

# Project NExT Course: Teaching Introductory Statistics in a Data-driven World

*MathFest 2022 – Philadelphia, PA*

*Thursday, August 4*

Michael A. Posner, PhD, PStat<sup>®</sup>

[michael.posner@villanova.edu](mailto:michael.posner@villanova.edu)

<http://homepage.villanova.edu/michael.posner>

<http://tinyurl.com/StatEdResources>

# To Mask or Not To Mask...that is the question...

I'm okay with Michael unmasking when in front of the room

I'd prefer Michael to keep his mask on all the time

Total Results: 0

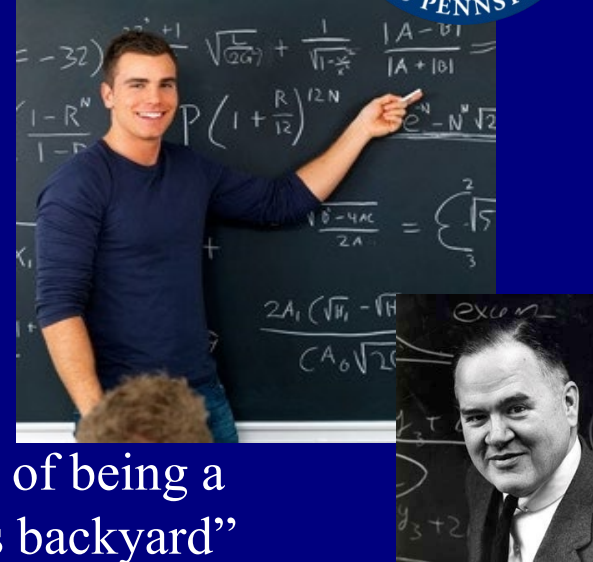
# Introductions

- Name
- Institution
- Best thing learned (so far) from Project NExT
- One interesting fact about you



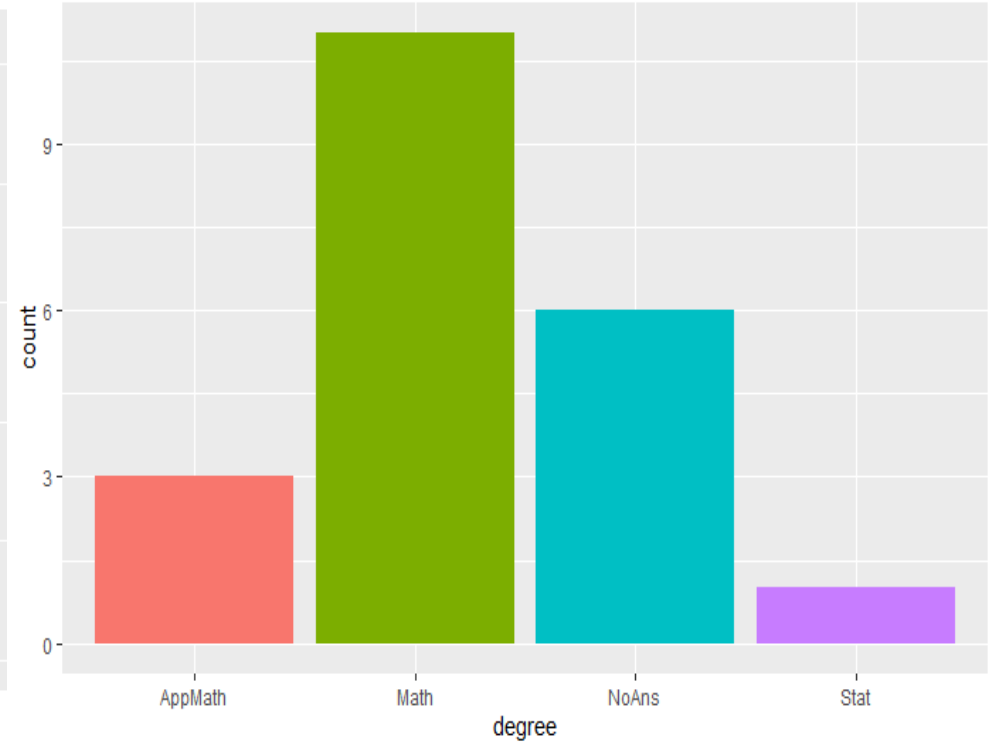
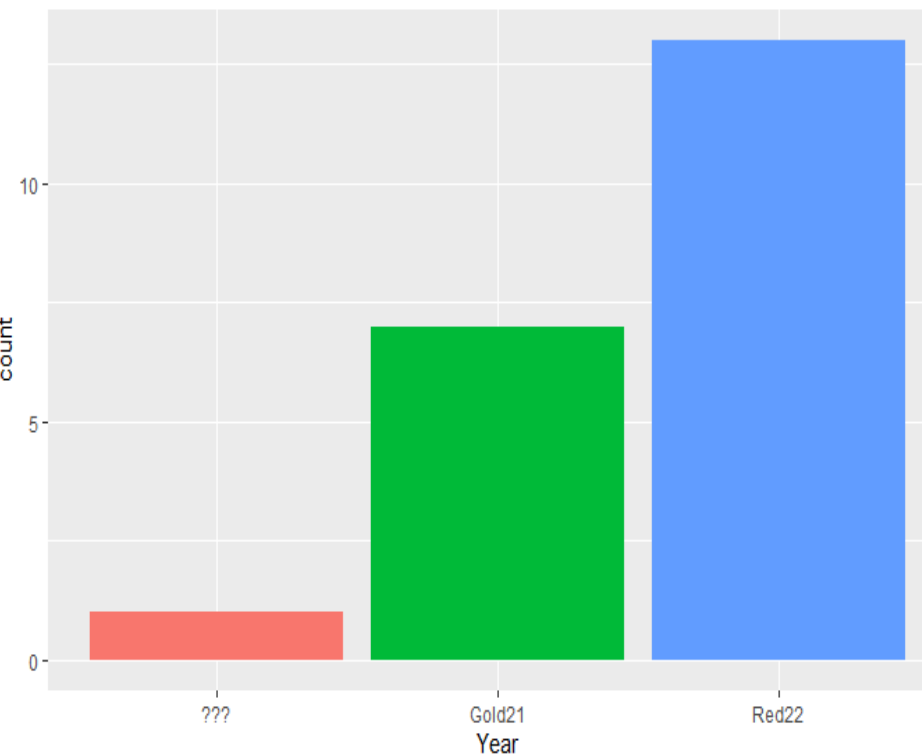
# Introduction - About Me

