CAL POLY

Community Action Computing: A Data-centric CS0 Course

(A curricular initiative paper.)

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Plan

- Motivation and design goals
- Course overview
- Preliminary evaluation of learning outcomes and 1-year persistence
- Future work: longer term impacts

Institutional context

Competitive enrollment policy

Who takes the course?

- In the fall: Mostly **Computing** majors
- In the winter: Mostly **Graphic Communication** majors

One of several available “flavors” of CS0

- Robotics
- IoT
- Art
- Music

Competitive Enrollment Policies in Computing Departments Negatively Predict First-Year Students' Sense of Belonging, Self-Efficacy, and Perception of Department (Nguyen & Lewis)

Mixed approaches to CS0: Exploring Topic and Pedagogy Variance After Six Years of CS0 (Wood et al.)

Our goal

- To improve retention of Hispanic/Latino students in early CS courses
- By strengthening sense of belonging in CS
- By demonstrating strong communal and societal relevance in all coursework

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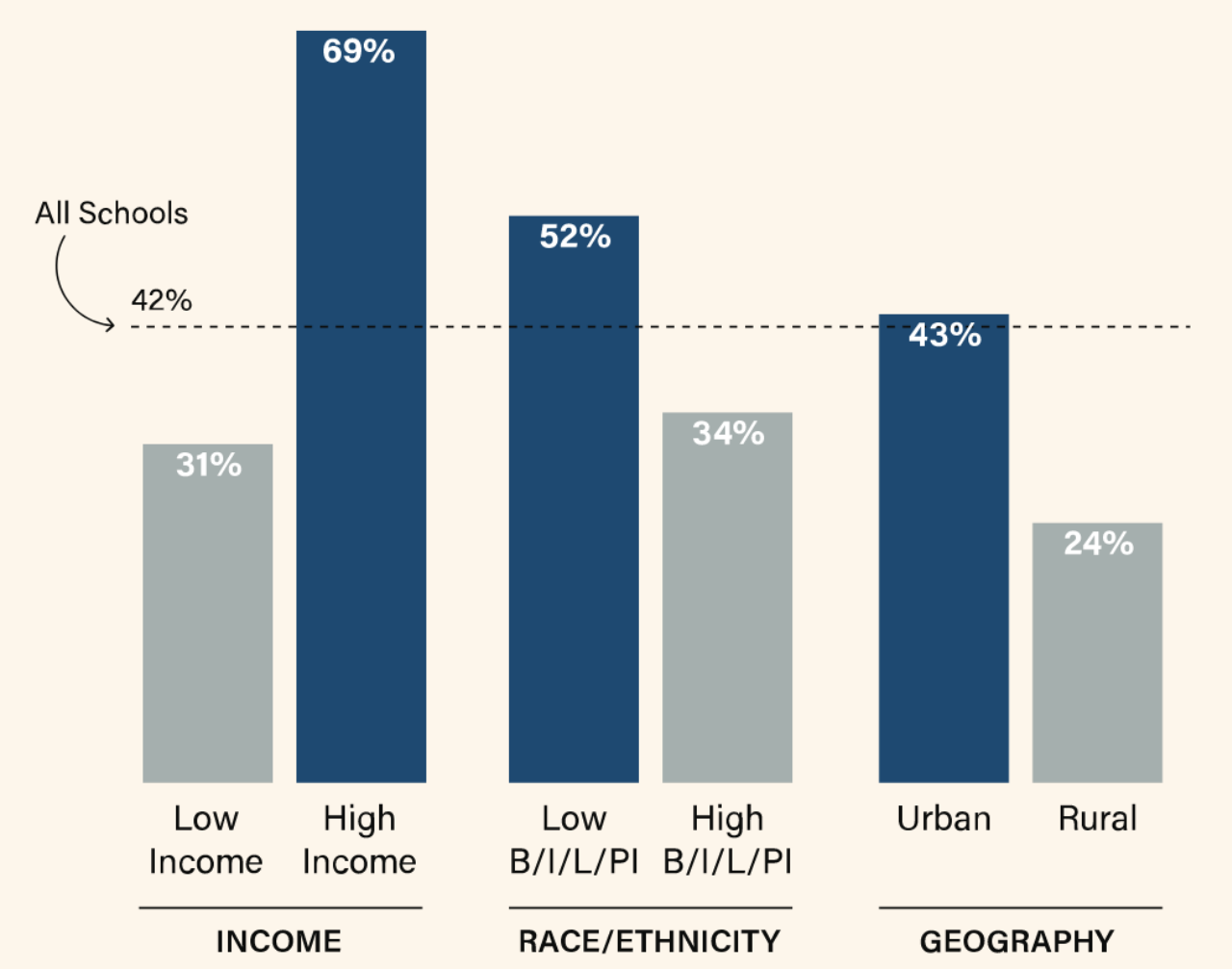
Who’s taking CS in California?

