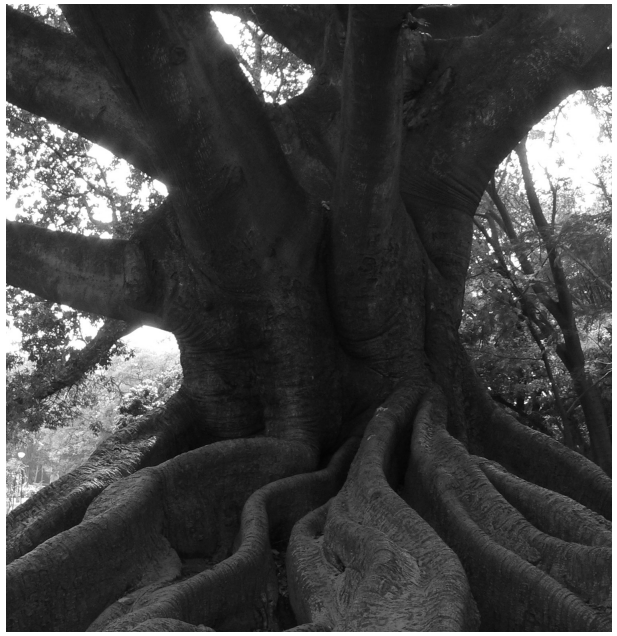
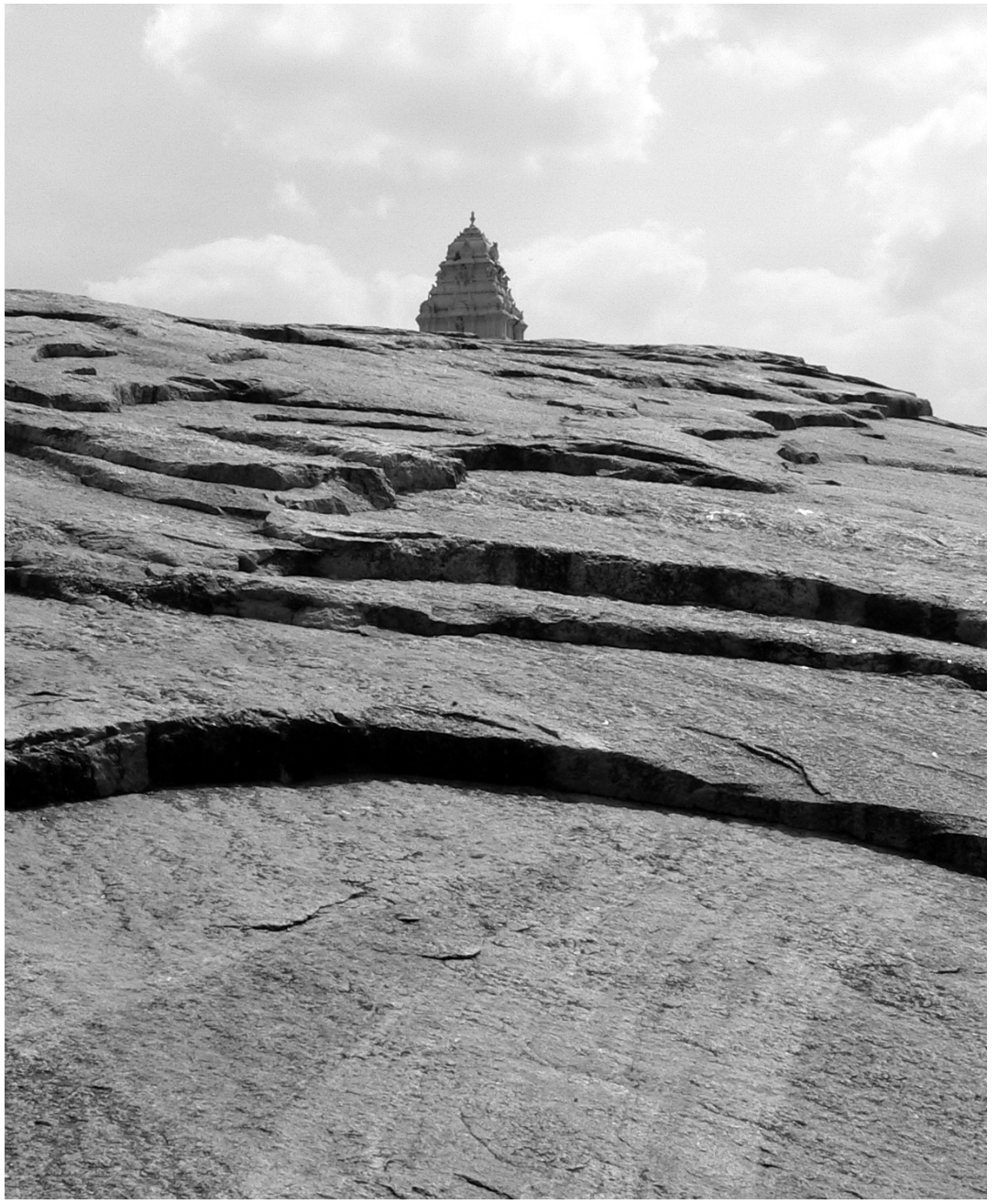
New York
Long Island





