Six Ways to Integrate GAISE into Your Introductory Statistics Course

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Outline

- What are the Guidelines for Assessment and Instruction in Statistics Education (GAISE)?
  - New emphases introduced in 2016
- Three ways to integrate GAISE in *what* we teach
- Three ways to integrate GAISE in *how* we teach
- Where does data science fit in?

GAISE College Report

- *Guidelines for Assessment and Instruction in Statistics Education* (GAISE) College Report endorsed by the ASA in 2005
- Primarily focused on the introductory statistics course at two- and four-year institutions
- First three focus on *what* to teach in introductory courses
- Second three focus on *how* to teach introductory courses
- Revised report with new emphases added in 2016.

GAISE College Report

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

Statistical Literacy, Reasoning, and Thinking

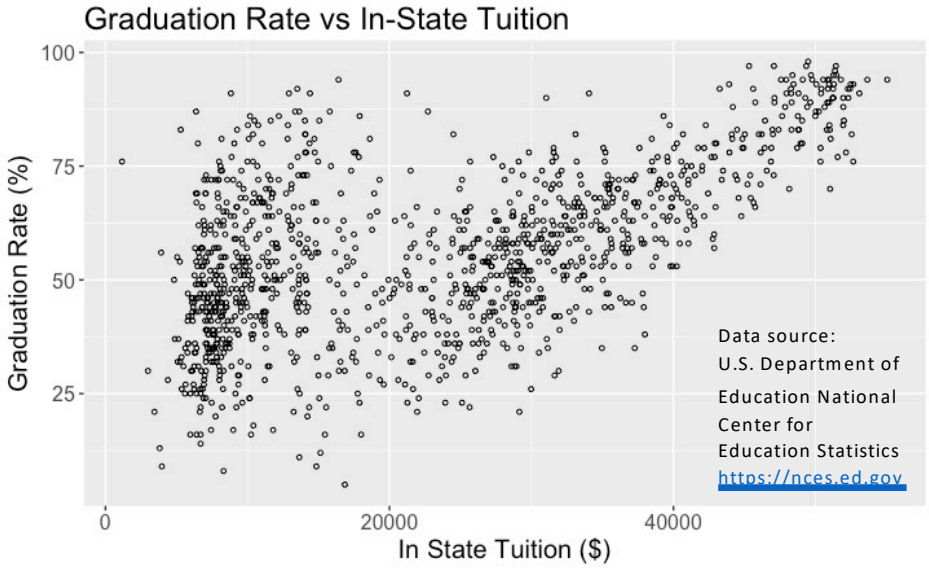
Ben-Zvi and Garfield (2004):

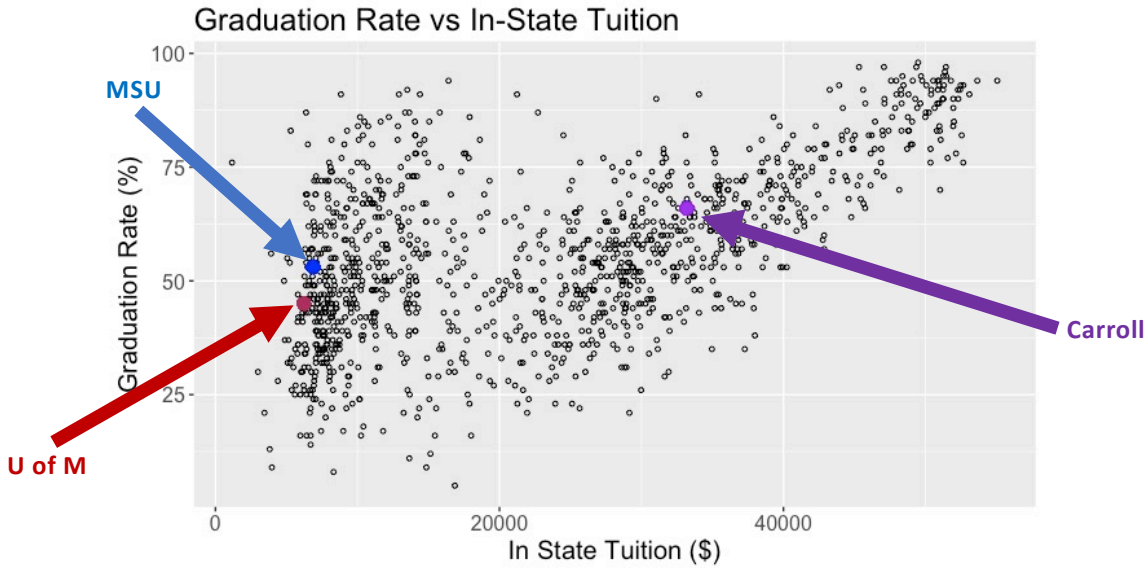
- ***Statistical literacy*** includes basic and important skills that may be used in understanding statistical information or research results.
- ***Statistical reasoning*** may be defined as the way people reason with statistical ideas and make sense of statistical information.
- ***Statistical thinking*** involves an understanding of why and how statistical investigations are conducted and the "big ideas" that underlie statistical investigations.

