Implementing GAISE Recommendations for Teaching Introductory Statistics

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GAISE

- Guidelines for Assessment and Instruction in Statistics Education
- Recommendations for teaching introductory statistics at college level
  - Comparable guidelines at PreK-12 level
- Developed by American Statistical Association
  - Originally in 2005, revised in 2016
- www.amstat.org/education/gaise

GAISE recommendations

1. Teach statistical thinking.
2. Focus on conceptual understanding.
3. Integrate real data with a context and purpose.
4. Foster active learning.
5. Use technology to explore concepts and analyze data.
6. Use assessments to improve and evaluate student learning.

1. Teach statistical thinking

- Example: Sex discrimination?

	Men	Women
Accepted	533	113
Denied	665	336
Total	1198	449

- Men: 533/1198 ≈ .445 were accepted
- Women: 113/449 ≈ .252 were accepted
- Does this provide evidence of discrimination against women?

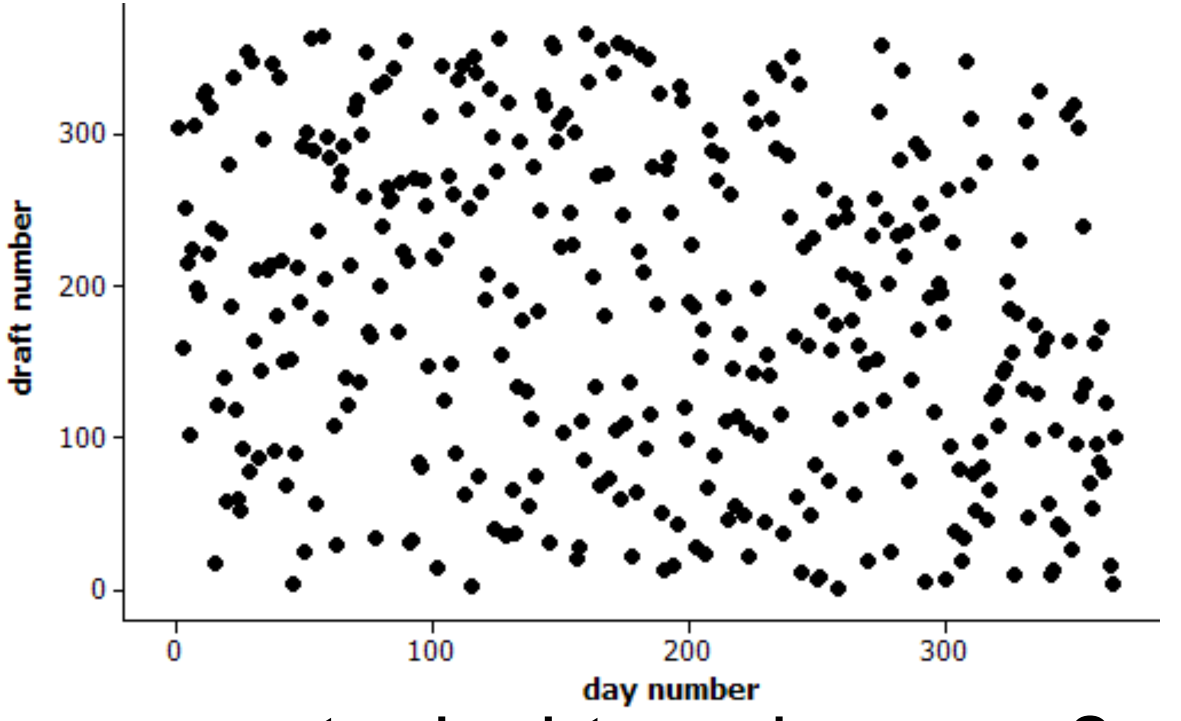
1. Teach statistical thinking

	Men		Women	
	Accepted	Denied	Accepted	Denied
Program A	511	314	89	19
Program F	22	351	24	317
Total	533	665	113	336

- Program A
  - Men: 511/825 ≈ .619
  - Women: 89/108 ≈ .824
- Program F:
  - Men: 22/373 ≈ .059
  - Women: 24/341 ≈ .070
- What's odd about this?
- How can you explain the oddity?

