Teaching Introductory Statistics: Implementing GAISE Recommendations

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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.

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

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.

Requests

- Please play the role of student today
  - Engage with activities
  - Try to experience from students' perspective
    - Well-behaved student, not problem student!
- Also keep your instructor hat on
  - Feel free to ask questions throughout
- Thanks for coming
  - Time is our most precious asset

Introductions

- Name, school
- How would you describe your comfort level with teaching statistics?
  - 1: Terrified, feel like I know nothing!
  - 2: Some comfort, but lots to learn
  - 3: Fairly comfortable, but still a ways to go
  - 4: Quite comfortable, always looking for new ideas
  - 5: I know everything, just here to stir up trouble!

Frank Sinatra

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

My similarly succinct suggestion

- What's the secret to being an effective teacher?
  - "Ask Good Questions"

What kinds/purposes of questions?

- Guide students to develop their understanding and skills
  - Formative assessment
  - Learning activities
- Assess what students have learned
  - Summative assessment
  - Quiz/exam questions

Descriptive statistics

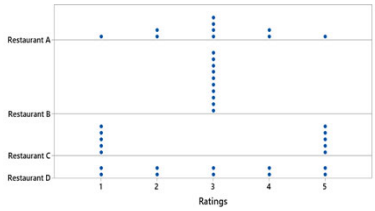
- I suspect that when I moved from PA to CA, the average IQ dropped in both states!
  - Is this possible?
  - What would have to be true (in principle) for this to happen?
- Yes, if (my IQ > average IQ in PA) and (my IQ < average IQ in CA)

Descriptive statistics

- 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.

Descriptive statistics

- Arrange the four restaurants in order from smallest SD of ratings to largest SD of ratings



Descriptive statistics

- 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.

Descriptive statistics

- Many of my students think that larger sample size produces smaller SD
- Do not realize that SD **of the sample mean** (or sample proportion) gets smaller as sample size increases
- Advice: When you talk about SD, always emphasize SD **of what**

Descriptive statistics

- Exam scores have mean 70, SD 8
  - Arturo's score is 75
  - Bella's score is 1.5 SDs above Arturo's
- What is Bella's score on the exam?
  - Concept: Measuring distance as number of SDs away from *something*
  - Not necessarily away from *mean*

Descriptive statistics

- Suppose that every student in our class scored 5 points lower on the second exam than on the first exam.
- What would be the value of the correlation coefficient between *exam1 score* and *exam2 score*?
  - Options: -5, -1, -0.5, 0, 0.5, 1, 5

Probability

- 2018 General Social Survey
  - 47% had a pet dog
  - 25% had a pet cat
- Does it follow that 72% (which is 47% + 25%) had a pet dog or a pet cat?
  - What would be required for this to happen?
- No!
  - Would require that *no* households have both

Probability

- Roll a fair, six-sided die
- Record number of dots on side that lands up
- Expected value = 3.5
- Do you really *expect* to see 3.5 dots?
- Interpret what expected value means here

My cats

Create your own example

- Create an example of 10 exam scores such that the mean is at least 20 points less than the median and the IQR = 0.
- Create an example with 100 dog owners and 50 cat owners, such that the proportion of dog owners who have taken their pet to a vet in the past year is more than two times larger than the proportion of cat owners who have taken their pet to a vet in the past year.

Create your own example

- Suppose that you want to test whether one-third of all adults in your county have a tattoo. Create an example of a sample with 500 people such that the two-sided p-value is less than .01.
- Create an example of 10 body temperatures such that the sample mean is 98.0 and a 95% CI for the population mean does not include the value 98.6.

Create your own question

- Observational units:
  - Transactions at the on-campus snack bar
- Variables:
  - Wait time
  - Amount of purchase
  - Number of items
  - Method of payment (credit, Cal Poly card, cash)
  - Day of week
  - Time of day (morning, afternoon, evening)

Create your own question

- State a research question for which it would make sense to produce comparative dotplots.
- State a research question for which it would make sense to calculate a correlation coefficient.
- State a research question for which it would make sense to conduct a chi-square test of association.

"Ask Good Questions" blog

- Ideas, examples, activities, assessments and advice for teaching introductory statistics
- Goals
  - Practical, for direct use with students
  - Thought-provoking, for discussion with peers
  - Casual writing style, fun to read
- One post/essay per week
  - Published on Mondays at 11am ET, 8am PT
  - 2000-3000 words per essay
  - 35 so far, 17 (at least) more to come

A recent post: 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.

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- 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"

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- 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 recent post: 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!

"Ask Good Questions" blog

- Sign up to receive weekly email messages containing post
- Post #1 answers ten questions
- Peruse annotated list of posts

https://askgoodquestions.blog/posts

Let's get started!