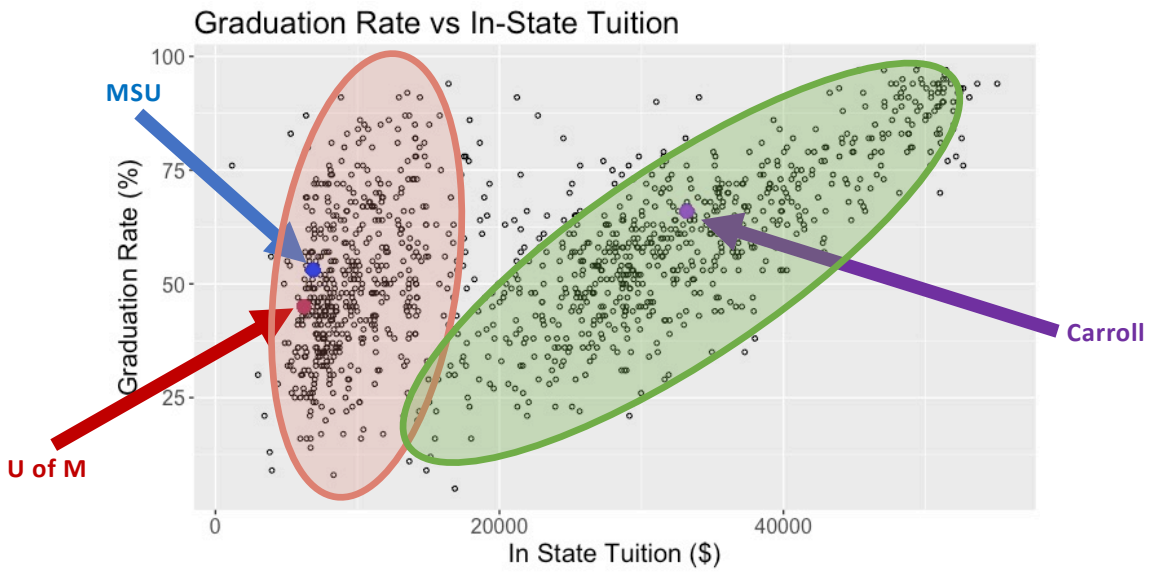
BOZEMAN DAILY CHRONICLE Nov 8, 2017

A Montana legislator in a guest column writes:

"A scatter-plot graph of tuition versus graduation rates in the 50 states reveals a strong correlation– low tuition is associated with low graduation rates, high with high."