1. Teach statistical thinking

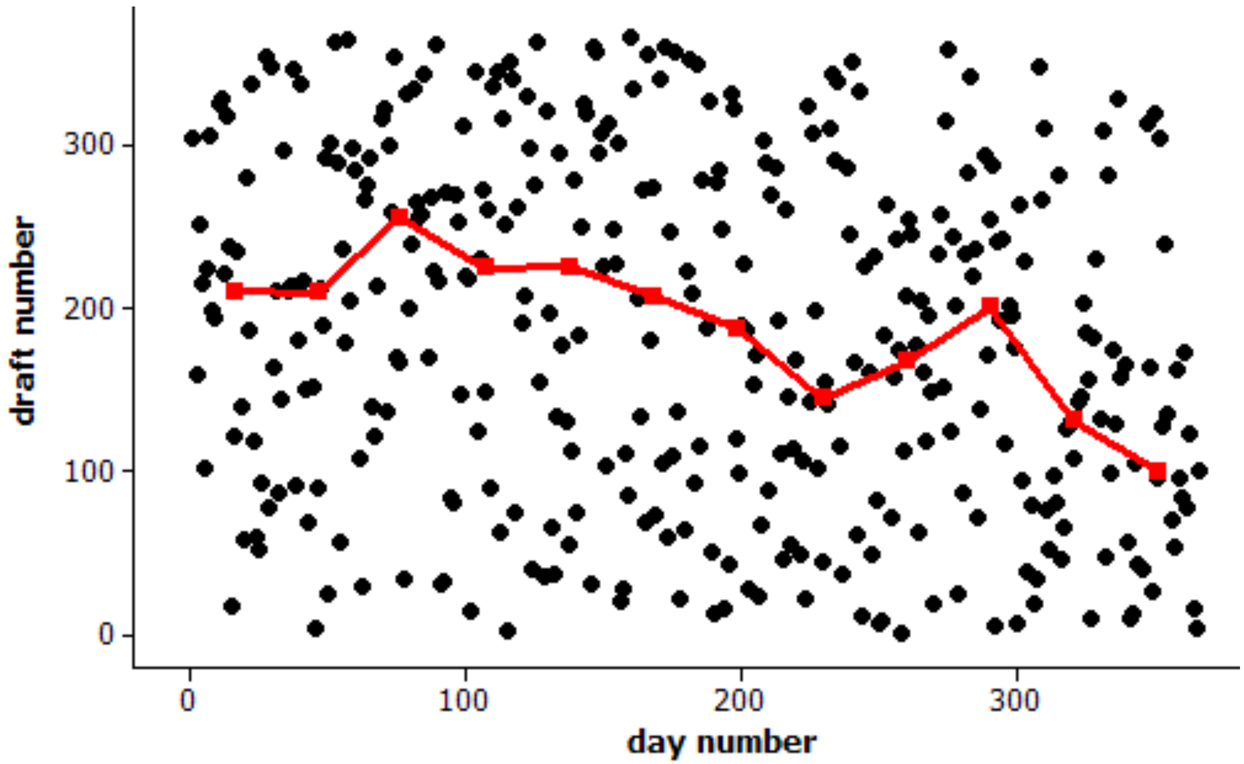
- Example: 1970 Draft Lottery



- Any reason to doubt randomness?
- Calculate median for each month.

1. Teach statistical thinking

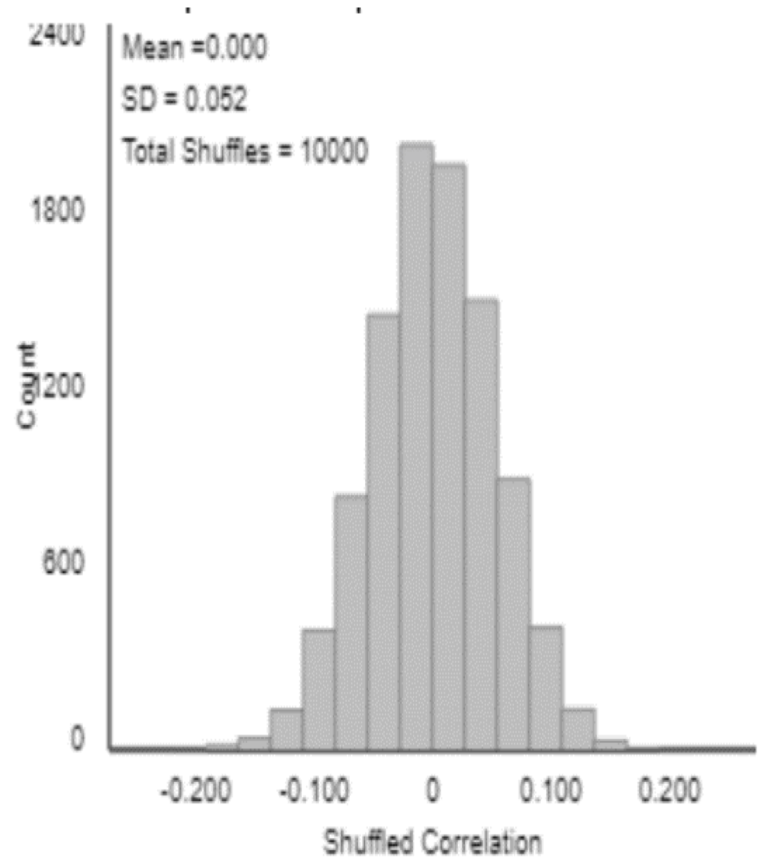
- Example: 1970 Draft Lottery



- Any reason to doubt randomness?

