

The data just got real

Preparing students to use statistics beyond the classroom

eCOTS
June 12, 2024

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Duke University



bit.ly/ecots24-beyond-the-classroom



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THE REAL WORLD

Source: [MTV](#)

“...when **data** stop being polite and start getting real.”

How to opt out of having your data ‘train’ ChatGPT and other AI chatbots

The reality: You are helping AI learn, whether you want to or not.



By [Shira Ovide](#)

May 31, 2024 at 12:30 p.m. EDT

[Washington Post](#)

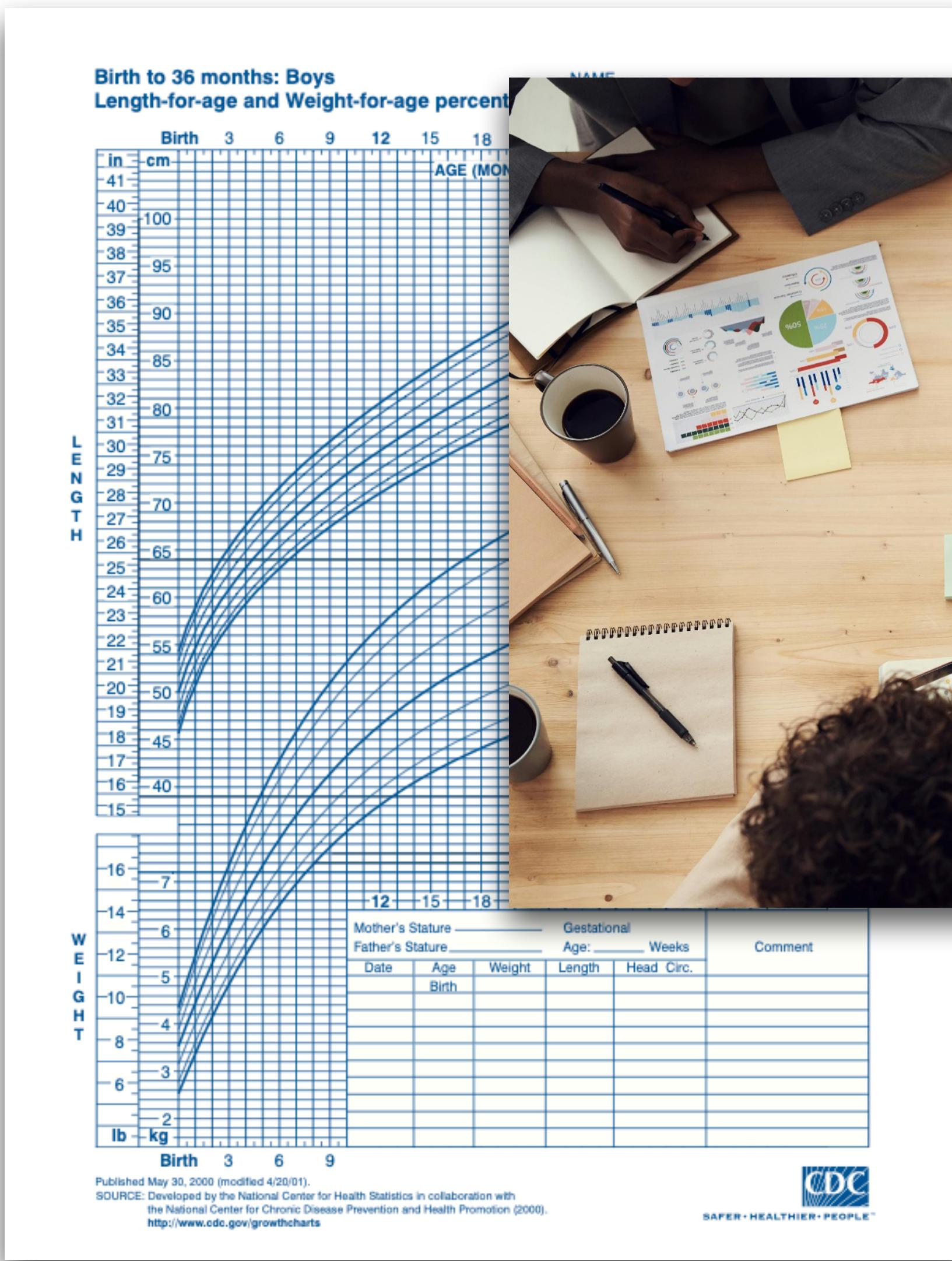
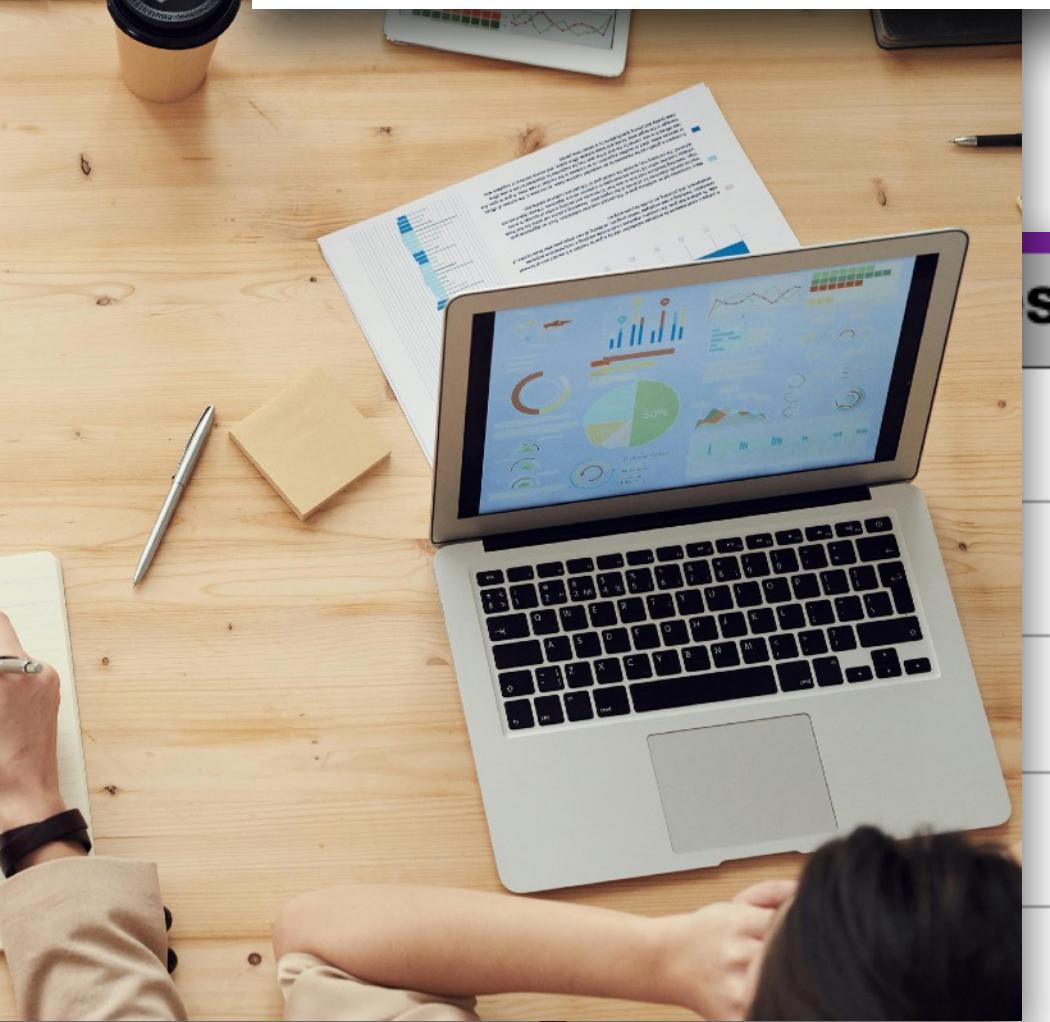