- Villanova University
  - Professor of Statistics and Data Science
  - Founding Director, Center for Stat/DS Education
- 3<sup>rd</sup> Grade – Predicted to be a Math Teacher
- Why Statistics?
  - Took a class on statistics in high school
  - Driven by applications: Tukey - “My favorite part of being a statistician is that I get to play in everyone else’s backyard”
- BA from U Roch, MS from CMU, PhD (Biostatistics) from Boston U
- Research/Consulting – Stat Ed, Public Health, Expert Witness, etc.
- Fun facts
  - Statistics Songs – [Stats Can Be Cool](#), [How Far He’ll Go](#), [She Taught Me Data Science](#)
  - Commencement Video – [An Unexpected Journey in Statistics](#)
  - Retired competitive ballroom dancer
- Learned from Project NExT – Community makes a difference, Use it!

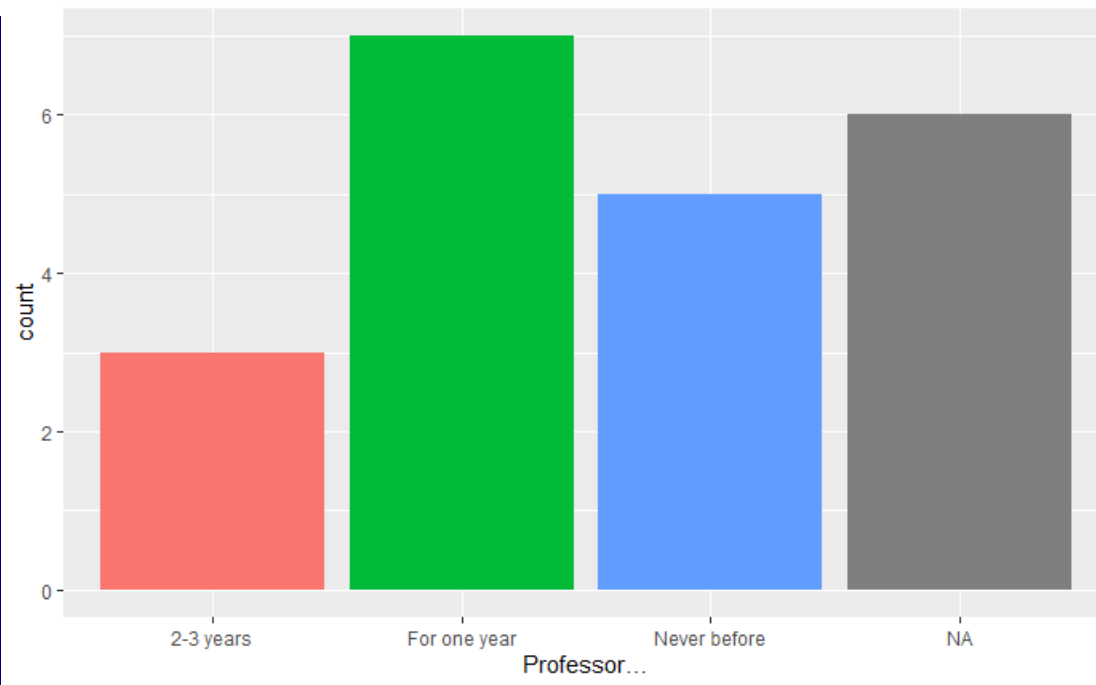


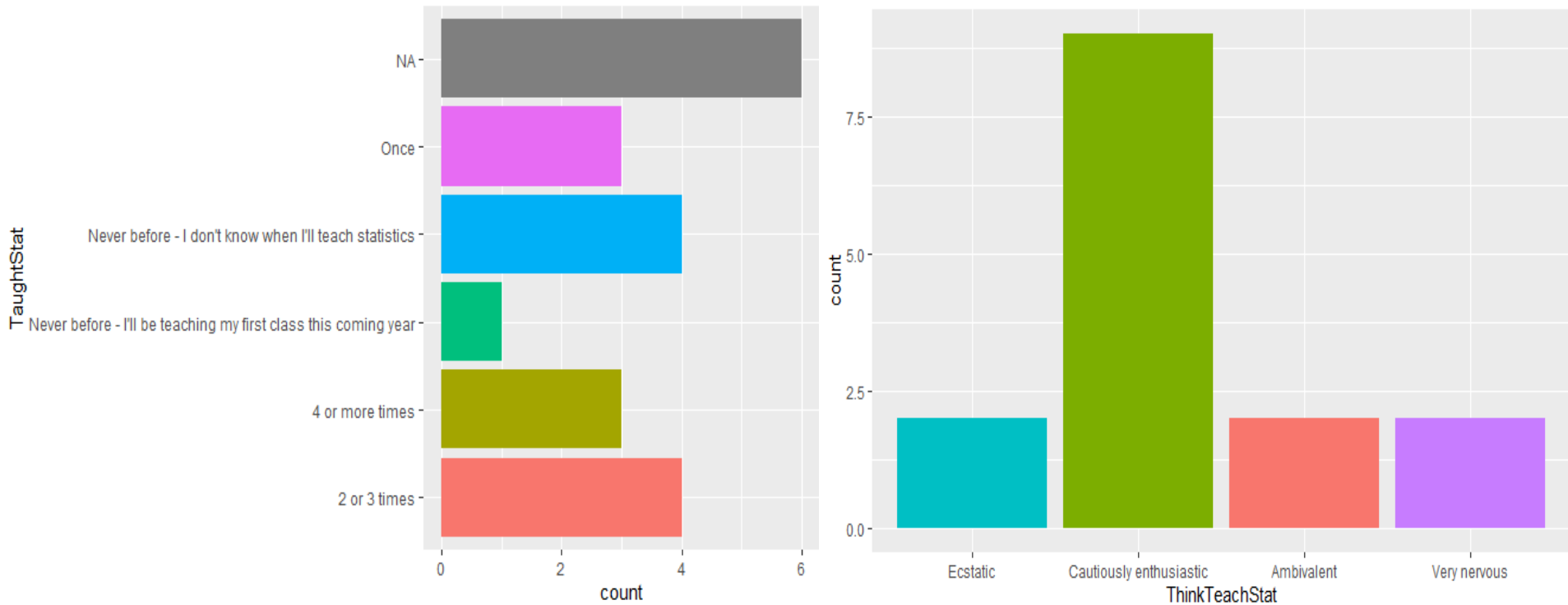
# (Tentative) Schedule

- Thursday August 4, 1-3pm
  - Introductions & Overview
  - First Day of Class
  - GAISE and Conceptual Understanding
  - Activities – Random Rectangle, Graphical Displays
  - Bias and Multivariate Thinking?
- Friday, August 5, 1-3pm
  - Review / Questions from Session One
  - Magic of Statistics
  - Technology for Teaching Statistics
  - Assessment



These slides have some (intentional) issues with them. Can you find them?