Statistical thinking

- How often would such an extreme outcome occur with a truly random lottery?
- What statistic might you use to determine "extreme"-ness?
  - Correlation ≈ -0.226



1. Teach statistical thinking

- Engage in proportional reasoning
- Think about alternative explanations
- Use summary statistics to help with distinguishing signal from noise
- Investigate random chance as an explanation

- Fairly sophisticated thinking
  - But uncomplicated mathematics

Interlude 1: Intro stat enrollments

- 2015 CBMS Survey

TABLE S.2 Total enrollment (in 1000s), including distance-learning enrollment, by course level in undergraduate mathematics, statistics, and computer science courses taught in mathematics and statistics departments at four-year colleges and universities, and in mathematics programs at two-year colleges in fall 2000, 2005, 2010, and 2015.

	Mathematics Departments				Statistics Departments				Two-Year College Mathematics Programs			
Course level	2000	2005	2010	2015	2000	2005	2010	2015	2000	2005	2010	2015
Probability and Statistics courses												
Introductory level	136	148	231	253	54	54	81	94	74	117	137	280
Upper level	35	34	32	60	20	24	27	50	0	0	0	0

- Look at this growth! Especially at TYCs
- < 20% of intro stat taught in Stat departments

2. Focus on conceptual understanding

- Example: Averages

When I moved from Pennsylvania to California, I believe that the average IQ dropped in both states.

Is this possible (in principle)?

If so, what would have to be true?

2. Focus on conceptual understanding

- Example: Variability/SD

Suppose that Abby records the ages of customers at The Avenue (on-campus snack bar) from 11am-2pm today, while Mary records ages of customers at McDonald’s (near freeway).

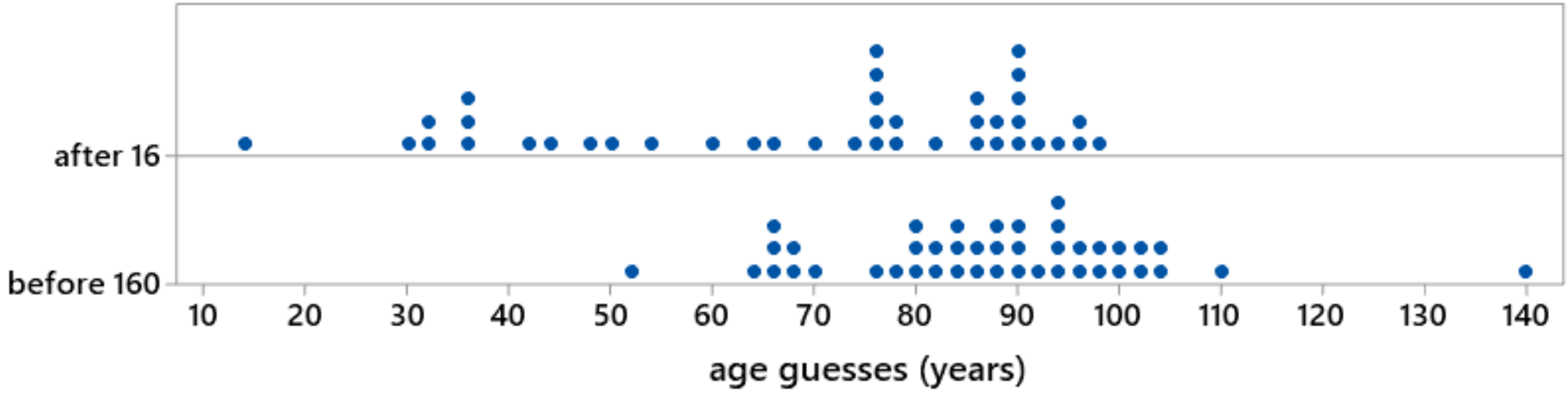
Who will have the larger standard deviation of customer ages: Abby or Mary? Explain.

3. Integrate real data

- Example: Anchoring
  - Group 1: Nelson Mandela was the first president of South Africa following apartheid.
    - Do you think he was older or younger than 16 years old when he died?
    - Make a guess for how old he was when he died.
  - Group 2: Nelson Mandela was the first president of South Africa following apartheid.
    - Do you think he was older or younger than 160 years old when he died?
    - Make a guess for how old he was when he died.