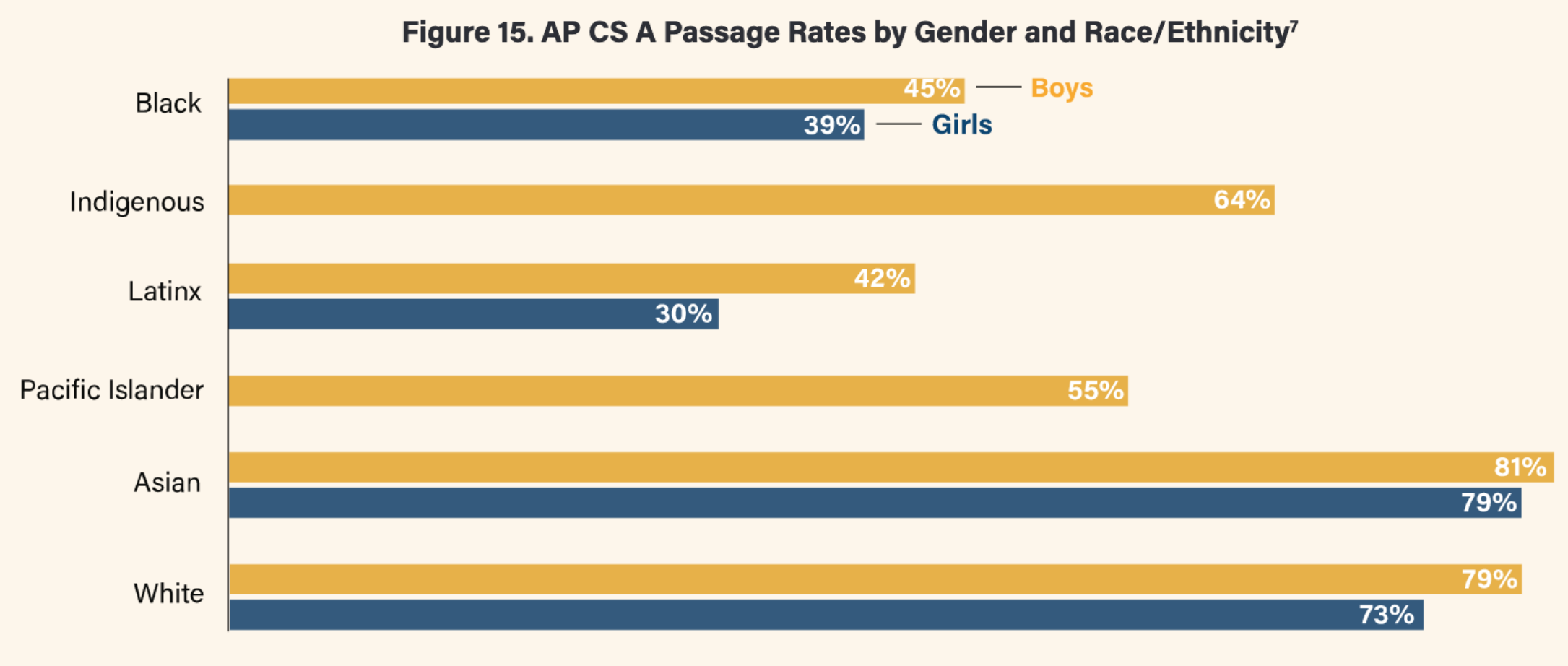
Access to high-school CS education in California is split along socio-economic lines.



The California Computer Science Access Report (2021) (csforca.org)

Who’s succeeding in CS in California?

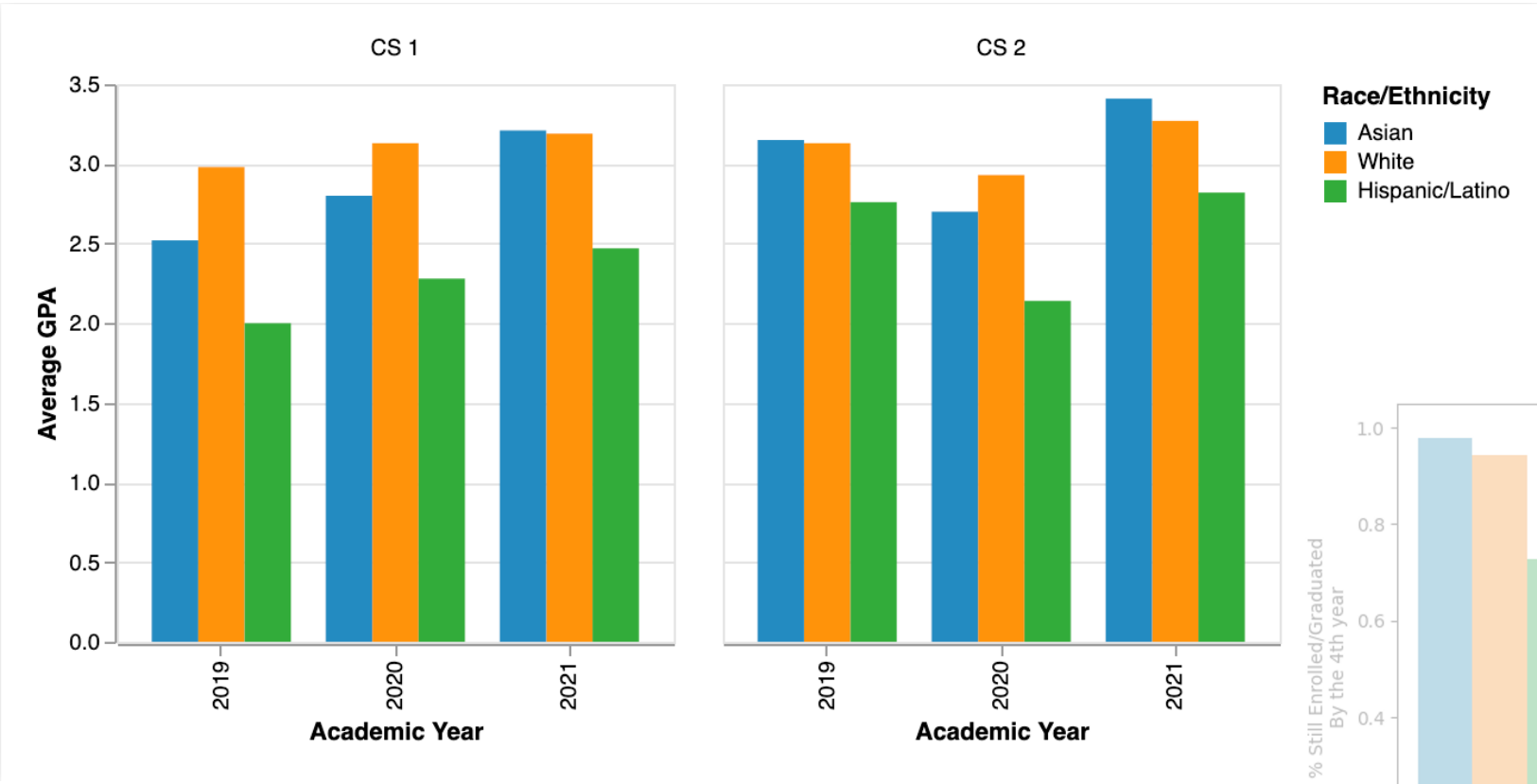
AP CS A performance is split along the lines of race and ethnicity.