Photo by [fauxels](#)



resident_data	spend_per_resident_points	basketball_data
\$62.00	30	2.4
\$65.00	27.5	2.2
\$62.00	10	2.2
\$58.00	6	2.3
\$59.00	6	2.2
\$68.00	7	2.2
\$63.00	6	2.2
\$64.33	6	2.2
\$60.11	5	NA
\$115.00	63	1.4

[Trust for Public Land](#)

Student
experience in
statistics/ data
science course(s)



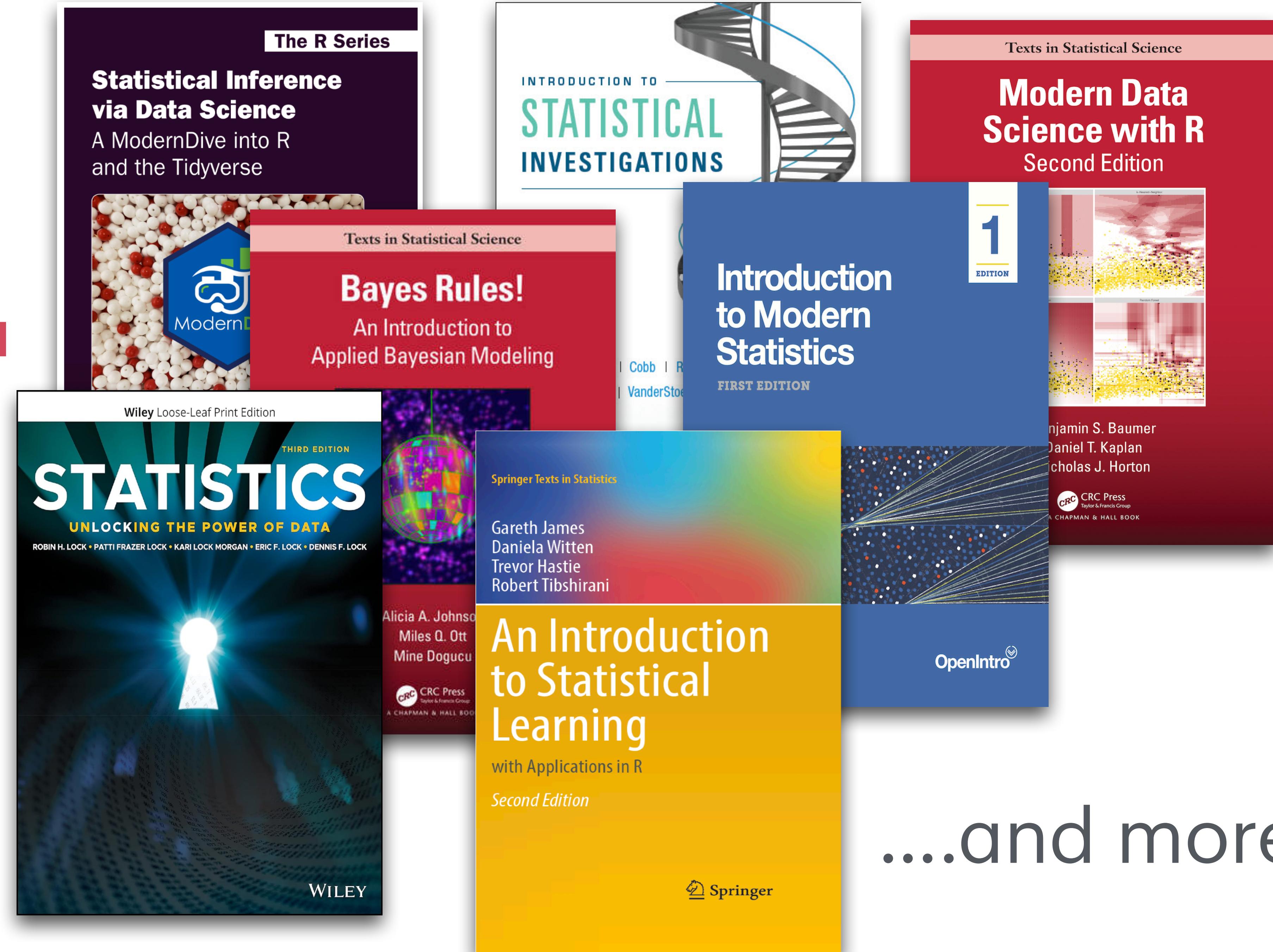
Student
experience in
the “real world”