### best way to teach formula

<chr>

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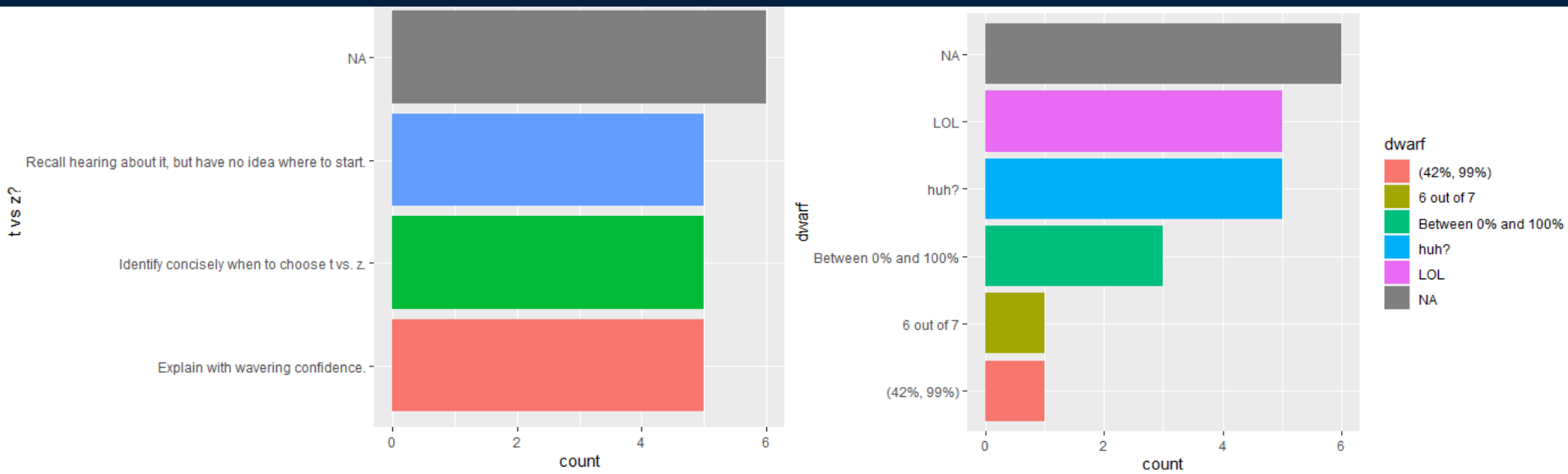
<int>

1 Show how formulas are derived, let students work it using a small dataset, then use technology to calculate it.

15

2 NA

6



# FIRST DAY OF CLASS



# Distracted Driving – Day 1 Activity

- You are an analyst for a cell phone company. A recent report has come to your attention on the safety of cell phones. In this study, 52 people were randomly assigned to one of two groups, each containing 26 people. The experimental group drove a driving simulator while using a cell phone and the control group used the simulator without the cell phone. Part of the task given to them in the simulator was to exit the freeway at a particular exit. Of the 26 people who used a cell phone ? missed the exit. Of the 26 people who did not use a cell phone ? missed the exit.



Start the presentation to see live content. For screen share software, share the entire screen. Get help at [pollev.com/app](https://pollev.com/app)

# Distracted Driving - Decision

- Examine the differences between these groups to determine the impact of using a cell phone on distracted driving.
  - How might you summarize these results numerically?
  - How might you summarize these results graphically?
  - Is there evidence that cell phones cause distracted driving?
    - Simulation-based inference
    - Formal inference