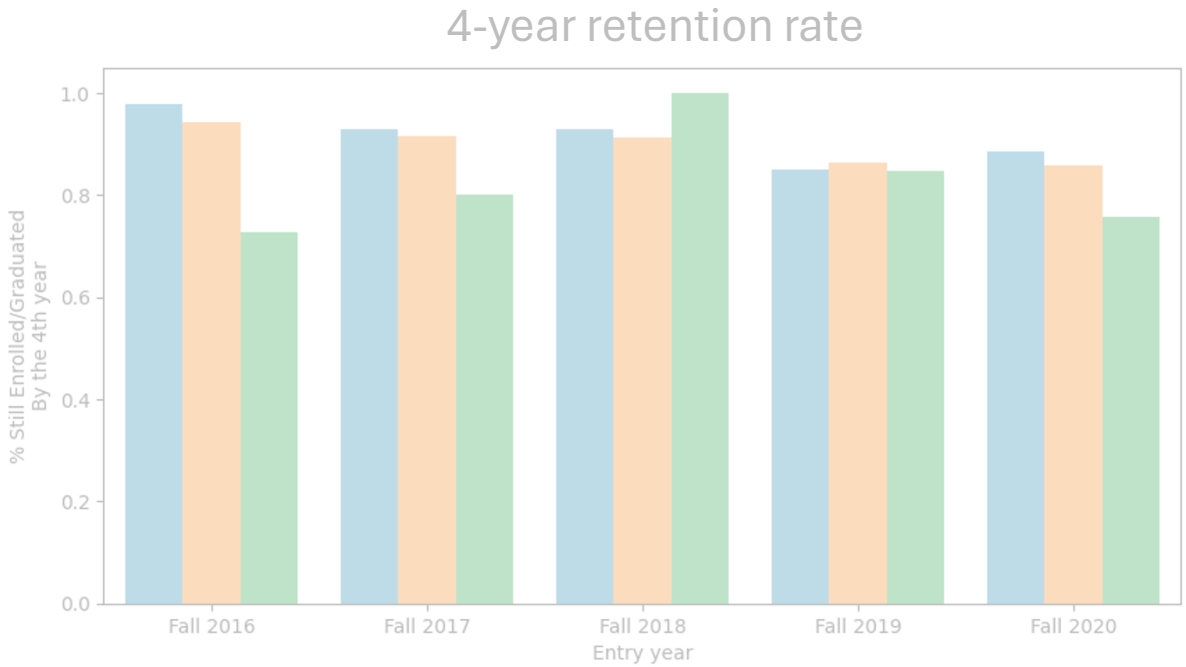
The California Computer Science Access Report (2021) (csforca.org)

CS Majors at Cal Poly

Performance in required early CS courses



Similar inequities exist in CS at Cal Poly.



Institutional data dashboard at Cal Poly SLO

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Goal congruity

Goal orientations

- Agentic
- Communal

Alignment of Goals and Perceptions of Computing Predicts Students' Sense of Belonging in Computing (Lewis et al.)

Goal congruity

Goal orientations

- Agentic
- Communal

Goals that are aimed at:

- Individual achievement
- Independence
- Self-promotion

Alignment of Goals and Perceptions of Computing Predicts Students' Sense of Belonging in Computing (Lewis et al.)

Goal congruity

Goal orientations

- Agentic
  Communal

Goals that are aimed at:

- Giving back to community
- Having a social impact
- Serving humanity
- Helping others

Alignment of Goals and Perceptions of Computing Predicts Students' Sense of Belonging in Computing (Lewis et al.)

Goal congruity

Goal orientations
- Agentic
- Communal

Perception of computing

Sense of belonging is positively impacted by this alignment.

Alignment of Goals and Perceptions of Computing Predicts Students' Sense of Belonging in Computing (Lewis et al.)

Computing for good

Hack4Impact Cal Poly

- Established 2017
- Around 85–100 students per year

- Building web applications for non-profits to manage their day-to-day operations.

CP Cat Program *2020*

A directory for storing cats health information, as well as streamline the intake process

ECOSLO *2020*

A data managment system tracking beach cleanup data for spreading awareness and gaining funding

Habitat for Humanity *2023*

An improved scheduling and delivery management platform for large-item donation pickups

Hospice of SLO *2023*

An improved scheduling app that allows doulas to easily sign up and communicate patient info across shifts

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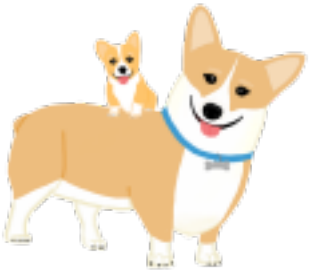
We are inspired by prior work

- **Computational Thinking @ Virginia Tech**
  - Transforming early CS projects by introducing real-world data
  - CORGIS — Dataset of datasets

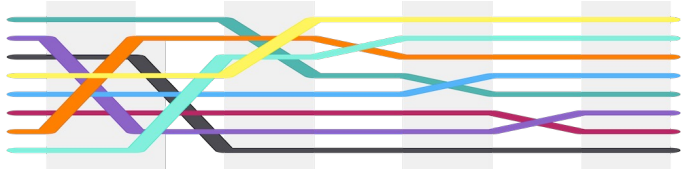


CT@VT

- **Socially Responsible Computing @ Brown University**
  - CS Education Which Puts Socially Responsible Computing Front and Center

SRC @Brown

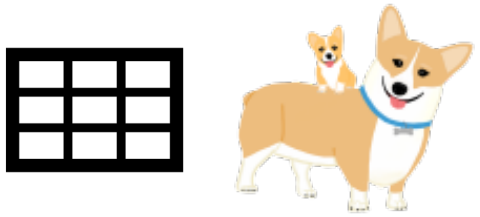
- **Ethical Reflection Modules for CS 1**
  - Introducing a deeper level of reflection in CS 1 courses
  - Developing reflection habits alongside coding habits



- The work of CT@VT (Bart, Gusukuma, Kafura, et al.)
- SRC@Brown (Fisler et al.)
- Ethical CS (Peck)

Course design goals

Data-centricity



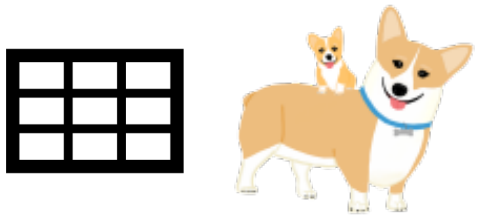
A vehicle to:

- Integrate real-world contexts into early computing
- To engage students' creativity through data visualization

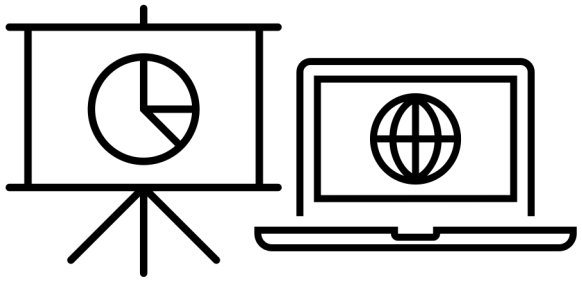
- Data-centricity: A Challenge and Opportunity for Computing Education (Krishnamurthi & Fisler)
- Computing with CORGIS: Diverse, Real-world Datasets for Introductory Computing (Bart et al.)