3. Integrate real data

- Example: Mandela's age



- *t* = -4.17; p-value ≈ .0000
- Very strong evidence for anchoring effect

3. Integrate real data

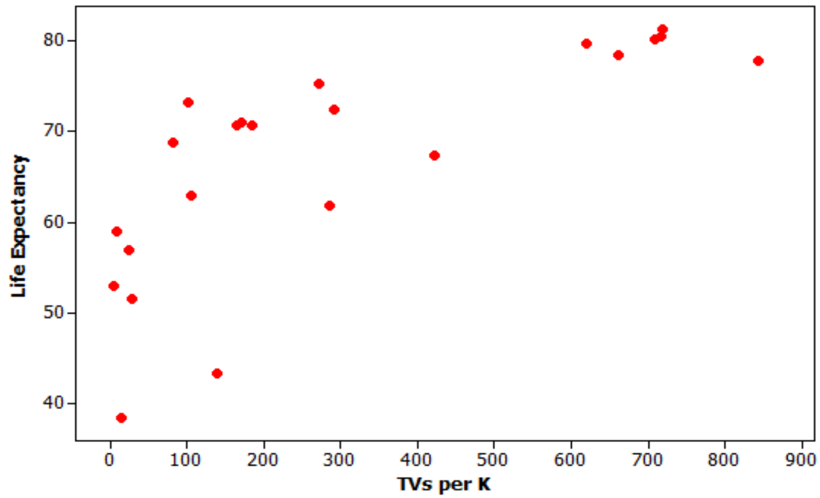
- Example: Facial prototyping

Do people tend to associate names with faces? (Lea, Thomas, Lamkin, & Bell, 2007)

Who is on the left: Bob or Tim?

4. Foster active learning

- Example: Televisions and life expectancy



- Is there an association?
- Can we infer causation?
- Could we make predictions?

4. Foster active learning

- Example: Gettysburg Address

- Select a sample of 10 words from the population of 268 words in the Gettysburg Address. (Just circle 10 words.)
- Record the length (# of letters) of each word.
- Calculate the average length for your sample.
- Produce graph of sample averages.

4. Foster active learning

- Example: Gettysburg Address
- Is this a reasonable sampling method?

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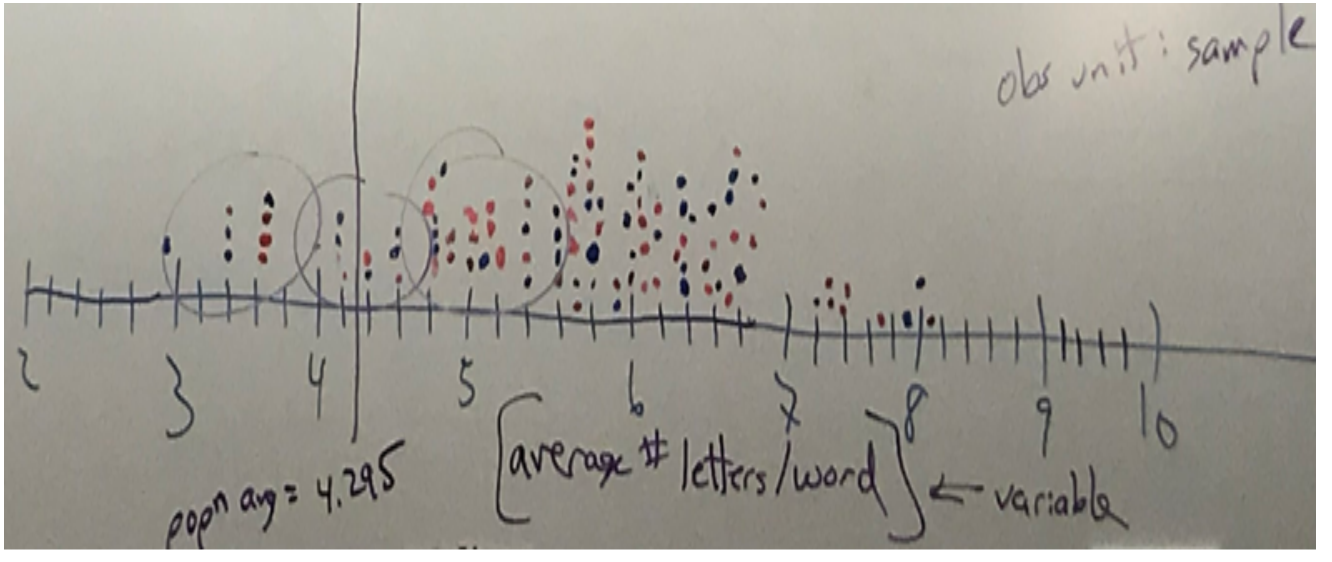
- Example: Gettysburg Address