# Numerical Summary

## 2x2 TABLE

	MissedExit	NotMissExit	
CellPhone	7	19	26
NoCellPhone	2	24	26
	9	43	52

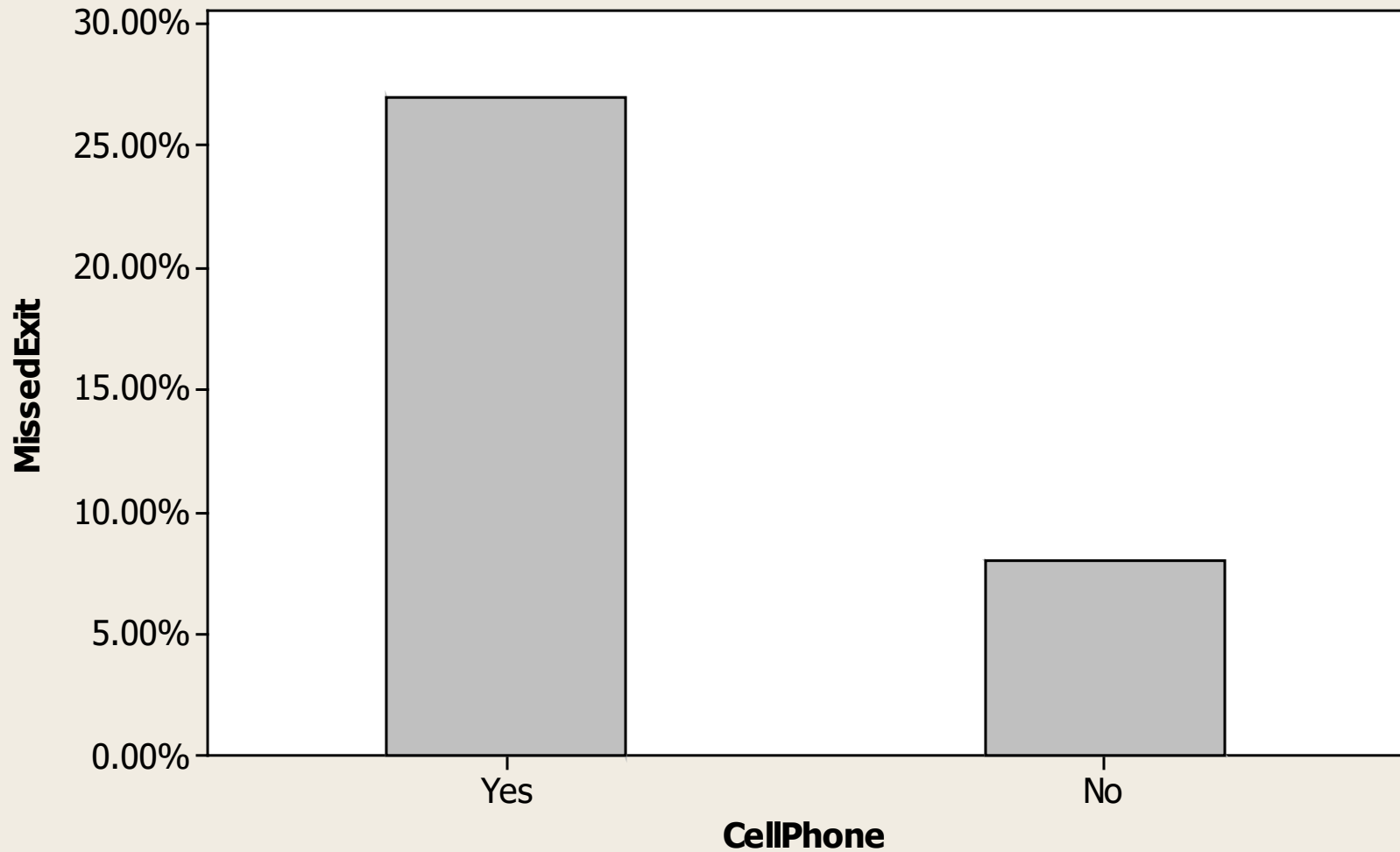
## PERCENTS

(% who missed the exit)