Course design goals

Data-centricity



Building and sharing



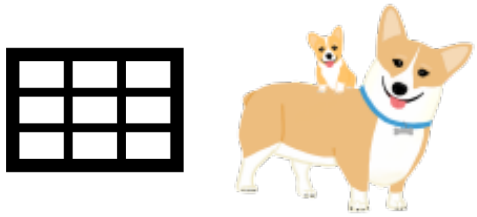
Constructionism

- Engaged students' creativity through data visualization
- Informed our choice of platform — the Web
- Scaffolded; Not just "learning by making"

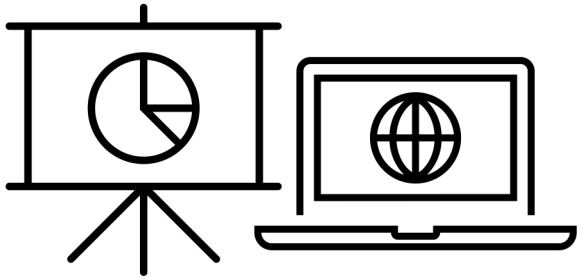
Situating constructionism (Harel & Papert)

Course design goals

Data-centricity



Building and sharing



Relevance to Society and Communities

Hack4Impact Cal Poly

CSforCA

EcoSlo Environmental Center of San Luis Obispo

Cal Poly Cat Program

- Sustained focus on societally or personally meaningful contexts
  - Local non-profit organizations
  - Data about CS education access in California

- Programming components were accompanied with written reflection components
  - (But we need to do more of this)

Course overview

Don’t worry, we won’t go through this whole table

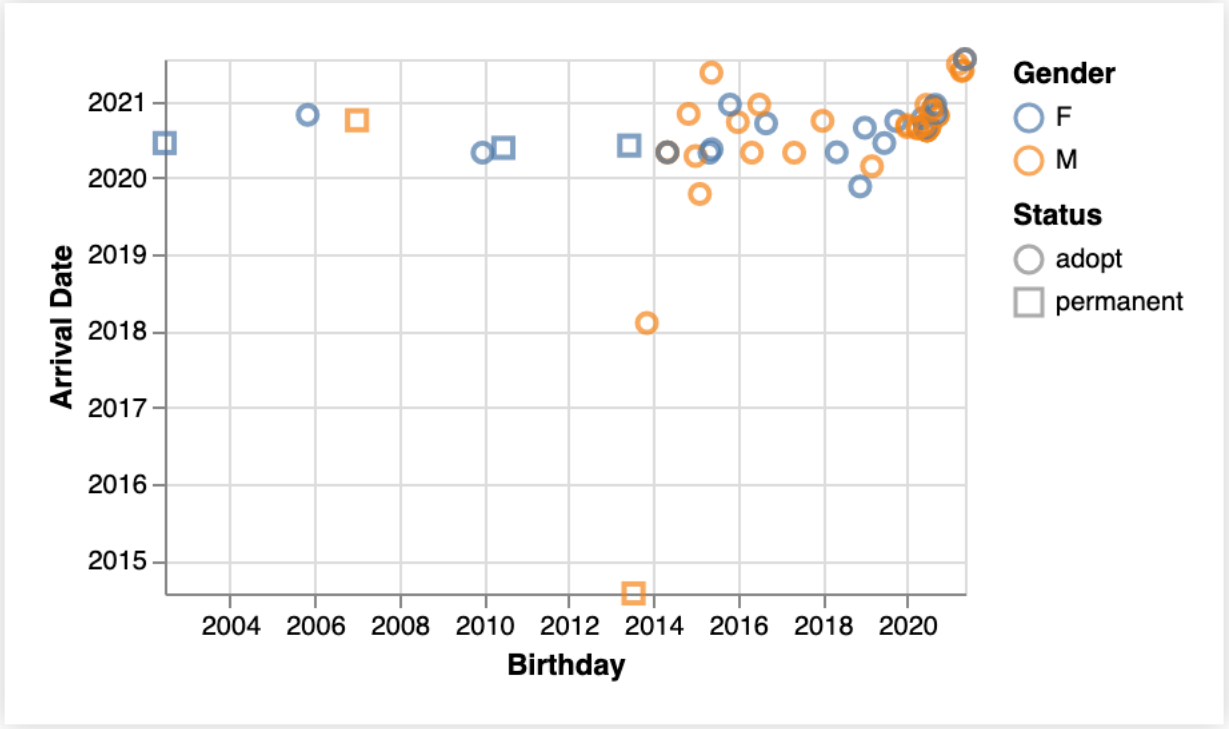
Table 1: An overview of the 10-week course, as taught to computing majors in the Fall 2022 term (Winter term included the alternative assignments as listed in the paper). ★ denotes a societally or personally (to the student) meaningful context.

Week	Topic	Major assessments
1	ACM Code of Ethics Introduction to data	Read the ACM Code of Ethics and respond to a reflection prompt ★ Identify the types of data used in a figure or problem (quantitative, nominal, or ordinal) Use Vega-lite to visualize data provided by the local cat shelter and housing data obtained from CORGIS [3] ★
2	HTML and CSS fundamentals Expressions and evaluation	Create a styled webpage with self-help materials for first-time college students ★ Evaluate the given compound numerical expressions
3	Statements and expressions in TypeScript Variables and data types Arrays	Declare and initialize variables with types for the given (string, number, or boolean) expressions Given arrays containing data about K-12 CS offerings in counties in California, compute statistics and answer questions about which counties can offer the least or most CS courses ★
4	Functions and control flow	Code tracing exercises Write functions to answer parameterized questions about CS education access using the data-set from the previous assignment ★
5	Loops and loop patterns (imperative map, filter, and reduce)	The Rainfall problem
6	Compound data (objects and interfaces)[4]	Given a richer data-set about CS education enrollments in California, declare an `interface` to represent individual records ★ Write functions to answer questions about girls’ enrollments in CS courses in secondary school ★
7	Functions as values	Code tracing exercises Use the in-built higher-order functions `map`, `filter`, and `reduce` to answer questions about the data-set from the previous assignment ★
8	TypeScript in a webpage	Given a still richer data-set about CS education in California—now including data about race—use Vega-lite to create figures and embed them in a website; respond to reflection prompts about your figures and analysis ★
9	Review	No new assessments
10	Final project (in groups)	In consultation with the instructor, choose a data-set and use what you have learned so far (Vega-lite, HTML, CSS, TypeScript) to create a website containing your insights and reflections on your chosen topic ★ Present your report to the rest of the class ★