Graduation Rate vs In-State Tuition
Graduation Rate (%)
100
75
50
25
0
20000
40000
In State Tuition ($)
Data source:
U.S. Department of
Education National
Center for
Education Statistics
https://nces.ed.gov


Graduation Rate vs In-State Tuition
MSU
U of M
Carroll
Graduation Rate (%)
100
75
50
25
0
20000
40000
In State Tuition ($)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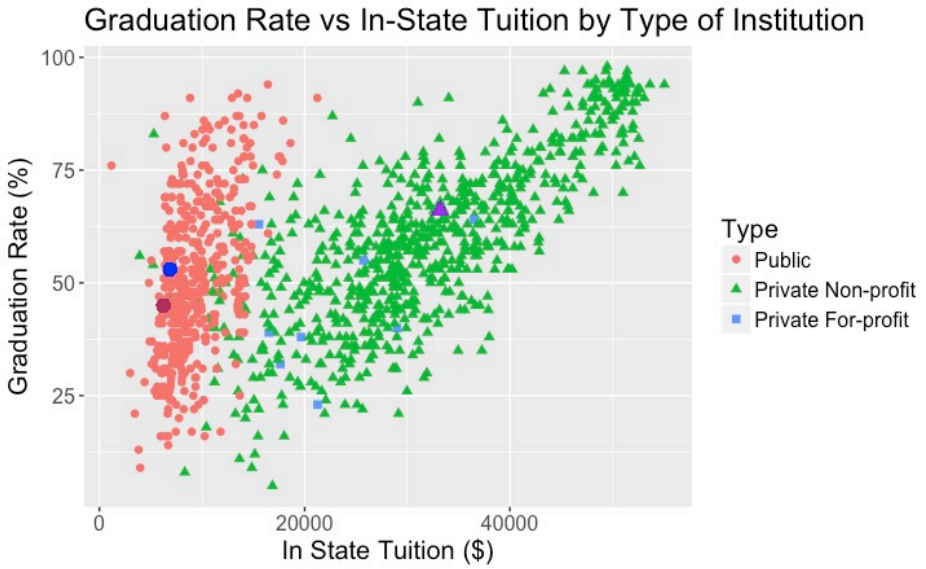
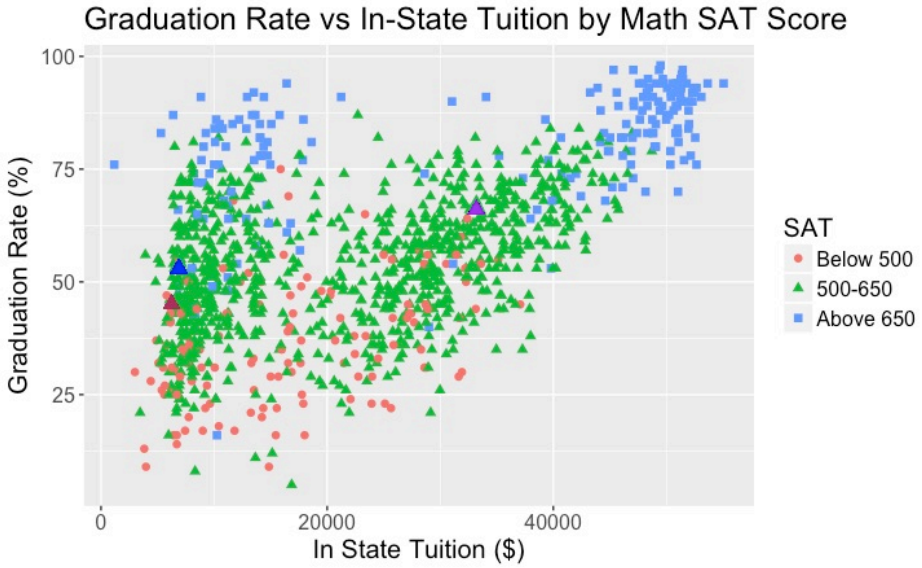

Graduation Rate vs In-State Tuition by Type of Institution
Graduation Rate (%)
100
75
50
25
0
20000
40000
In State Tuition ($)
Type
Public
Private Non-profit
Private For-profit



BOZEMAN DAILY CHRONICLE

Nov 8, 2017

"The clear expectation is that taxpayers should fork over escalating amounts to keep tuition low… [but] low tuition *spurs* a high dropout rate." (emphasis added)