CellPhone	7/26	<b>27%</b>
NoCellPhone	2/26	<b>8%</b>

# Graphical Summary

## Distracted Driving

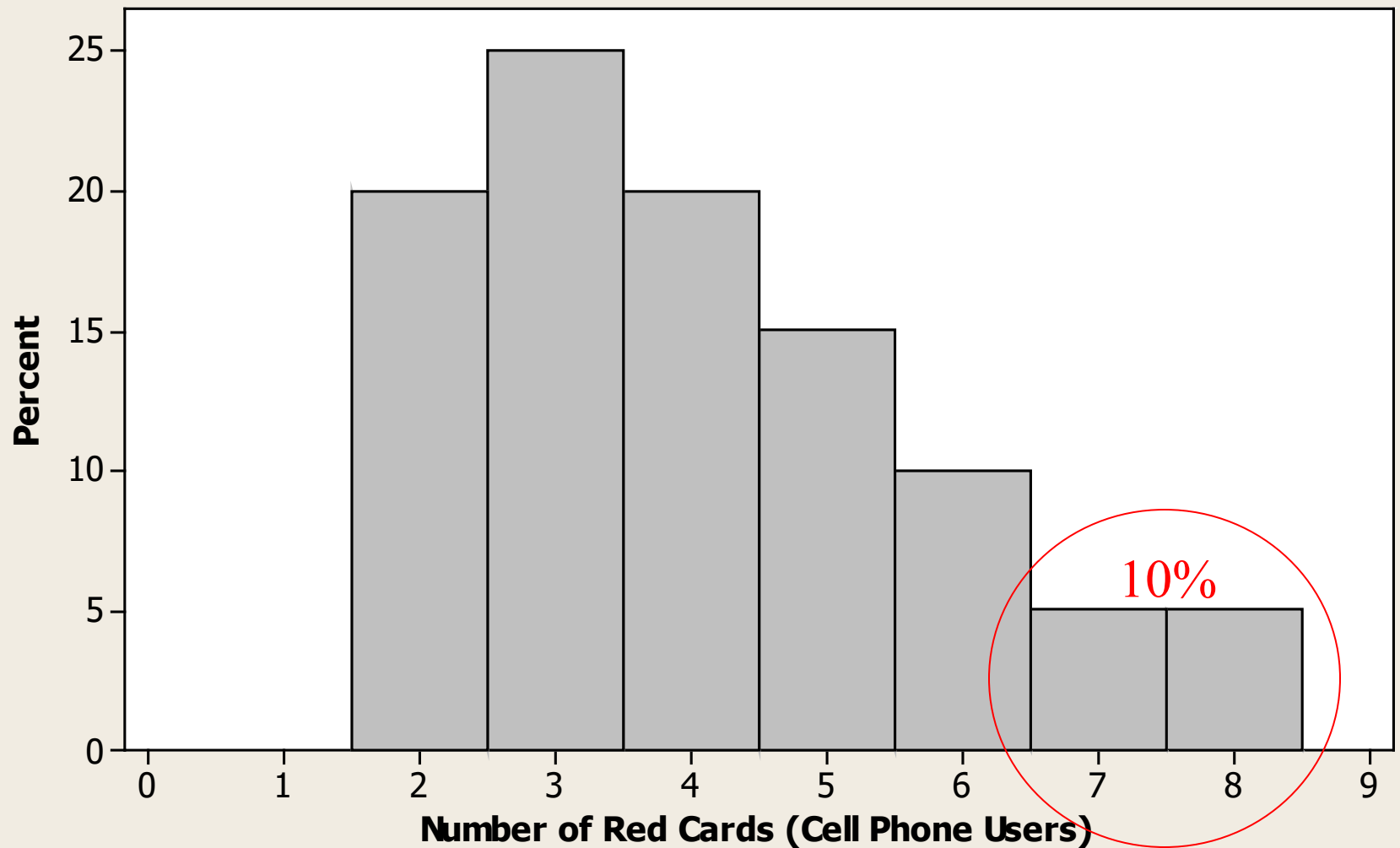


# Simulation-based Inference

Get into groups of 3-4 students. Each group should have a deck of cards. There are 52 cards in a deck, 26 are red and 26 are black. Imagine that these 52 cards represent the drivers in the simulation. If you know that 9 of them missed their exit, can you determine the chance that 7 of those 9 would have come from the cell phone group, if the selection were done by random chance alone. To do this simulation, consider the red cards to be the cell phone group and the black cards are the no cell phone group. Draw nine cards at random (by shuffling the deck or random selection) and