Course overview (highlights)

Week 1

- ACM Code of Ethics
- Introduction to data
- Data visualization with Vega-lite




```
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        "url": "..."
    },
    "mark": {
        "type": "point"
    },
    "encoding": {
        "x": {
            "field": "Birthday",
            "type": "temporal"
        },
        "y": {
            "field": "Arrival Date",
            "type": "temporal"
        },
        "color": {
            "field": "Gender",
            "type": "nominal"
        },
        "shape": {
            "field": "Status",
            "type": "nominal"
        }
    }
}
```

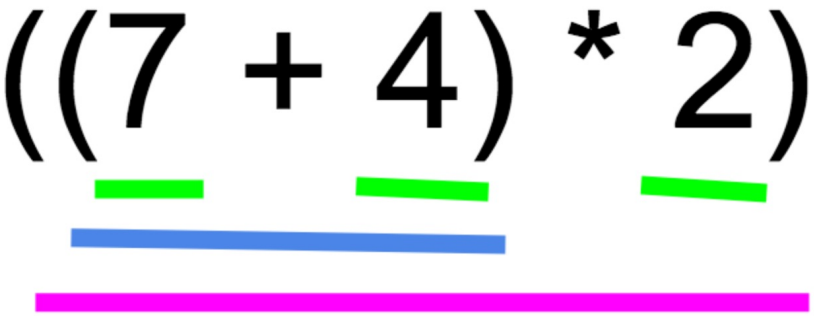
Course overview (highlights)

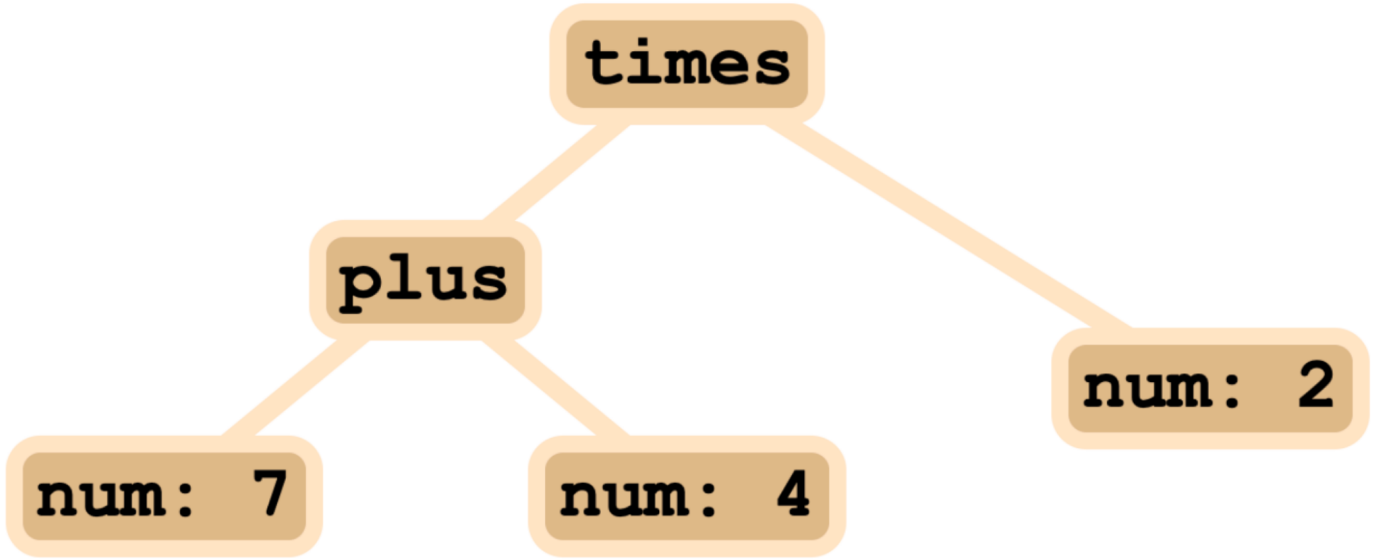
Week 1

- ACM Code of Ethics
- Introduction to data
- Data visualization with Vega-lite

Week 2

- HTML & CSS
- Expressions and evaluation





Course overview (highlights)

Week 1

- ACM Code of Ethics
- Introduction to data
- Data visualization with Vega-lite

Week 2

- HTML & CSS
- Expressions and evaluation

Weeks 3–9: Programming using TypeScript

- Data types, lists
- Statements and expressions
- Functions
- Control flow
- Loops and loop patterns
- Compound data (objects and interfaces)
- Functions as values

Replit


```
string[], number[]
```

```
function(string[], number[])
```

```
interface CSCounty {
  countyName: string,
  schoolsWithCS: number,
  overallEnrollment: number,
  totalCSEnrollment: number,
  womenTakingCS: number,
  medianHouseholdIncome: number,
  isRural: boolean
}

function(CSCounty[])
```

(county names, % of schools offering CS)

How do API Documentation and Static Typing Affect API Usability? (Endrikat, Hanenberg, Robbes, & Stefik)
An Empirical Study of the Influence of Static Type Systems on the Usability of Undocumented Software (Mayer, Hanenberg, Robbes, Tanter, & Stefik)

Course overview (highlights)

Week

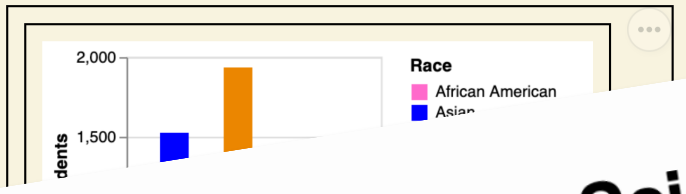
- AC
- Int
- Da

Wee

- HT
- Ex

figures

Number of Women in Urban Counties Enrolled in AP CS Courses Based on Race in CA



Diversity Barriers in K–12 Computer Science Education: Structural and Social

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account rural counties instead of urban counties, the graph becomes