Student
experience in
statistics/ data
science course(s)



Student
experience in
the “real world”

Methods to process, visualize, & analyze data





Computing

Communication

Collaboration

Ethics

the “other” skills

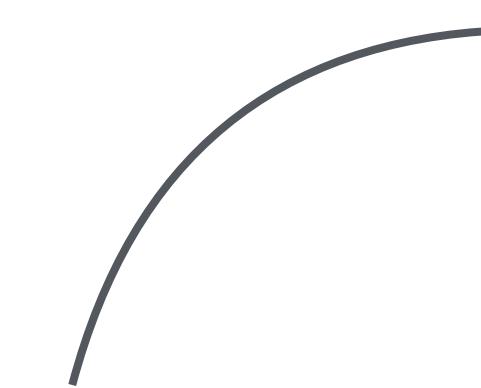
Curriculum guidelines: More than methods

- "...facile with **professional statistical software and other appropriate tools** for data exploration, cleaning, validation, analysis, and communication."*
- "... write clearly, speak fluently, and construct effective visual displays and compelling written summaries....They should be able to **communicate complex statistical methods in basic terms** to managers and other audiences and visualize results in an accessible manner."*
- "...demonstrate ability to **collaborate in teams** and to organize and manage projects."*
- "...exposure to and **ethical training** in areas such as citation and data ownership, security and sensitivity of data, consequences and privacy concerns of data analysis, and the professionalism of transparency and reproducibility."**

* ASA Undergraduate Guidelines Workgroup (2014), *Curriculum Guidelines for Undergraduate Programs in Statistical Science*

** De Veaux, R. D., Agarwal, M., Averett, M., Baumer, B. S., Bray, A., Bressoud, T. C., ... & Ye, P. (2017). Curriculum guidelines for undergraduate programs in data science. *Annual Review of Statistics and Its Application*, 4, 15-30.

“This shift reflects the belief that **statistics is a universal discipline**, not just needed for a handful of students, but required for a number of disciplines and recommended for many others.”



Increased enrollment in AP statistics courses and introductory statistics courses at two-year colleges.

Computing

Communication

Collaboration

Ethics

Computing

Communication

Collaboration

Ethics

Teacher's Corner

Computing in the Statistics Curricula

Deborah Nolan & Duncan Temple Lang

Pages 97-107 | Received 01 Jul 2009, Published online: 01 Jan 2012

“ Cite this article

 <https://doi.org/10.1198/tast.2010.09132>

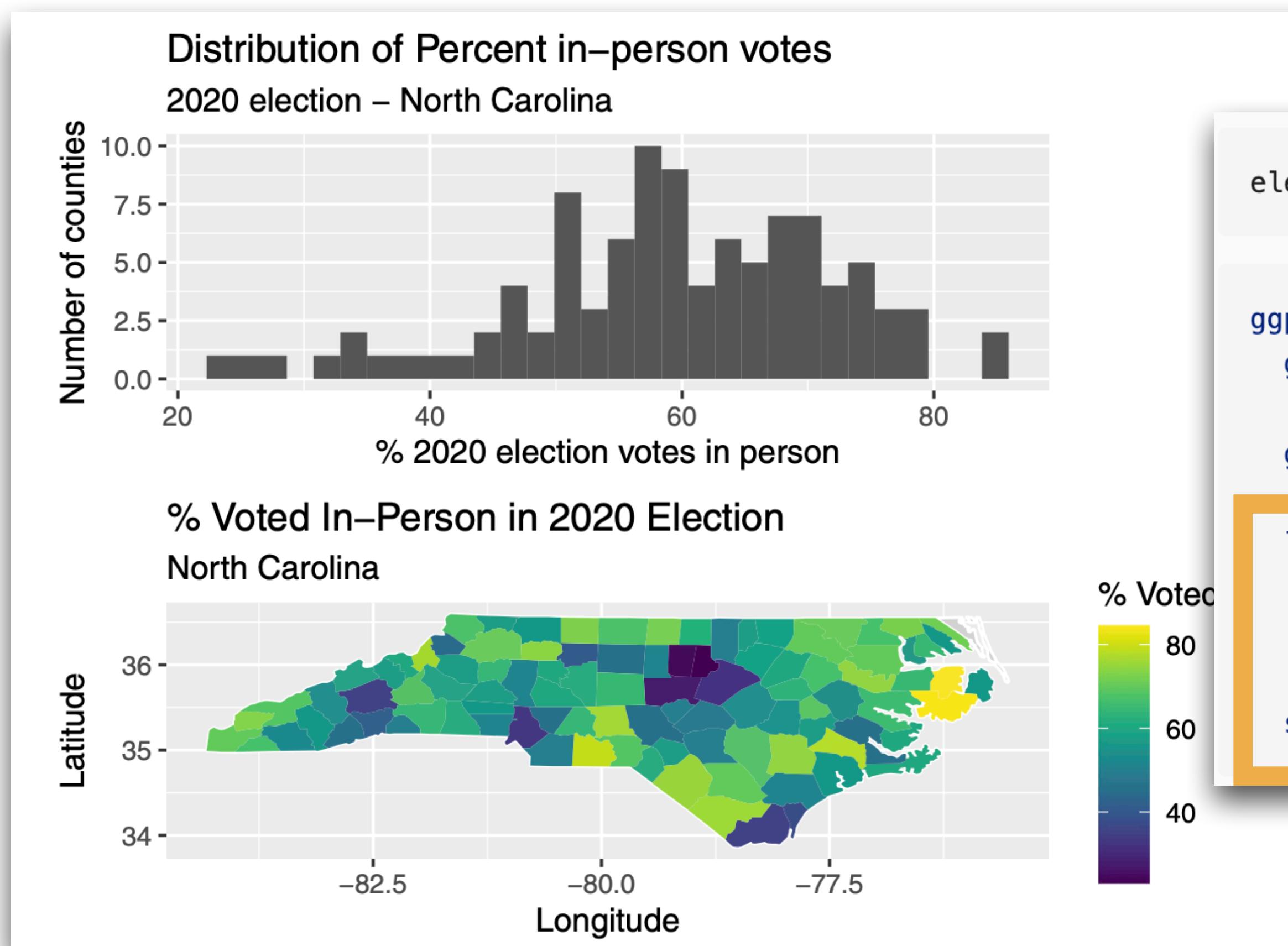
“The goal of teaching computing and information technologies is to remove obstacles to engagement with a problem.”