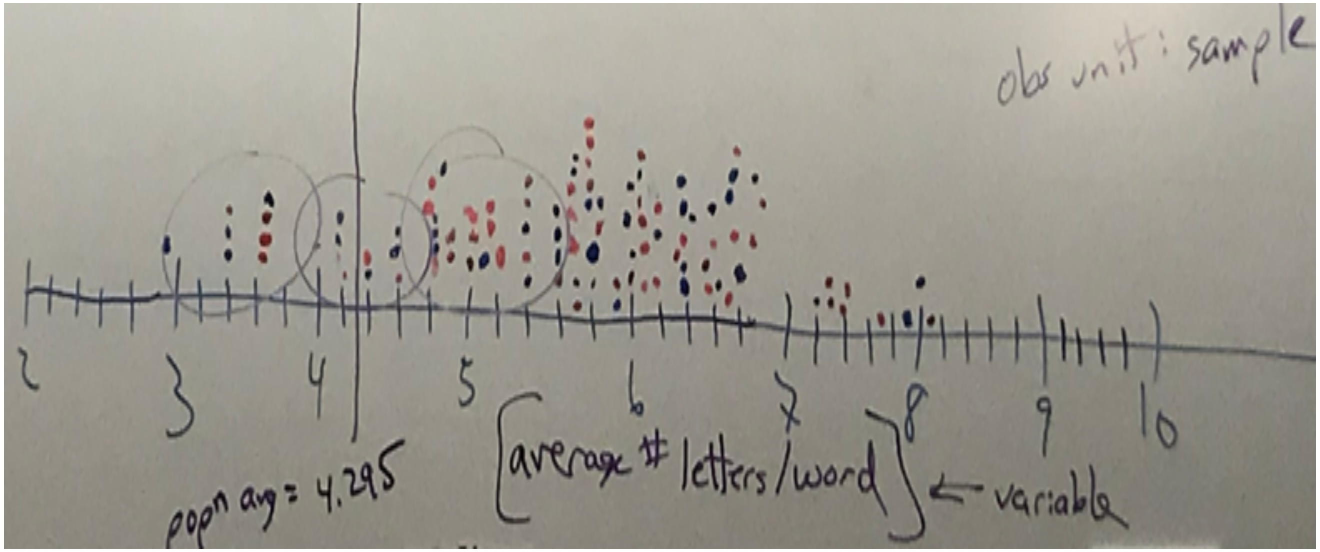
- Is this a reasonable sampling method?



4. Foster active learning

- Example: Gettysburg Address

- How does this graph indicates sampling bias?



- Would closing eyes and pointing be unbiased?

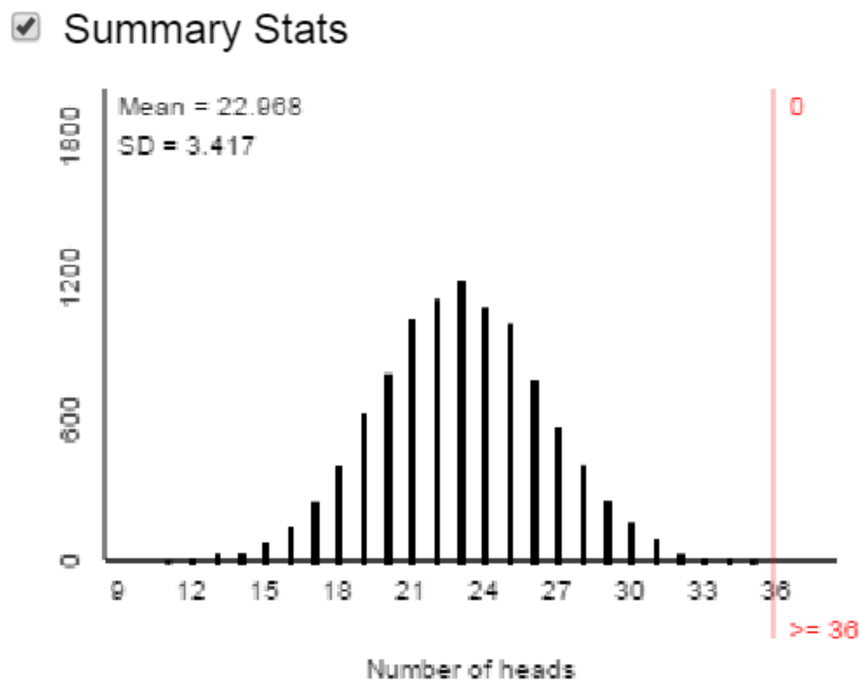
4. Foster active learning

Example: Facial prototyping (cont)

- 36 of 46 students put Tim on the left
  - What are two possible explanations for our observed sample result?
  - Which explanation can we investigate/model? How?
  - How often would such an extreme sample result occur by chance alone (if there were no facial prototyping)?
  - Have students flip coins to investigate

5. Use technology to explore concepts

- Facial prototyping: 10,000 simulated samples of 46 students



- Very strong evidence: people tend to put Tim on left

6. Use assessments to improve learning

- Example: Anchoring (Mandela's age)

a) What are the observational units in this study?

b) What are the variables in this study? Which type is which variable? Which variable plays which role?

c) Did this study make use of random sampling, random assignment, both, or neither?

d) Is this an observational study or an experiment?

6. Use assessments to improve learning

- Example: Anchoring (Mandela's age)

e) Summarize your conclusion from the (approximate) p-value.

f) Estimate magnitude of effect with confidence interval.

g) Is it reasonable to draw a cause-and-effect conclusion? Explain why or why not.

h) Is it reasonable to generalize the results to all people? Explain why or why not.