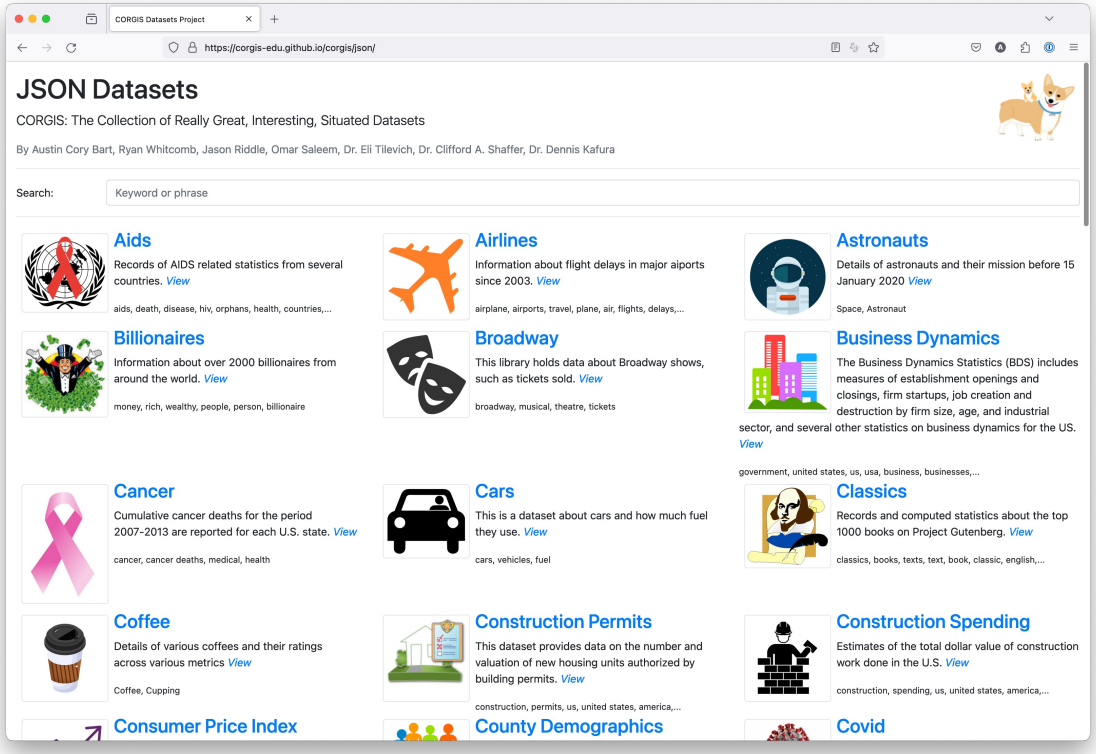
AP CS in rural counties. When you look at this graph and do take urban counties into

not high at all when you see that the overall CS student population of most of these demographics in CA is in or near the

, one demographic even exceeding 40k. Latina students have the highest enrollment once again, but another difference between this chart and the overall CS enrollment chart is that Filipina students just barely take the lead for 4th place against African American women students and multiple races/other female students, which is a feat they've jumped to from their previous 6th place in the overall CS enrollment chart.Overall, there needs to be more inclusion for both women and other minority races in the CS field, and that starts by making the field more accepting, accessible, non-daunting, and non-stereotypical.

Final project

- In groups of 3–4
- Choose a publicly available dataset
- “Tell me something interesting”
- Open-ended, with some minimum requirements
  - At least 3 Vega-lite figures
  - At least 2 *types* of figures
  - Must use TS to transform data into the “shape” you need for your chart idea
- **Present your findings to the rest of the class**