What is in (Collegiate) CS1?

Numbers / Strings

Variables

Assignment statements

Conditionals

Loops

Functions

Arrays

Data Structure Progress Since the 1970s

1970s	Pascal	arrays
1980s	C	arrays
1990s	C++	arrays
2000-2015	Java	ArrayList
2015-now	Python	associative arrays

Pressure From Above:
“The Unreasonable Effectiveness of Data”

Pressure From Below:
Code Synthesis from Text

Pressure From Below:
“LowCode/NoCode” Ssytems

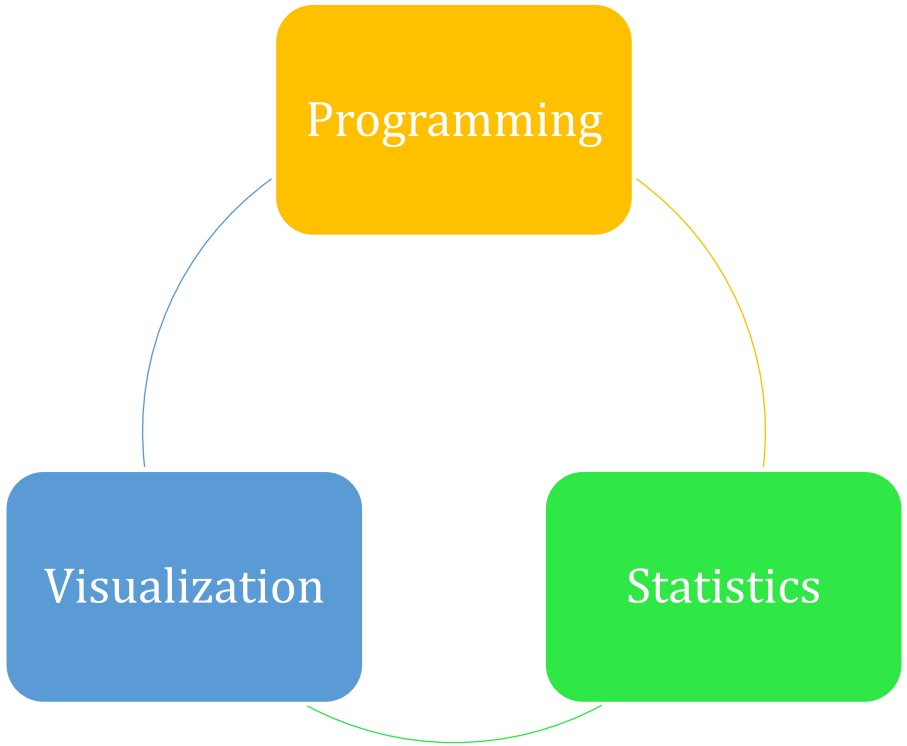
Needs from many more disciplines

Student diversity concerns

Negative societal impacts

Major new curricular trend:
Data Science

Courses, bootcamps, even degrees



How Should We View This?

“They don’t teach even the basics!”

“This is a threat to our degree programs!”

“This is actually a (valid) criticism of current CS Ed”

What Are the Valid Criticisms of CS 1?