6. Use assessments to improve learning

- Example (adapted from Jay Lehmann):

a) Which would be larger – the mean weight of 10 randomly selected people or the mean weight of 1000 randomly selected cats? Explain briefly.

b) Which would be larger – the standard deviation of the weights of 1000 randomly selected people or the standard deviation of the weights of 10 randomly selected cats? Explain briefly.

Interlude 2: My cats

New emphases in GAISE revision

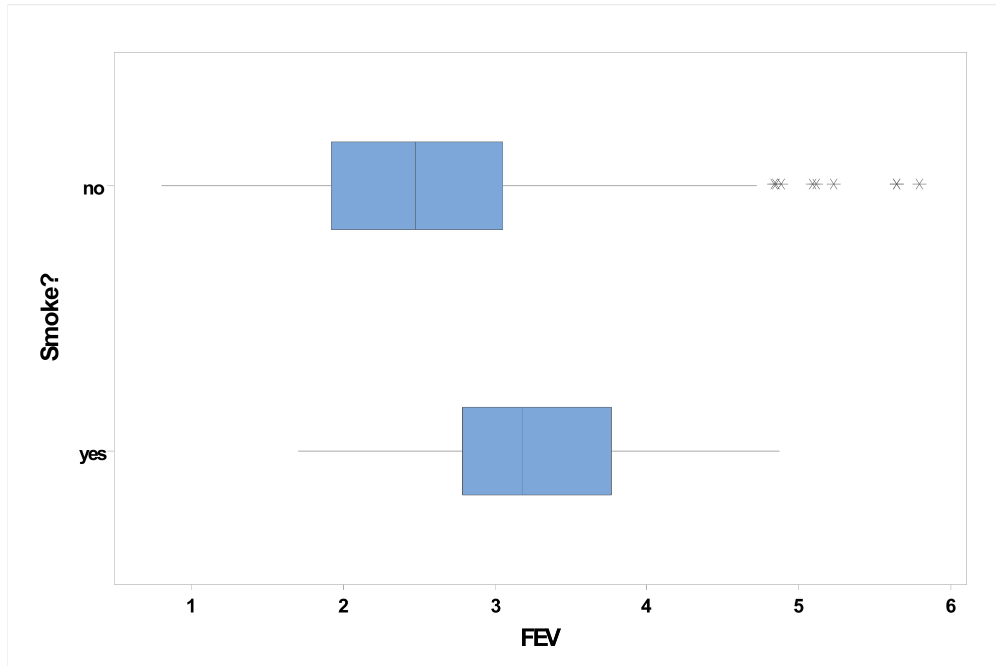
1. Teach statistical thinking
   a) Teach statistics as investigative process of problem-solving and decision-making
   b) Give students experience with multivariable thinking

1a. Investigative process

- Assessment example: Collect data on transactions at campus snack bar – student/not, day of week, amount of transaction, waiting time
  - State a research question for which a two-sample *t*-test would be appropriate
  - State a research question for which two-proportion *z*-test would be appropriate
  - State a research question for which one-sample *t*-interval would be appropriate

1b. Multivariable thinking

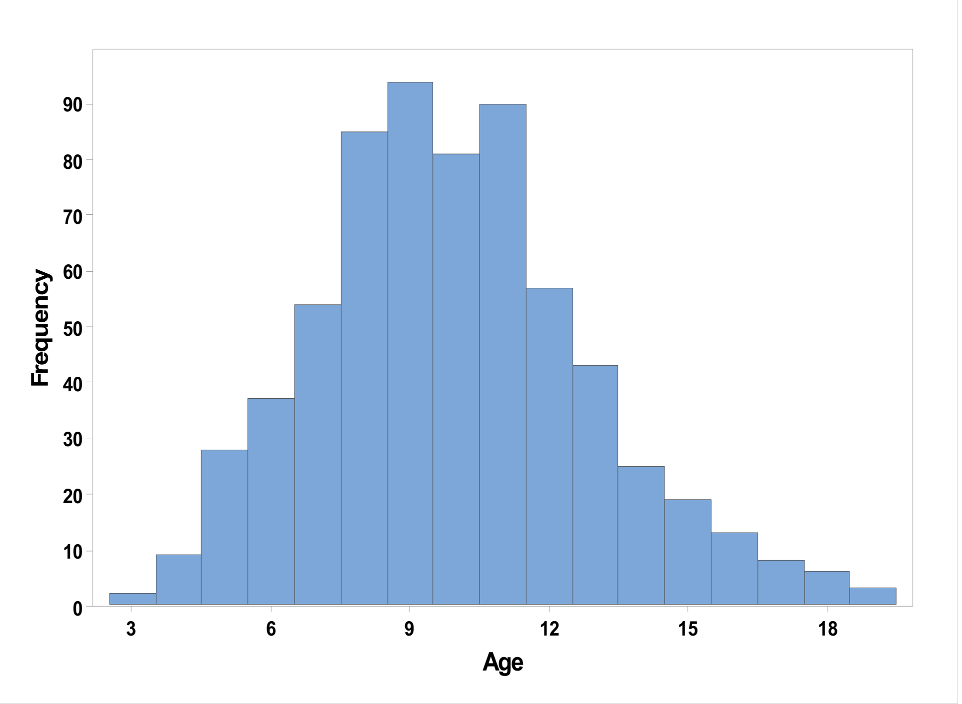
- Example: Lung capacity and smoking



- $t = 7.15$
- p-value ≈ .0000
- What's going on here???