record the number of red cards that you get. Do this 2-3 times for each person in your group. Combining the results for your group, what percent of times did you get at least 7 from the red group? Is this an unlikely event?

# Simulation-based Inference

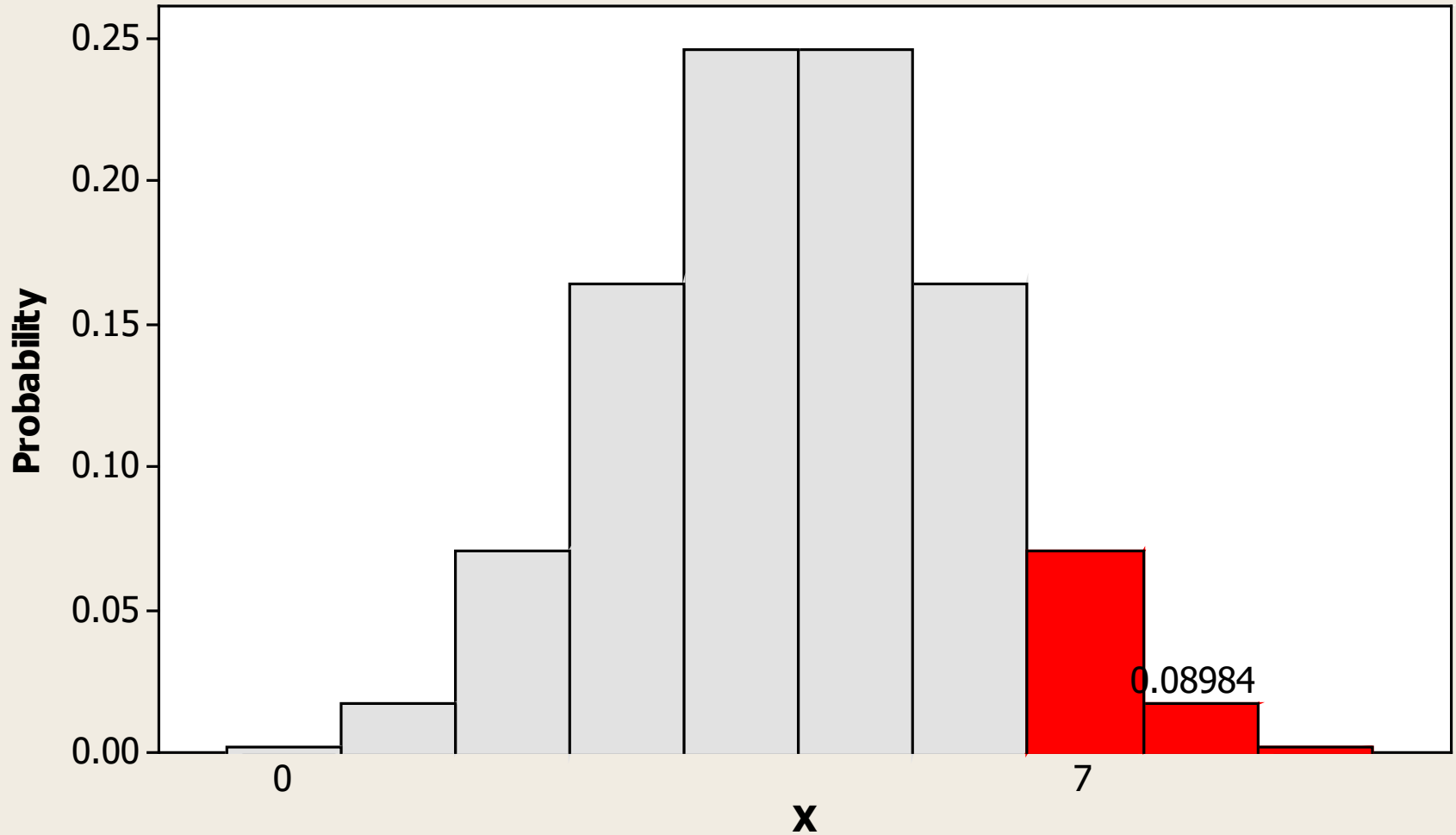
**Histogram of Number of Red Cards (Cell Phone Users)**



# Formal Inference

## Distribution Plot

Binomial,  $n=9$ ,  $p=0.5$





# Ask Good Questions

- Where do these data come from?
- Is the relationship causal?
- Are there measurement issues?
- What if the data were observational and not a designed experiment?
- Can you control for other factors (potential confounders)?
- What decision should be made about cell phone usage and driving distractions?