Curricula do not engage students

Curricula do not connect to society/real-world phenomena

You can’t do anything useful after a course

Computing is used everywhere; students aren’t prepared

Reforming CS for the Data Era

Data Structure Progress Since the 1970s

1970s	Pascal	
1980s	C	rays
1990s	C++	ar
2000-2015	Java	ArrayList
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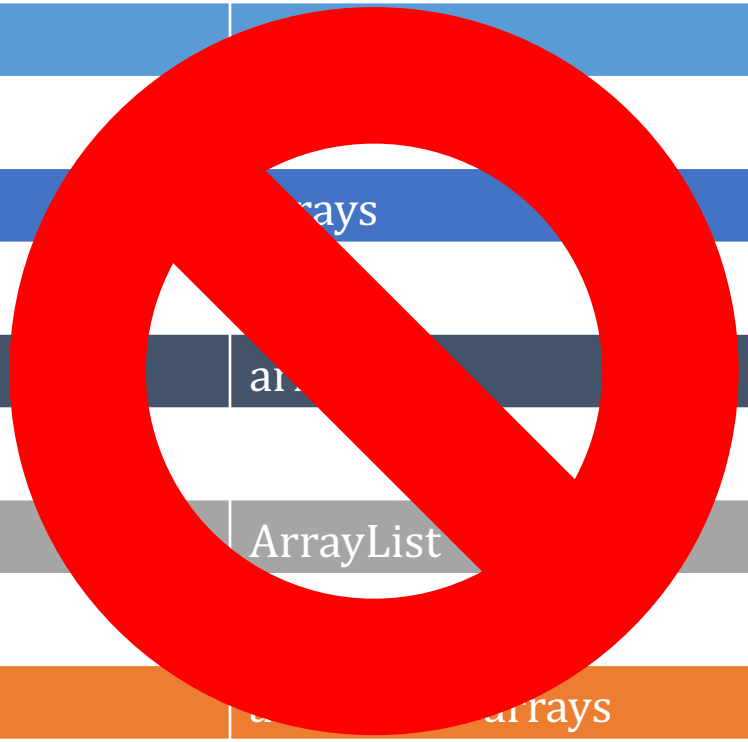

First Name	Last Name	Email	Tickets	Discount	Birthday
Josie	Zhao	josie	2	birthday	Jan 1, 1970
Guy Lewis	Steele Jr	guy@steele.com	4		
Bart	Simple	bart@simpsons.com	1	student	
Robby		robby	2		
Shweta	Mysore	shweta@np.org	1		
Alvina	Velasquez	avlina@school.edu	three	student	
Sam	Ochibe	s@sweb.com	10		

Rich structure

Already parsed

Familiar even to kids

MODELING AS A CORE COMPONENT OF STRUCTURING DATA

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Time & Date	Segment Number	Direction of traffic	Width of Lanes	Type of vehicle	Speed (mph)	Distance to the vehicle in front (in ft)
8:00am 8/12/2010	03	westbound	15'	SUV	75	50'
				car	64	75'
8:00 am 8/12/2010	03	Eastbound	15'	car	24	15'
				SUV	12	12'
				car	12	8'
				car	12	8'
				truck	12	15'
4:00 pm 8/15/2010	08	westbound	20'	car	73	25'
				car	75	35'
				truck	50	50'
4:00 pm 8/15/2010	08	Eastbound	20'	car	85	60'

(763)

Graphs in order from front to back

8:00AM on 8/12/10
Segment 03 (W/E, 15' wide per side)

West

car type	speed (mph)	ft to next car
C	64	75
S	75	50

East

T	12	15
C	12	8
C	12	8
S	12	12
C	24	15

4:00PM on 8/15/10
Segment 08 (W/E, 20' wide per side)

West

car type	speed (mph)	ft to next car
T	50	50
C	75	35
C	73	25

East

C	85	60

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Data Commons

Data Commons aggregates data from a wide range of sources into a unified database to make it more accessible and useful. More on why we are building Data Commons.

Integrated Data Science for Secondary Schools: Design and Assessment of a Curriculum

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Bootstrap
USA

Nancy Pfenning
University of Pittsburgh
USA

Flannery Denny
Bootstrap
USA

Sam Dooman
Brown University
USA

Joe Gibbs Politz
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Brown University
USA

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Brown University
USA

"I chose my dataset because…" Students could choose more than one option. Here, 42.6% said they chose it because it was something they already knew something about, while just as many (40.2%) chose it because "I don't know much about it, and I was curious". In addition, 16% said "It affects me personally". Numerous students used free-response to express specific interests such as representing a favorite hobby or activity, or "I am interested in the medical field". Still, small numbers contained a potentially negative response: 11.7% said they had no reason, 4.3% said it was their partner's choice, and 3.2% said they did not have a choice (presumably meaning the dataset was chosen by the teacher).