Teaching computing

- Opportunity for students to gain experience using **professional computing tools**
 - Ability to work with more **realistic and complex data**
 - Develop a **reproducible workflow** while learning statistical methods
- Give students experience with (exposure to) computing in **early courses**
 - Incorporate **more advanced skills** in subsequent courses
 - Reach a **broad and diverse** student population

Example: Assessing spatial dependence

Students visualize the distribution of the percentage of in-person votes in North Carolina counties in the 2020 election.



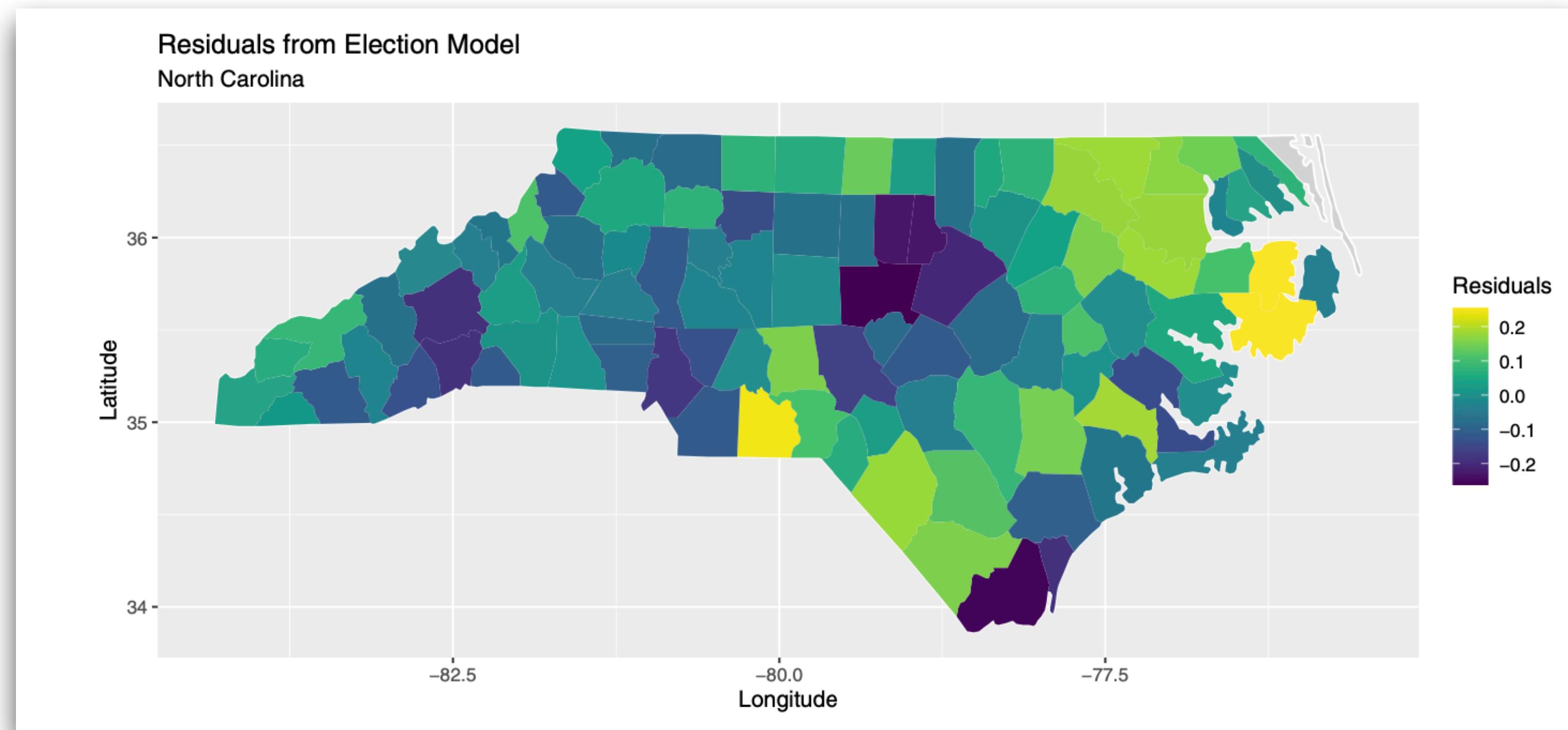
```
election_map_data <- left_join(election_nc, county_map_data)

ggplot() +
  geom_polygon(county_map_data, mapping = aes(x = long, y = lat, group = group),
              fill = "lightgray", color = "white") +
  geom_polygon(election_map_data, mapping = aes(x = long, y = lat, group = group,
                                                fill = inperson_pct)) +
  labs(x = "_____",
       y = "_____",
       fill = "_____",
       title = "_____") +
  scale_fill_viridis()
```