1. Data visualization

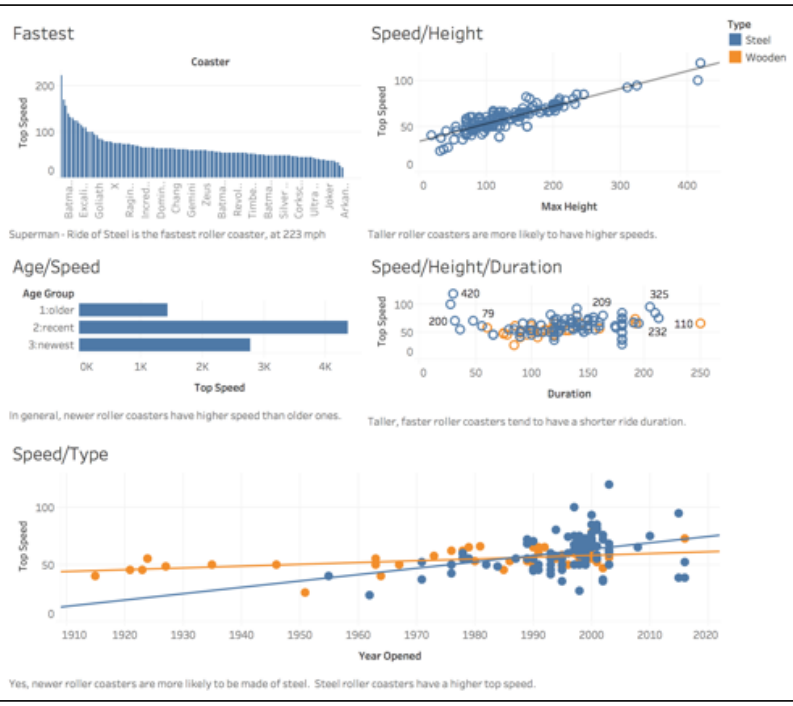
- Exploratory data analysis with multiple variables can be introduced in the first week of the intro course
- Tableau is a data visualization software that
  - is powerful and authentic,
  - is free for academic use,
  - provides a platform for sharing work,
  - has a drag-and-drop interface that facilitates data exploration,
  - produces quality graphics without requiring programming skills
  - requires minimal training in how to use the software.

Example: Roller Coaster Data

- Sample of 157 roller coasters in the US that opened between 1915 and 2016
- 15 Variables: Coaster, Park, City, State, Type, Design, Year Opened, Top Speed, Max Height, Drop, Length, Duration, Inversions?, # of Inversions, Age Group
- Data from Roller Coaster DataBase (https://rcdb.com/) and https://www.UltimateRollerCoaster.com/
- Activity questions from ESTEEM: Enhancing Statistics Teacher Education with E-Modules (http://hirise.fi.ncsu.edu/project/esteem/)
- Activity worksheet posted at: http://www.math.montana.edu/courses/s216/TableauActivityS18.pdf

Example: Roller Coaster Data

1. How fast is the fastest roller coaster? What is the name of this roller coaster?
2. Do newer roller coasters seem to have higher top speed than older ones? Create a data visualization that answers this question.
3. Are newer roller coasters more likely to be made of steel than older ones? What about roller coasters with a high top speed?
4. Is there a relationship between top speed and maximum height? Describe this relationship.
5. Investigate some other factors that you think might have a relationship with top speed. Create a Dashboard comprised of data visualizations which you think summarize the relationship between top speed and at least two other variables that seem to be related to top speed. Add text to the Dashboard and write a few sentences describing what you find.