Overall, then, we see that the personalization is accompanied in general by a high degree of engagement and, most importantly, low degrees of *dis*-engagement. This suggests that the technique of providing a (limited) range of curated datasets still gives many students room for personal expression.

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"How many tickets sold with a student discount?"

Interesting problems

Concrete, easy to envision and manipulate

Lend themselves to decomposition and planning

Computing Education Research Blog

A Challenge to Computing Education Research: Make Measurable Progress

August 16, 2010 at 9:50 pm | 41 comments

In computing education research, we repeatedly conduct studies showing just how little students are learning in our classes. We've been doing it for almost 30 years. I have a challenge to our community: ***Let's show that we can do better!***

After 30 years, why hasn't somebody *beaten* the Rainfall Problem? Why can't someone teach a course with the ***explicit*** goal of their students doing ***much*** better on the Rainfall Problem — then publish how they did it? *We ought to make measurable progress.*

I don't think that this is an impossible goal. In fact, I bet that some of the existing research projects in computing education could "beat" (generate published reports with better results) these current studies.

- The TeachScheme approach focuses on design based on data. I bet that their students could beat the Rainfall Problem or the McCracken working group problem.

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Variety of programming forms (functions, methods, loops, …)

```
t1 = sieve tickets using discount:
  discount == "student"
end

sum(extract tickets from t1 end)
```

Pyret

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Data quality, normalization, cleansing

Consequences of bad data

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Falsehoods Programmers Believe About Names

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What gets collected about you?

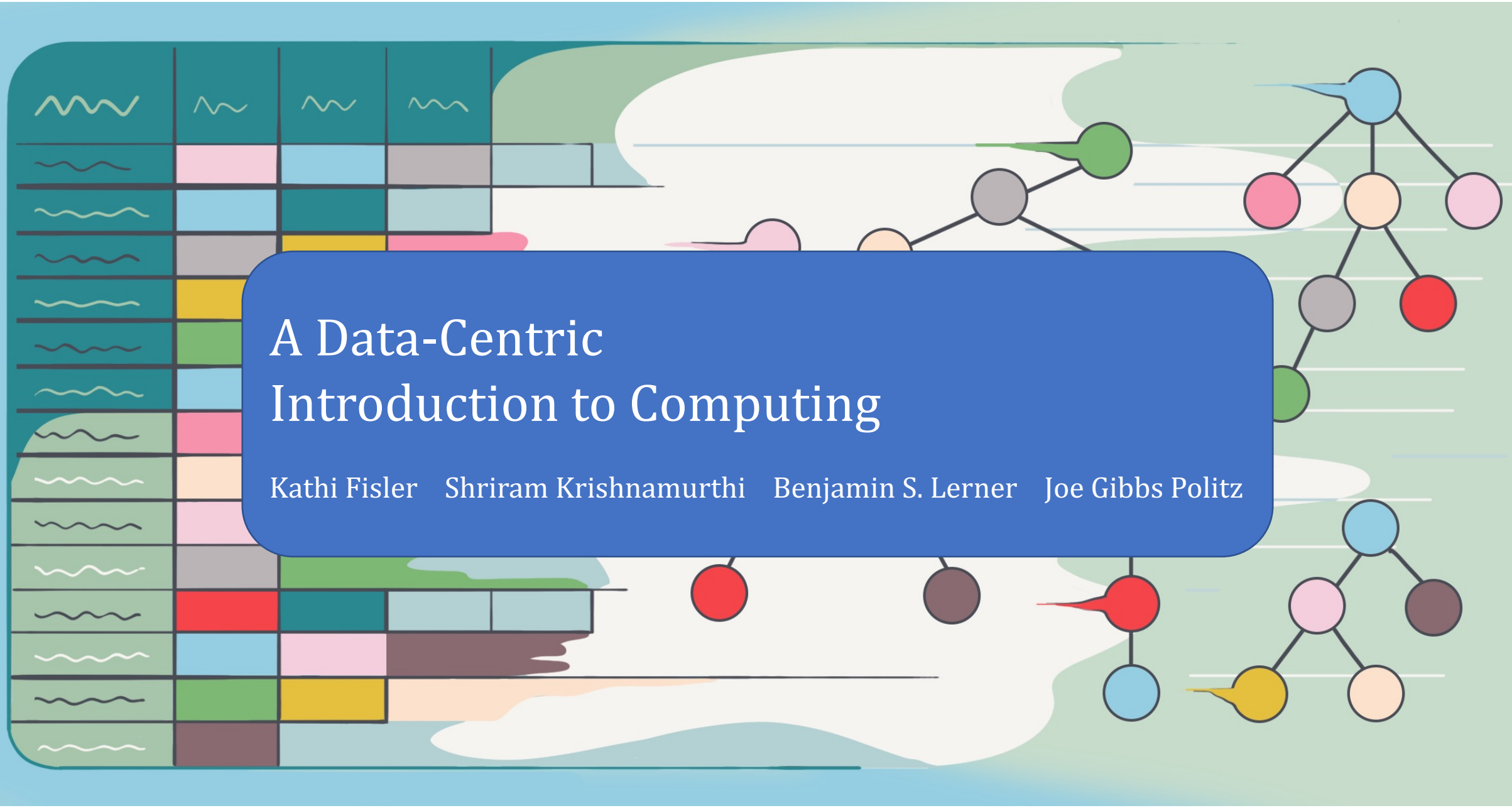
What gets *inferred* about you?