[Ask Good Questions blog](#) (Rossman)

# About the First Day of Class

“The first class is not the time to make sure students understand your inadequacies and limitations. Frankly admitting that you don’t know something is fine after the course is underway, but apologies in advance for lack of experience or expertise simply increase student insecurity. They need to feel that you are competent and in charge even if you are shaking in your boots”

McKeachie, T. & Svinicki, M. (2006). *McKeachie’s Teaching Tips: Strategies, Research, and Theory for College and University Teachers*. Houghton Mifflin Company.

Some resources about the first class in statistics

- [Beth Chance’s SSDSE newsletter post](#) – see next slides
- [Larry Lesser’s webinar](#) based on his [JSE paper](#)
- [Some Key Comparisons between Statistics and Mathematics and Why Teachers Should Care](#) (Rossman, Chance, Medina)
  - Critical role of context, issues of measurement, data collection, lack of definitive conclusions, terminology, why should teachers care
- [Statistical Thinking vs. Mathematical Thinking](#) (Cobb & Moore)

# Day One – Myths

1. Statistics is a math course.
2. It's completely impossible for me to get a good grade for this course.
3. This course will be a cakewalk.
4. I can continue to cram for an exam the night before.
5. Statistics is memorizing formulas.
6. There is usually only one right answer.
7. The teacher is going to physically harm me if I ask a stupid question.
8. Statistics is not interesting, and I will never use it.

# Day One – Student Survey

- Students want to talk about sports, environment, and themselves!
- Sample questions – make sure to choose different variable types
  - Class year, gender, age, race/ethnicity, GPA, HW, Job, Fin Aid, Smoke, TV (hrs/wk), Exercise (hrs/wk), Books (# over summer), Sleep (hrs/night), Award (Nobel, Academy, Olympic), Random Number, Professor's Age, Parent's Income, Height, Weight
- Discussions of real issues with data
  - Bias – some people didn't answer or lied
  - Open-ended variables, like race/ethnicity, require discussions/decisions
    - Are “White” and “white” the same?
    - What do you do if they answer “White/Black”?
    - Is “3/4 White, 1/4 Black” equal to “White/Black”?
  - Should we categorize age or GPA?
  - Some GPAs are >4.0 but our school max is 4.0???
- Gives you data to use throughout the semester (fewer datasets is better)
- Allows for novel discoveries!

# Homework 0: Find Article

- Assignment - Find an “article” online that uses statistics. Your “article” may be a journal article, a media report, a magazine ad, etc. Please hand in 2-3 sentences about the article, including the URL, commenting on what you learned from it and the use of statistics in the article.
- Gets students to start thinking about statistics early on
- Last HW – ask them to redo the assignment with the same article and reflect on how their knowledge has increased.
- Creates resource of students’ interests, perhaps even with data

# Day One - Opening Prayer

*Though I've taught this material many times,  
may I be open to fresh ways of making connections,  
sharing the passion that brought me to this field,  
and seeing how each year's students extend my learning  
by their backgrounds and beliefs, their questions and answers.*

*So may you have the courage to ask your questions,  
trusting me to respect any sincere contribution (usually shared  
silently by others),  
knowing that the worst outcome is simply my offer to discuss it  
later.  
And may you also be willing to offer answers,  
knowing that class dialogue is enriched by multiple methods and  
points of view,  
and that exploring even incomplete answers yields insight for all.*

*May you be curious and open to how this course may count in life  
- beyond a degree plan - even if this kind of course has been a  
source of struggle.  
May the 45 hours in this room add up to knowledge that yields  
wisdom, and may the wisdom lead to more capacity to improve  
our world.*

*Together, may we use the time we have in this room as a  
creative, intentional, supportive learning community:*

*May the door of this classroom be wide enough to receive  
all who seek understanding.*

*May the door of this classroom be narrow enough to keep  
out fear or closed-mindedness.*

*May its threshold be no stumbling block to those whose  
knowledge—or language—is shaky.*

*May the window of this classroom inspire us to connect  
our learning to the world beyond these walls.*

*And may this classroom be, for all who enter, a doorway  
to growth and purpose.*