Example: Assessing spatial dependence

Students fit a linear regression model of the relationship between political leaning and percentage of in-person votes.

They plot the residuals on a map to assess the independence condition.



“Hint: Start with the code from Exercise 2.”

Computing

Communication

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The most underrated skill in Data Science: Communication

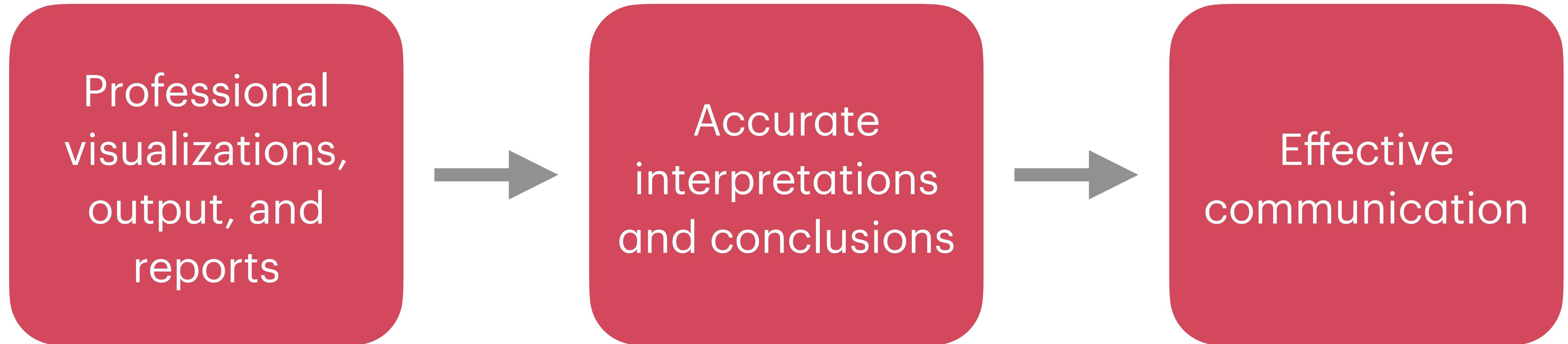


Karen Church · [Follow](#)

Published in intercom-rad · 7 min read · Jul 25, 2023

“...communication is the competency that is often the difference between a truly high performing data scientist and a data scientist who is simply good.”

Teaching written communication



Example: Analyze data and communicate results

Analysis objective

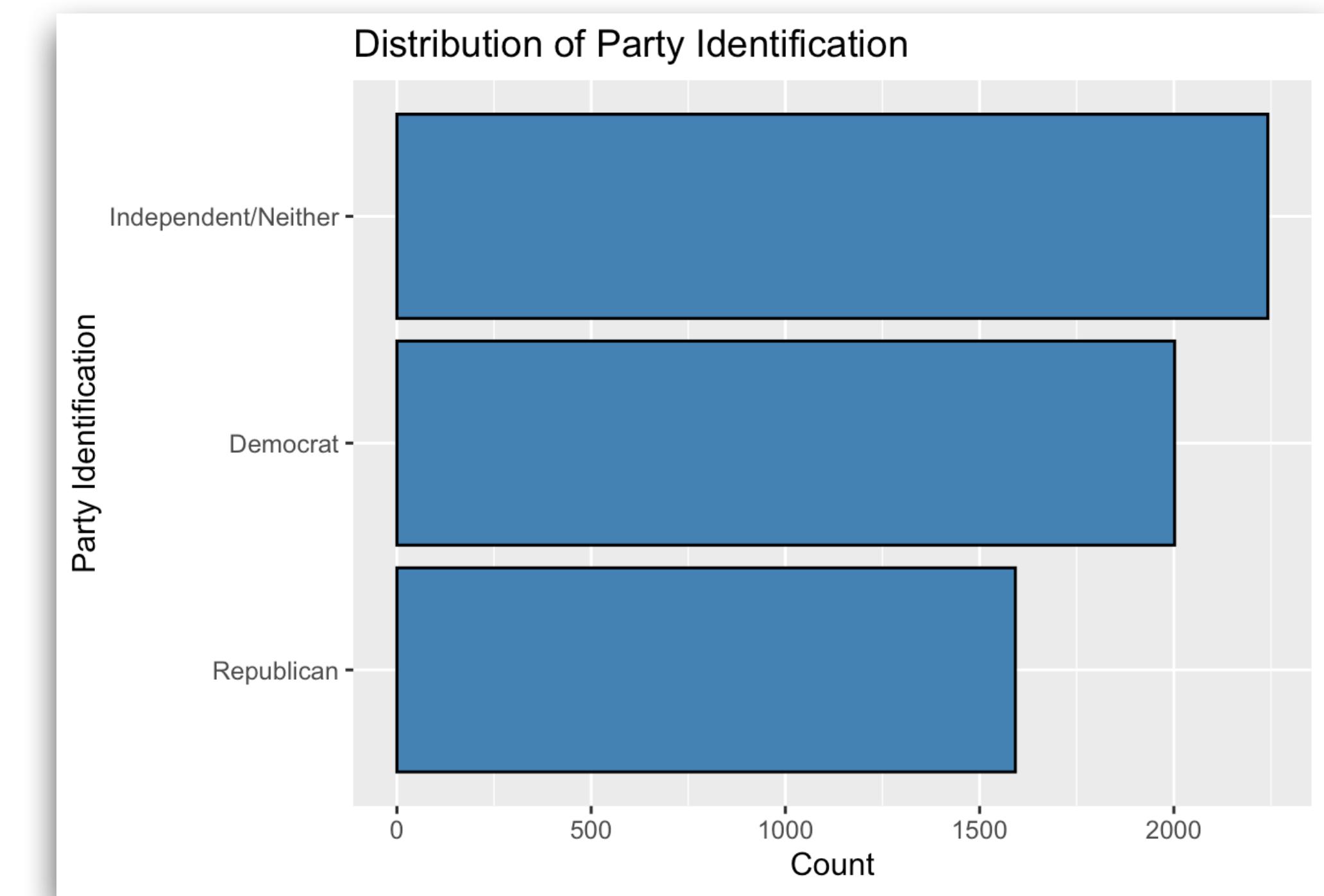
Analyze data from the FiveThirtyEight article “Why Many Americans Don’t Vote” to examine the relationship between political party identification and voting behavior of adults in the United States.