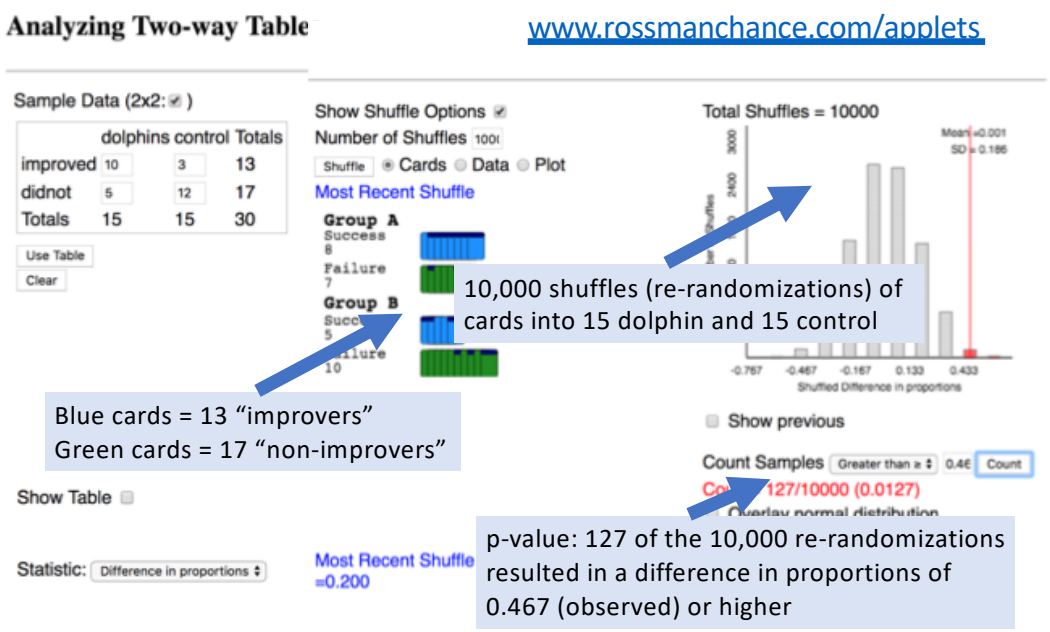
2. Simulation-based tests

- Tintle et al. (2014) large scale empirical study on the use of randomization based methods in the intro course.
- Overall, improvement on CAOS test was 11.6% for randomization curricula, and 5.6% for traditional (p-value < 0.001).
- Randomization curricula showed significantly higher performance in: data collection and design, graphical representations, probability, confidence intervals, and tests of significance. (Randomization curricula significantly lower in descriptive statistics.)
- Hildreth et al. (2018) found simulation-based curricula helped increase student understanding in several key concepts.

Example: Swimming with Dolphins

Is swimming with dolphins therapeutic for patients suffering from clinical depression?

	Animal care program (dolphin therapy)	Outdoor nature program (control group)	Total
Showed substantial improvement	10	3	13
Did not show substantial improvement	5	12	17
Total	15	15	30



3. Bootstrapping confidence intervals

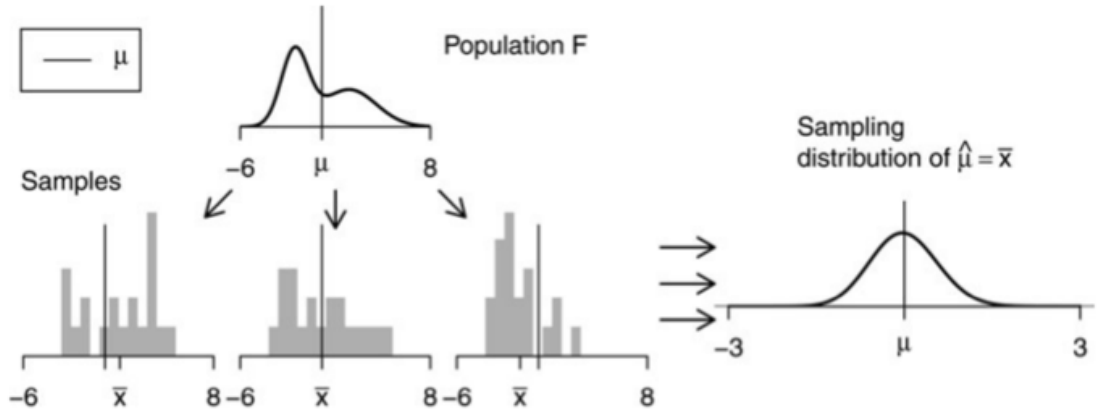
Idea behind **sampling distributions**:

1. Draw samples from the *population*, and
2. Compute the statistic of interest (mean, median, etc.) for each sample.

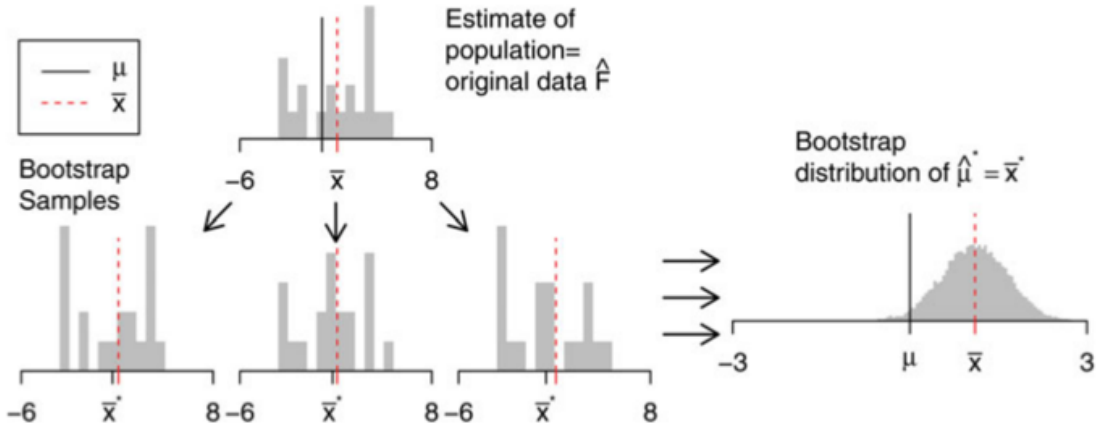
Idea behind **bootstrapping**:

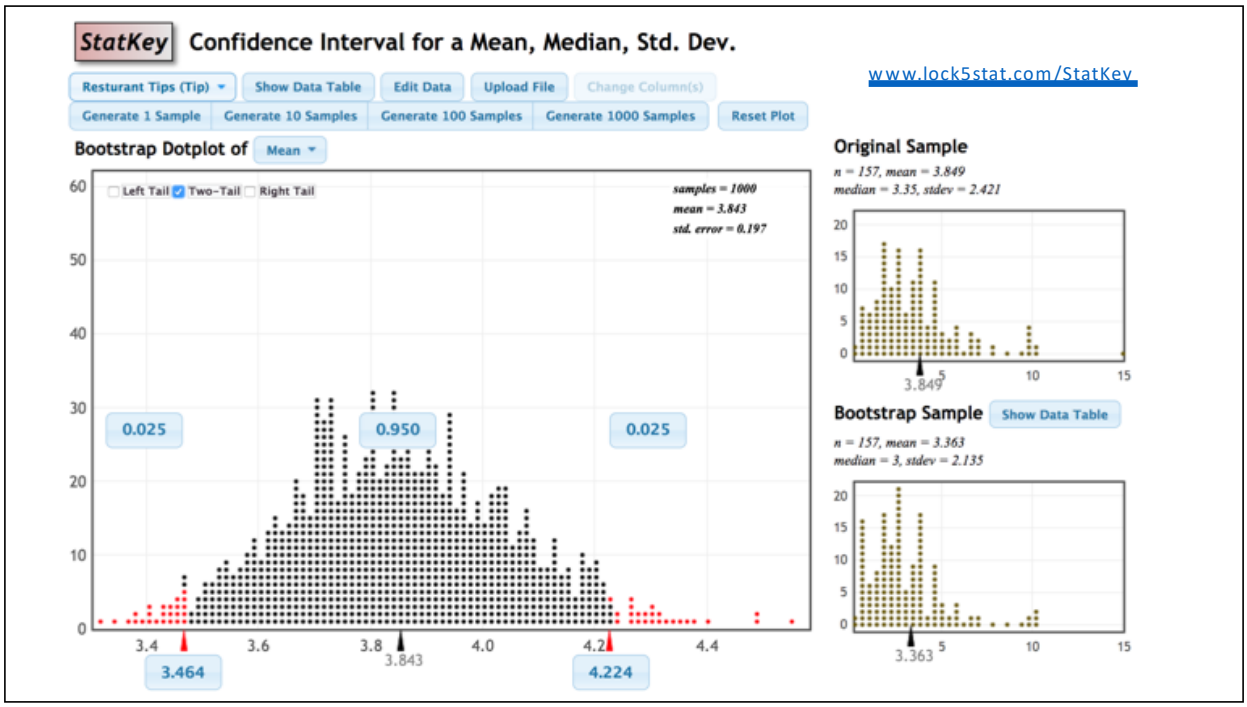
1. Draw samples from *an estimate of* the population, and
2. Compute the statistic of interest for each sample.