What *decisions* are made on those inferences?

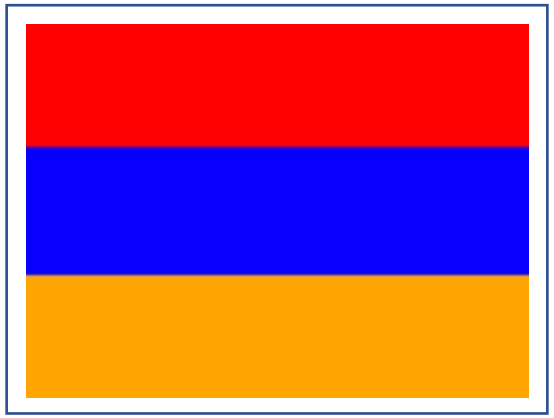
Limitations

```
ancestry = table: name, birthyear, eyecolor, fempar, malepar
    row: "Anna", 1997, "blue", "Susan", "Charlie"
    row: "Susan", 1971, "blue", "Ellen", "Bill"
    row: "Charlie", 1972, "green", "NoInfo", "NoInfo"
    row: "Ellen", 1945, "brown", "Laura", "John"
    ...
end
```

Motivate new data structures (and rest of CS)


A Data-Centric
Introduction to Computing
Kathi Fisler Shriram Krishnamurthi Benjamin S. Lerner Joe Gibbs Politz