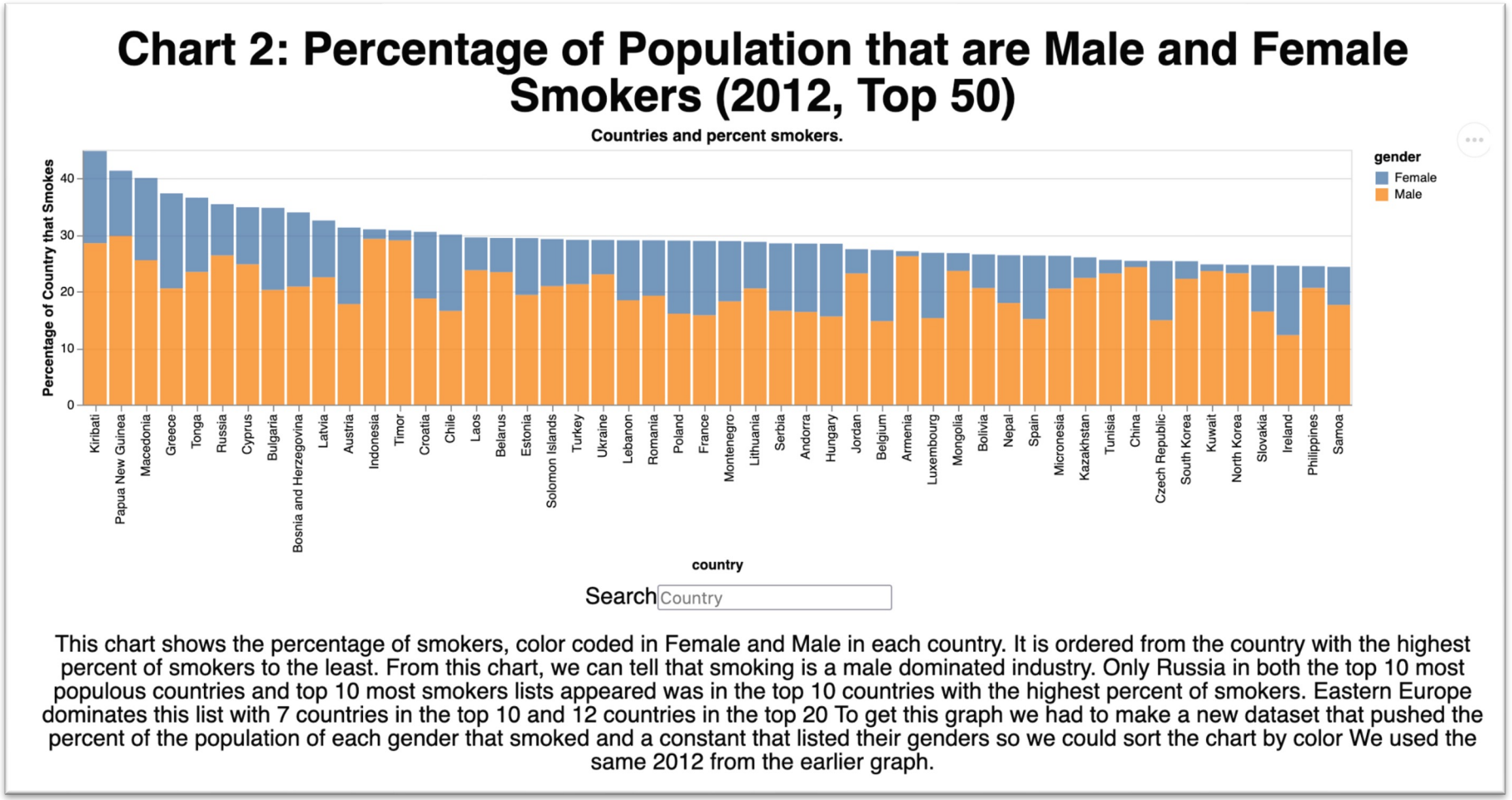


Computing with CORGIS: Diverse, Real-world Datasets for Introductory Computing (Bart et al.)

Example submission (Fall 2023)

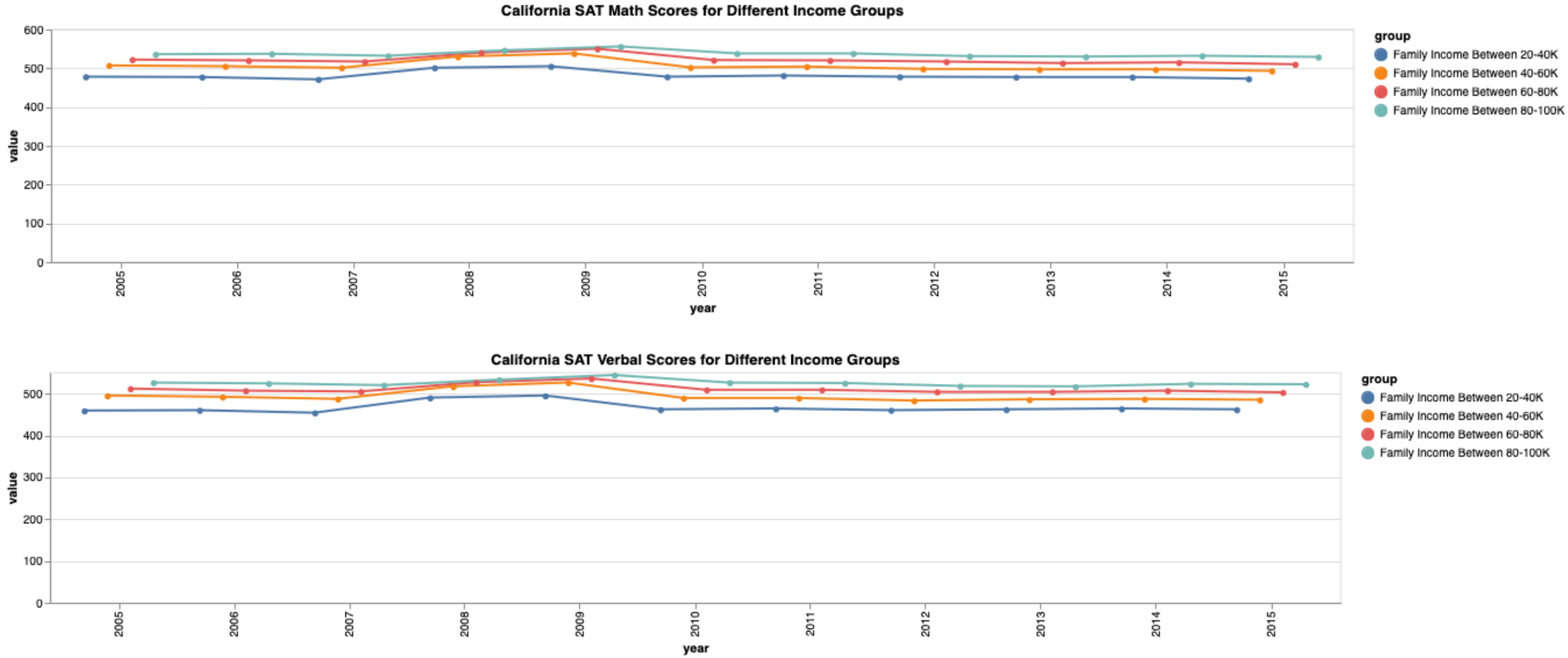
- This group examined a CORGIS dataset about billionaires
- Discussion about where billionaires come from and how they make their fortunes
- Found that a large proportion of billionaires (in the dataset) came from the healthcare and real estate industries
- Closed with an open-ended discussion about the ethics of being a billionaire

Example submission (Fall 2023)

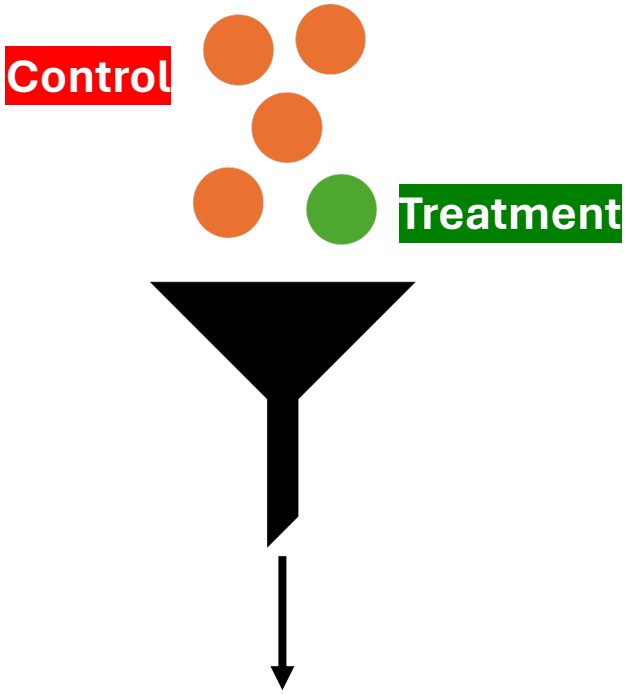


- This group studied (tobacco) smoking prevalence
- Looked for countries with high populations but low smoker counts (Mexico and Nigeria), and looked into their smoking laws
- Then showed that smoking is declining in the US, arguing that smoking restrictions indoors and near buildings is working

Example submission (Winter 2022)



But did they learn programming?