Sampling Distribution (Hesterberg, 2015)



Bootstrap Distribution (Hesterberg, 2015)





Sampling variability is the core of statistical inference.

Pedagogical value of bootstrapping and simulation-based tests (Hesterberg, 2015):

- Reinforces central role that sampling from a population plays in statistics
- Sampling variability is visible
- Measure variability of a sampling distribution using already familiar methods (sample standard deviation)
- Reinforces the Central Limit Theorem
- Makes the abstract concrete
- Works with a wide variety of statistics
- Focus on ideas rather than formulas

4. Exam reflections

- Use the class day after an exam for a group activity where students work through a selection of exam problems.
- Include metacognitive questions such as "what exam study strategies seemed to work well?"
- Another option: two-stage collaborative exams

5. Student-led projects

- Semester-long projects where students develop a research question, collect data, analyze data, and communicate both with a presentation and written report.
- Benefits:
  - Students work through the entire statistical investigation process
  - Help students develop soft skills – working in a team, communication, project organization
  - Increase student motivation since topic is generated from the student rather than from the instructor

Tips for Student Group Projects

- Build in group evaluation into the project grade
- Spread out multiple due dates throughout the semester
- Teach students how to work in groups
- Use collaborative project tools (e.g., Google Docs, Slides, Sheets)
- Have students turn in draft of report in pieces

6. Flipped classroom

- Students introduced to content in class
- Practice working through problems at home

http://www.montana.edu/pdc/projects/2013/teal.htm

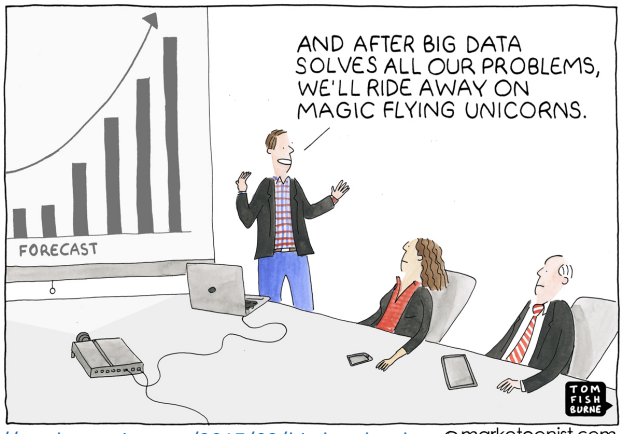
What does the research say?

- Consistent with cognitive psychology research – generation effect, testing effect (Winquist & Carlson, 2014)
- Student perceptions mixed, but generally positive; tend to prefer in-person lectures to video lectures, but prefer interactive classroom activities over lectures (Bishop & Verleger, 2013)
- Many single-classroom studies, but lacking large empirical studies using objective learning outcomes in controlled experiment/quasi-experiment (Bishop & Verleger, 2013)
- Might improve student motivation and help manage cognitive load (Abeysekera & Dawson, 2015)

MONTANA STATE UNIVERSITY 125 YEARS

	GAISE Guideline							
Activity	**1**	**a**	**b**	**2**	**3**	**4**	**5**	**6**
What								
1. Data visualization								
2. Simulation-based tests								
3. Bootstrapping intervals								
How								
4. Exam reflections								
5. Student-led projects								
6. Flipped classroom								