Example: Analyze data and communicate results

Students collapse the variable `party_id` into three levels and visualize the results.

```
voter_data <- voter_data |>  
  mutate(party_id = case_when(  
    Q30 == 1 ~ "Republican",  
    Q30 == 2 ~ "Democrat",  
    TRUE ~ "Independent/Neither"  
  ))
```

Data processing



Professional visualizations

Example: Analyze data and communicate results

After fitting an initial model, students conduct a hypothesis test to determine whether to include `party_id` in the model.

term	df.residual	residual.deviance	df	deviance	p.value
frequent_voter ~ ppage + educ + race + gender + income_cat	4366	5072.595	NA	NA	NA
frequent_voter ~ ppage + educ + race + gender + income_cat + party_id	4364	5052.151	2	20.444	0

Example: Analyze data and communicate results

After fitting an initial model, students conduct a hypothesis test to determine whether to include `party_id` in the model.

*“Our p-value is approximately 0. **Since it is very small, we reject H_0 .** The data provides sufficient evidence that at least one of the coefficients from `party_id` is not equal to 0. **Therefore, we should add `party_id` to the model.**”*

- Student response (emphasis mine)

Accurate interpretations

Example: Analyze data and communicate results

Students write a short paragraph summarizing the association between party identification and voting behavior.

“...The biggest difference between the odds is in the Independent/Neither party_id with the Republican and Democratic party_id respectively. This tells us that voters who identify as Independent or Neither are much less likely to be frequent voters than their Republican and Democratic counterparts. Whereas the odds between frequent voters who identify as being Republican and Democrat are similar.”

- Student response (emphasis mine)

Effective communication

Computing

Communication

Collaboration

Ethics

**Data science is a team sport.
Do you have the skills
to be a team player?**



IBM: Data science is a team sport.

Why incorporate teamwork?

Model collaborative and interdisciplinary nature of data-driven work in practice

Skills developed

- Communication
- Interpersonal
- Computing for collaborative work

Skills enhanced

- Statistical reasoning
- Problem solving
- Critical thinking
- Conceptual understanding

Strategies for effective teamwork

- Form **diverse teams** and avoid isolating students
- Keep the teams **consistent**
- Provide **guidance** on how to work on a team
- Incorporate regular **peer feedback and self-reflection**
- Dedicate time for teams to **work together during class**
- Start with a **team agreement**

Computing

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TECHNOLOGY

Cambridge Analytica made “ethical mistakes” because it was too focused on regulation, former COO says

“It felt like, well, once that was done, then we’ve done what we needed to do and we forgot to pause and think about, ethically, what was going on.”

by [Eric Johnson](#)

Jul 31, 2019, 6:20 AM EDT



Vox

TECHNOLOGY

How big data is helping states kick poor people off welfare

“These systems make our values visible to us in a way that calls us to a moral reckoning.”

by [Sean Illing](#)

Feb 6, 2018, 9:00 AM EST



Vox

AI researchers uncover ethical, legal risks to using popular data sets

The Data Provenance Initiative analyzed data sets used to build generative AI and found confusion surrounding licensing and fair use



By [Nitasha Tiku](#)

October 25, 2023 at 12:01 p.m. EDT

Washington Post

Opinion

Boeing’s manufacturing, ethical lapses go back decades

Jan. 22, 2024 at 2:19 pm | Updated Jan. 22, 2024 at 3:19 pm

The Seattle

Business And Society

The Ethics of Managing People's Data

The five issues that matter most by Michael Segalla and Dominique Rouziès

From the Magazine (July–August 2023)



[Harvard Business Review](#)

Ethical Guidelines for Statistical Practice

Prepared by the Committee on Professional Ethics of the American Statistical Association

[American Statistical Association](#)

McKinsey Digital

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Data ethics: What it means and what it takes

September 23, 2022 | Article

[McKinsey](#)

future tense

The Ethical Data Scientist

People have too much trust in numbers to be intrinsically objective.