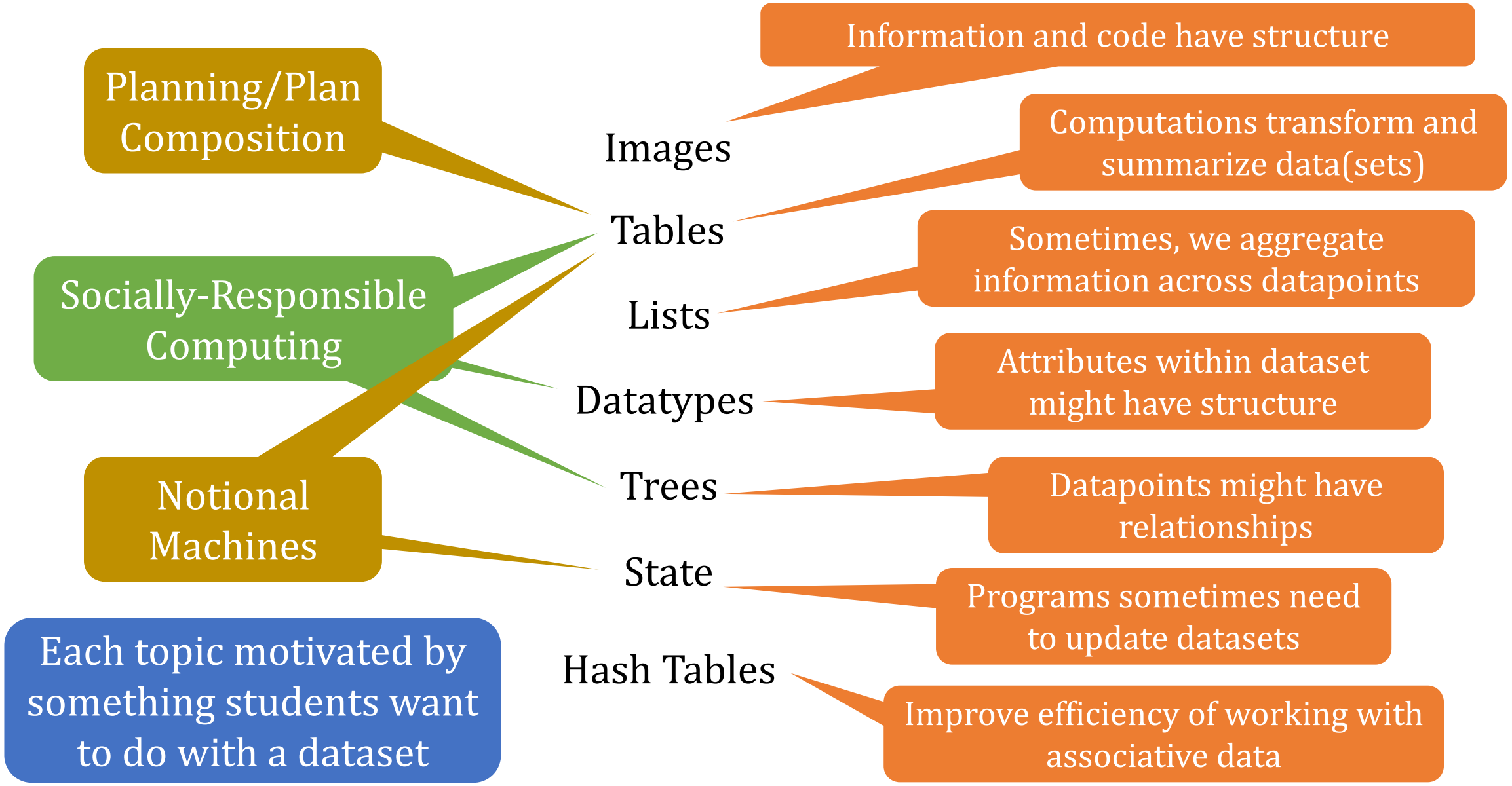
Data-Centric Intro to Computing (DCIC)



```
frame(
  above(rectangle(200, 50, "solid", "red"),
    above(rectangle(200, 50, "solid", "blue"),
      rectangle(200, 50, "solid", "orange"))))
```

Structure of code follows structure of image

Data-Centric Intro to Computing (DCIC)



Research-Driven Curriculum!

Using Design Alternatives to Learn About Data Organizations

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Developing Behavioral Concepts of Higher-Order Functions

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What Help Do Students Seek in TA Office Hours?

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Adapting Student IDEs for Blind Programmers

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Early Post-Secondary Student Performance of Adversarial Thinking

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Article


COLUMN

Data-centricity: a challenge and opportunity for computing education

Authors: Shriram Krishnamurthi, Kathi Fisler Authors Info & Affiliations

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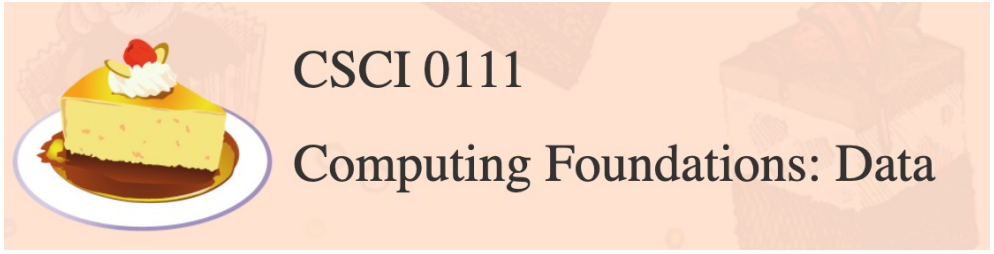
CACM July 2020

Book

All materials are free and on-line!