- Grades in follow-on courses
- Withdrawal, failing grade rates in follow-on courses
  - Follow-on courses taught in Python
  - By different instructors

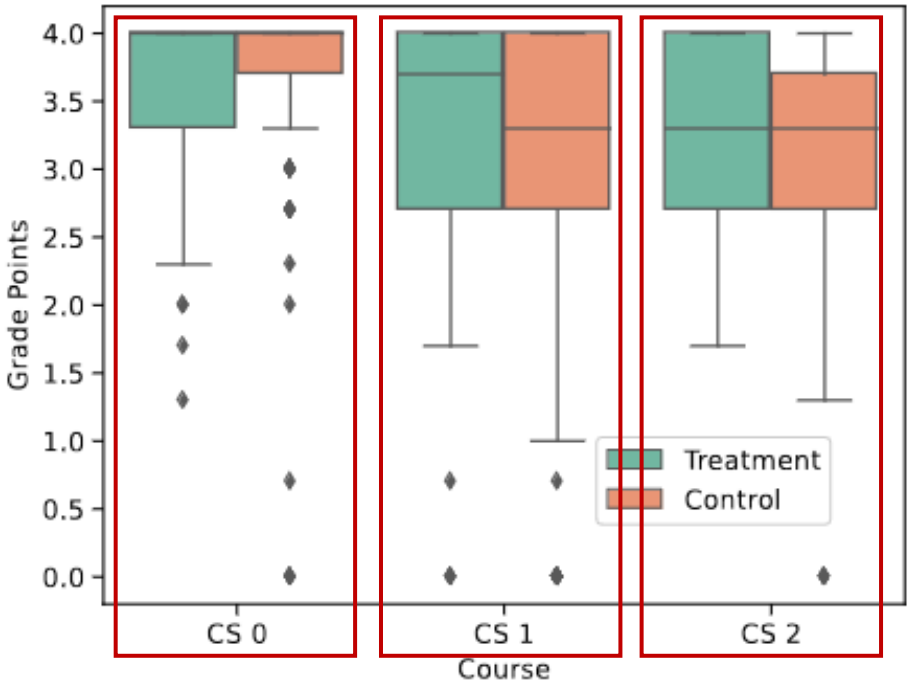


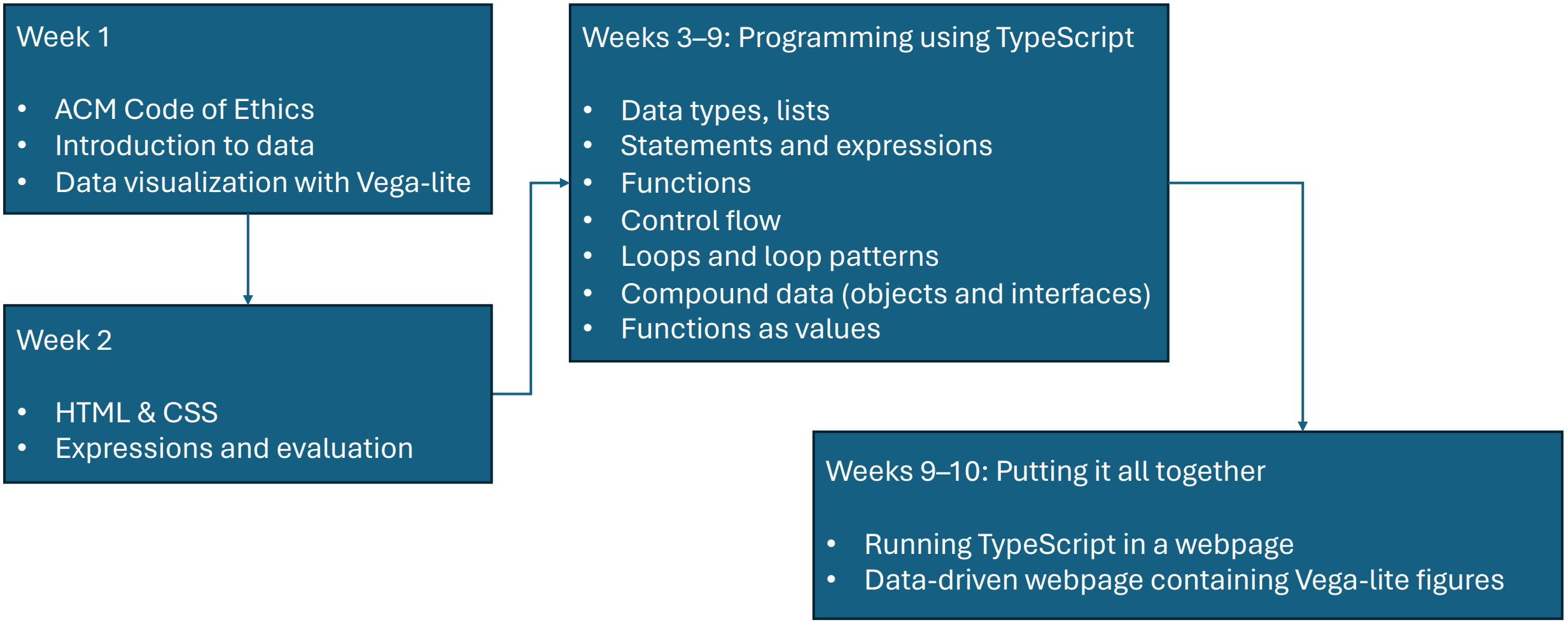
Figure 1: Distribution of grade points in CS0, CS1, and CS2 courses for students in the treatment and control groups.

Mixed approaches to CS0: Exploring Topic and Pedagogy Variance After Six Years of CS0 (Wood et al.)

Future work

- Part of a larger NSF-funded effort involving six CSU campuses (NSF #2216687)
  - You will hear from one of them next!
- Working with an external evaluator to measure changes in sense of belonging (across six campuses)
- We will also be able to look at 4–6 year persistence results soon

Course overview (highlights)



D, F, W rates

		CS0	CS1	CS2
# Students	**C**	133	125	107
	T	32	29	23
Median grade	**C**	A	B+	B+
	T	A	A–	B+
# Failing Grades	**C**	4 (3%)	18 (14.4%)	4 (3.7%)
	T	1 (3.1%)	4 (13.7%)	0 (0%)
# Withdrawals	**C**	0	1 (0.8%)	1 (0.9%)
	T	1 (3.1%)	1 (3.4%)	0 (0%)