BY CATHY O'NEIL

FEB 04, 2016 • 8:30 AM

[Slate](#)

Ethical considerations

What you're doing

- Data security and privacy
- Honest reporting
- Algorithmic bias
- ...

How you're doing it

- Reproducibility
- Transparency
- Treatment of others
- ...

What you're doing: Proxy variables

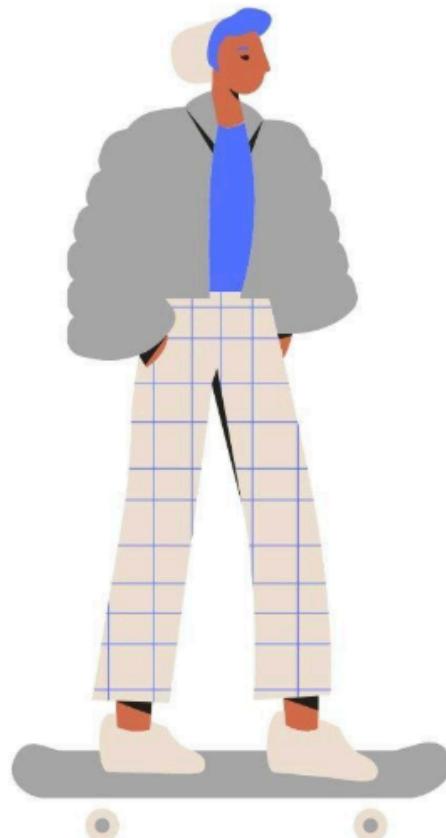
Redlining Analogy



Individual 1

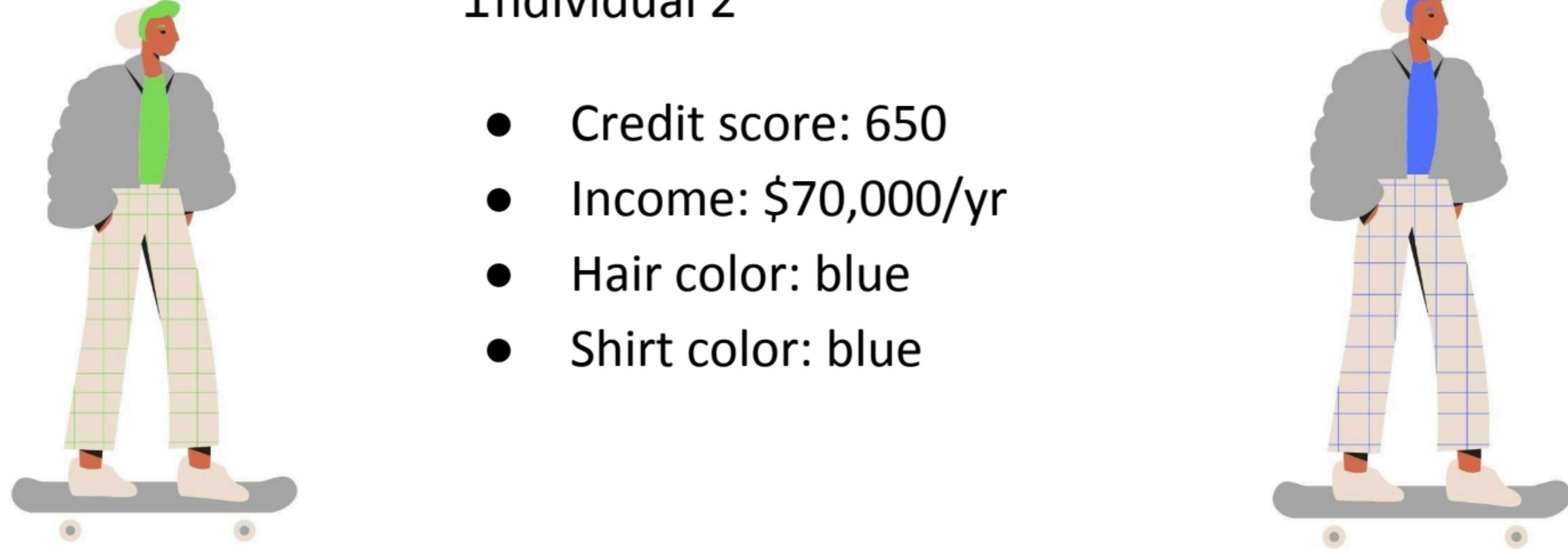


- Credit score: 650
- Income: \$70,000/yr
- Hair color: green
- Shirt color: green



What you're doing: Proxy variables

Redlining Analogy



A diagram illustrating the concept of proxy variables. On the left, a person with light brown skin, short dark hair, and a green shirt is standing on a skateboard. On the right, the same person is shown with light brown skin, short dark hair, and a blue shirt, also standing on a skateboard. A large blue arrow points from the first person to the second, indicating a transformation or change. Below the first person, the text "Individual 2" is written, followed by a bulleted list of four items:

- Credit score: 650
- Income: \$70,000/yr
- Hair color: blue
- Shirt color: blue

What you're doing: Proxy variables

Redlining Analogy

Individual 2

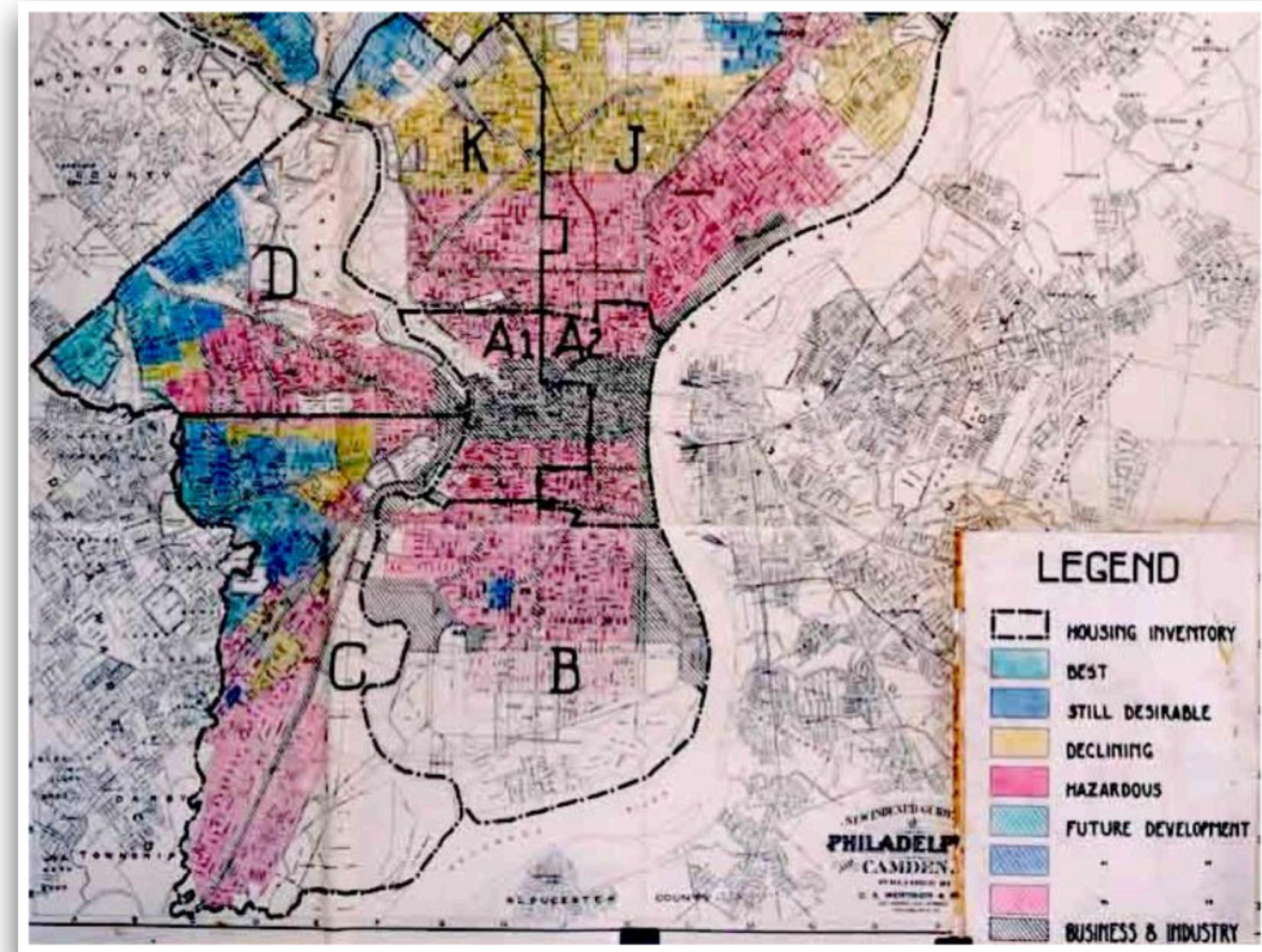
- Credit score: 650
- Income: \$70,000/yr
- **Race:** blue
- **Zip code:** blue

What you're doing: Proxy variables

“What are the ethical considerations of including hair color and shirt color in a model?”

What you're doing: Proxy variables

Redlining: Practice in the mid-20th century in which neighborhoods with a high percentage of Black residents were considered ineligible for government-backed mortgages



How you're doing it: Course policy on using AI

- **Use of artificial intelligence (AI):** You should treat AI tools, such as ChatGPT, the same as other online resources. There are two guiding principles that govern how you can use AI in this course:² (1) *Cognitive dimension:* Working with AI should not reduce your ability to think clearly. We will practice using AI to facilitate—rather than hinder—learning. (2) *Ethical dimension:* Students using AI should be transparent about their use and make sure it aligns with academic integrity.
 - **AI tools for code:** You may make use of the technology for coding examples on assignments; if you do so, you must explicitly cite where you obtained the code. Any recycled code that is discovered and is not explicitly cited will be treated as plagiarism. You may use [these guidelines](#) for citing AI-generated content.
 - **No AI tools for narrative:** Unless instructed otherwise, AI is not permitted for writing narrative on assignments. In general, you may use AI as a resource as you complete assignments but not to answer the exercises for you. You are ultimately responsible for the work you turn in; it should reflect your understanding of the course content.

sta210-fa23.netlify.app/syllabus

Guiding principles*

Cognitive dimension: AI should facilitate, not hinder, learning

Ethical dimension: Be transparent about use and make sure it aligns with academic integrity

*Adapted from [Policies related to ChatGPT and other AI tools](#) by Joel Gladd

Final thoughts

- **Start small:** Slowly incorporate the “other” skills in your course
- **Be intentional:** Include these skills in the course learning objectives
- **Explain why:** Get student buy-in
- **Be open:** Try new things and get student feedback early

Computing

Communication

Collaboration

Ethics

incrementally

^ Bridge the gap
between the
classroom and the
“real world”

Thank you!

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bit.ly/ecots24-beyond-the-classroom

References

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Courses I teach



Introduction to
Data Science



Regression
Analysis*



Generalized
Linear Models

* Described in Tackett, M. (2023). Three principles for modernizing an undergraduate regression analysis course. *Journal of Statistics and Data Science Education*, 31(2), 116-127.