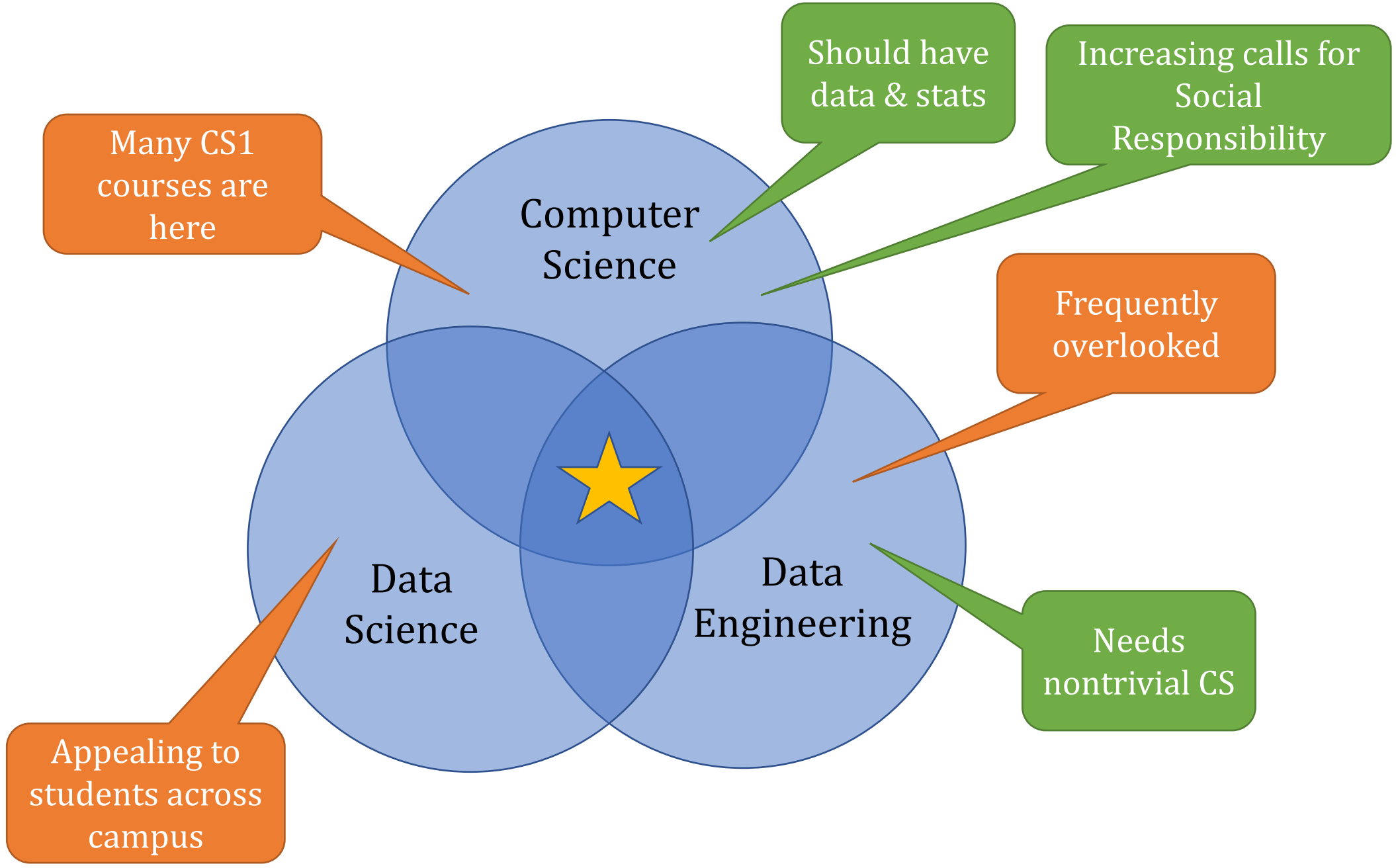
`dcic-world.org`

Course



(at Brown & others)

Stepping Back Out


Should have data & stats
Increasing calls for Social Responsibility
Many CS1 courses are here
Computer Science
Frequently overlooked
Data Science
Data Engineering
Needs nontrivial CS
Appealing to students across campus

What About Primary/Secondary?

Ports all these ideas to students as young as 10yo

State of CS 1

The Rise of Data Science

Redesigning CS 1 with Data