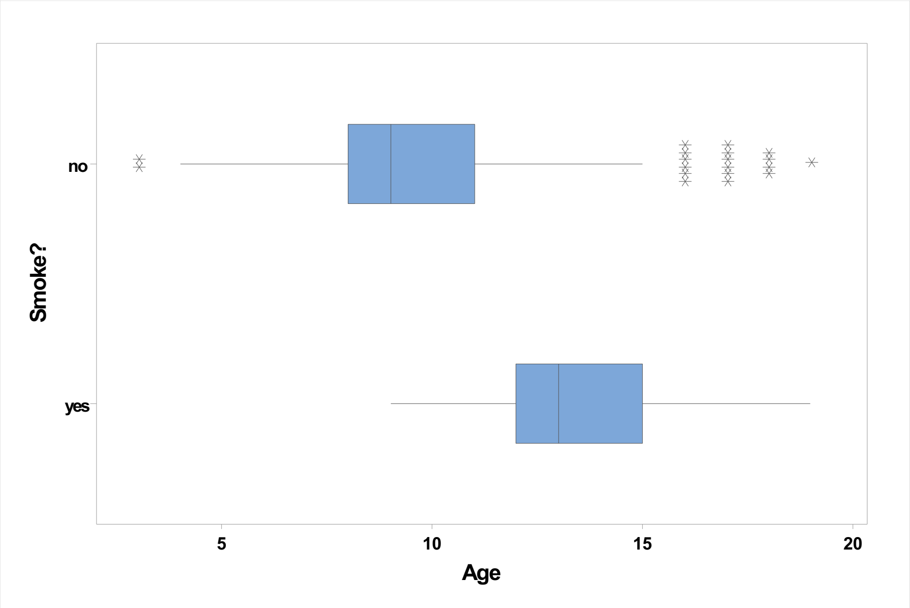
1b. Multivariable thinking (cont)

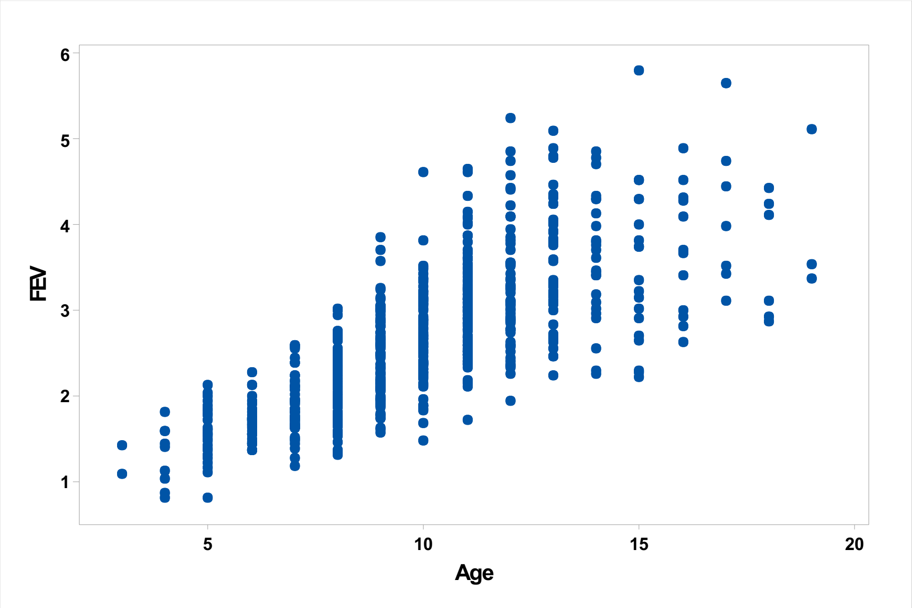
- Confounding variable
- These data are from children aged 3 – 19
- How does age explain why smokers have significantly larger lung capacities than non-smokers?