“Big Data” and Data Science



https://marketoonist.com/2017/03/bigdata.html

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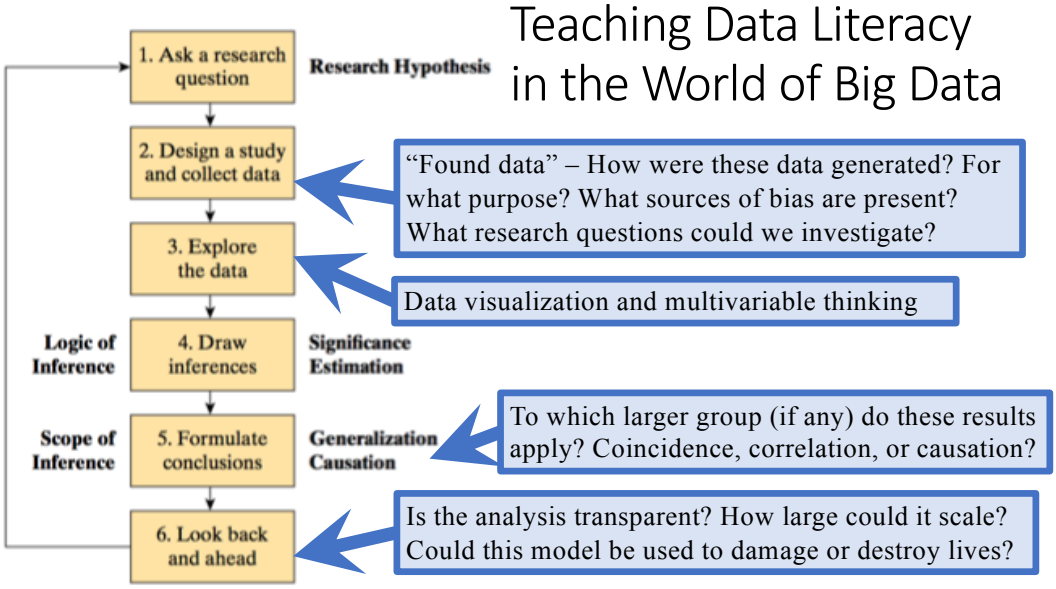
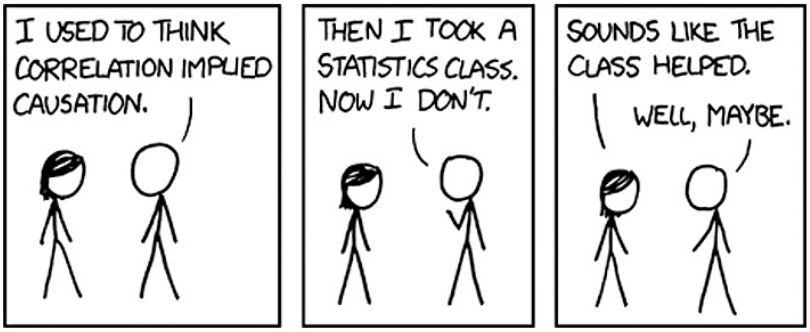
Teaching Data Literacy in the World of Big Data



Tintle et al., 2016

Thank you!



xkcd.com

Other Guidelines and References

- ASA Curriculum Guidelines for Undergraduate Programs in Statistical Science
- ASA's Statement on p-Values
- Curriculum Guidelines for Undergraduate Programs in Data Science, *Annual Review of Statistics and Its Application*, Vol. 4:15-30, 2016
- *The American Statistician* special issue on statistics and the undergraduate curriculum, Vol. 69, No. 4, 2015

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Winquist, J. R., Carlson, K. A. (2014). Flipped statistics class results: Better performance than lecture over one year later, *Journal of Statistics Education,* Vol 22, No 3. http://ww2.amstat.org/publications/jse/v22n3/winquist.pdf

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