1b. Multivariable thinking (cont)

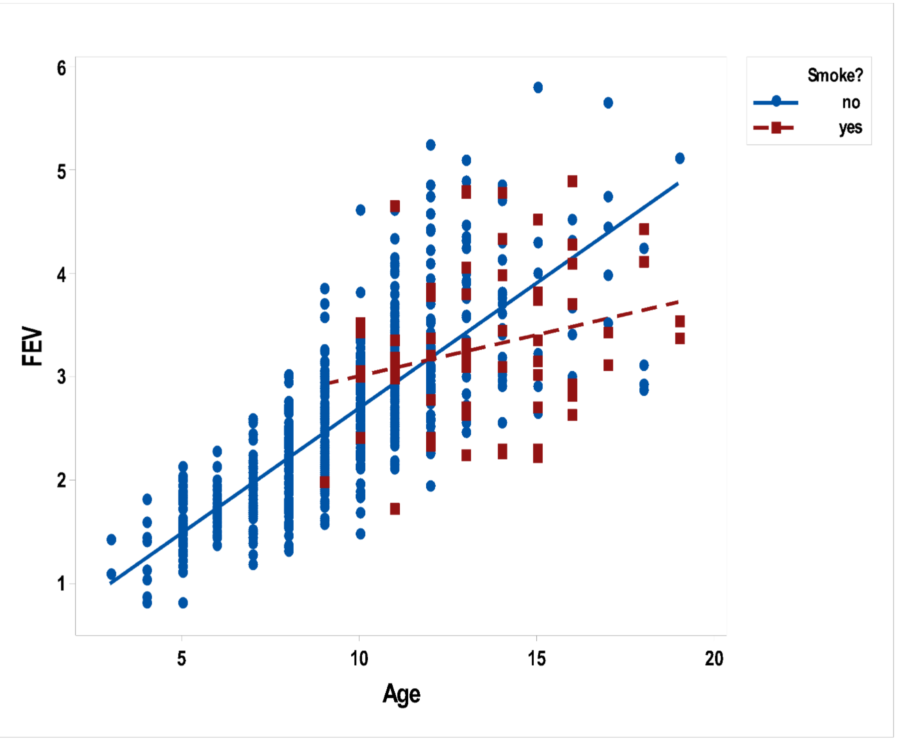
- Age is associated with both smoking status and lung capacity





1b. Multivariable thinking (cont)

- After controlling for age, smokers have smaller lung capacity than non-smokers (12 or older)
- Rate of increase in lung capacity per year of age is smaller for smokers than for non-smokers



Interlude 3: My teaching philosophy

- What's the key to being a successful singer?
  - Sing Good Songs

Interlude 3: My teaching philosophy

- What's the key to effective teaching?
  - Ask Good Questions
  - https://askgoodquestions.blog

Ask Good Questions blog

- Ideas, examples, activities, assessments, and advice for teaching introductory statistics
  - Practical, for direct use with students
  - Thought-provoking, for discussion with peers
  - Conversational style, perhaps even fun (?)
  - New post published on Mondays at 8am PT
  - 2000-3000 words per essay
  - Goal: 52 essays by end of June 2020
    - 45 posted thus far

A pervasive pet peeve

- 2017 Youth Risky Behavior Surveillance Survey

Seat belt use when riding with someone else driving	Arizona	California
Rarely or never	173	103
Sometimes, most of the time, or always	1966	1675
Total	2139	1778
Proportion who responded “rarely or never”	0.081	0.058

- Were Arizona youths 2.3% more likely to respond “rarely or never” than California youths?
- No! The Arizona percentage was 2.3 *percentage points* higher than California’s.

A pervasive pet peeve

- Percentage difference:

  $(.081-.058)/.058 \times 100\% \approx 39.6\%$
- Arizona youths were 39.6% more likely than California youths to respond “rarely or never”
- Relative risk: $.081/.058 \approx 1.396$
- Arizona youths were 1.396 times more likely than California youths to respond “rarely or never”
- % difference = (relative risk – 1) × 100%

A pervasive pet peeve

- Potential title: *A persnickety post that preaches about a pervasive, persistent, and pernicious pet peeve concerning percentages* (60% P-words)
- Actual title: *A pervasive pet peeve* (75%)
- So, is this a 15% increase in % of P-words?
  - No, that's the pet peeve!
  - Actually a 25% increase

GAISE goals for introductory students

1. Become ***critical consumers***.
2. Be able to apply ***investigative process***.
3. Produce and interpret results of ***graphical displays*** and ***numerical summaries***.
4. Recognize and explain fundamental role of ***variability***.
5. Recognize and explain central role of ***randomness*** in designing studies and drawing conclusions.

Goals for introductory students (cont)

6. Gain experience with ***statistical models***, including multivariable ones.
7. Demonstrate understanding of, and ability to apply, ***statistical inference*** in variety of settings.
8. Interpret and draw conclusions from standard output of ***statistical software***.
9. Demonstrate awareness of ***ethical issues*** associated with sound statistical practice.

GAISE Appendices

A. Evolution of Introductory Statistics
B. Multivariable Thinking
C. Activities, Datasets, and Projects
D. Examples of Using Technology
E. Examples of Assessment Items
F. Learning Environments

Breakout discussions

- How do you already incorporate, or plan to incorporate, GAISE recommendations into your teaching?