*Welcome!*

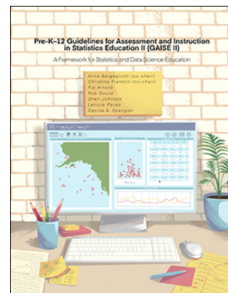
Source: Lesser, L. (2010) Opening Intentions. *The Teaching Professor*.  
Republished at <http://www.facultyfocus.com/articles/teaching-and-learning/opening-intentions-first-day-class/>. His poet  
"Larry-ate" page is at  
<http://www.math.utep.edu/Faculty/lesser/poet.html>

GUIDELINES FOR  
ASSESSMENT AND  
INSTRUCTION IN  
STATISTICS  
EDUCATION  
(GAISE)

# GAISE Guidelines

- Guidelines for Assessment and Instruction in Statistics Education
  - College Report – 2005, updated 2016
  - PreK-12 Report – 2007, updated 2020
- Serve as a guiding document for this course

Pre-K–12 Report



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[Full Report \(PDF format\)](#)

College Report



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[2016 GAISE College Report](#)

[Full Report \(PDF Format\)](#)



# GAISE Recommendations

1. Teach statistical thinking
  - a) Teach statistics as an investigative process of problem-solving and decision-making.
  - b) Give students experience with multivariable thinking.
2. Focus on conceptual understanding
3. Integrate real data with a context and a purpose
4. Foster active learning in the classroom
5. Use technology for developing concepts and analyzing data
6. Use assessment to improve and evaluate students' learning

# Goals for Statistics Course

1. Students should become *critical consumers* of statistically-based results reported in popular media, recognizing whether reported results reasonably follow from the study and analysis conducted.
2. Students should be able to recognize questions for which the *investigative process* in statistics would be useful and should be able to answer questions using the investigative process.
3. Students should be able to produce *graphical displays and numerical summaries* and interpret what graphs do and do not reveal.
4. Students should recognize and be able to explain the central role of *variability* in the field of statistics.
5. Students should recognize and be able to explain the central role of *randomness* in designing studies and drawing conclusions.
6. Students should gain experience with how *statistical models*, including multivariable models, are used.
7. Students should demonstrate an understanding of, and ability to use, basic ideas of *statistical inference*, both hypothesis tests and interval estimation, in a variety of settings.
8. Students should be able to interpret and draw conclusions from standard output from *statistical software packages*.
9. Students should demonstrate an awareness of *ethical issues* associated with sound statistical practice.

# Appendices (>100 pages)

A: Evolution of Intro Stat and Stat Ed Research

B: Multivariate Thinking

C: Activities, Project, and Datasets

D: Using Technology

E: Assessment Items

F: Learning Environments

# Conceptual vs. Procedural

## From ASA/MAA Joint Committee on Undergraduate Statistics Report:

Almost any course in statistics can be improved by more emphasis on data and concepts, at the expense of less theory and fewer recipes. To the maximum extent feasible, calculations and graphics should be automated.

Any introductory course should take as its main goal helping students to learn the basics of statistical thinking. [These include] the need for data, the importance of data production, the omnipresence of variability, the quantification and explanation of variability.

# Concept vs. Procedure – StDev Example

Which one should we teach?

$$\text{Common formula: } s = \sqrt{\frac{\sum_{i=1}^N (x_i - \bar{x})^2}{n-1}}$$

$$\text{Shortcut formula: } s = \sqrt{\frac{\sum_{i=1}^N x_i^2 - \frac{\left(\sum_{i=1}^N x_i\right)^2}{n}}{n-1}}$$

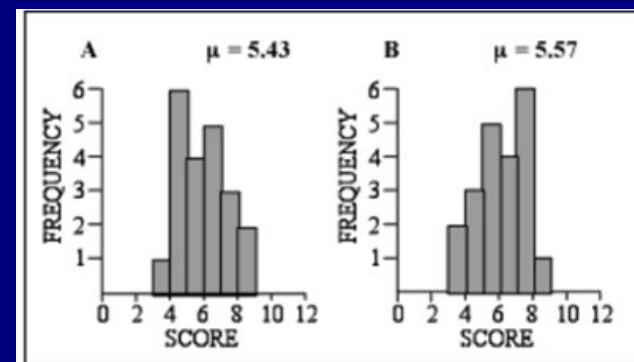
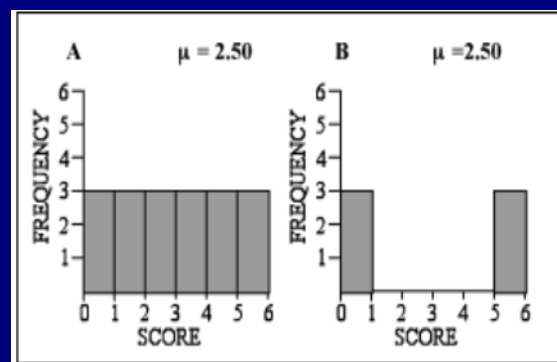
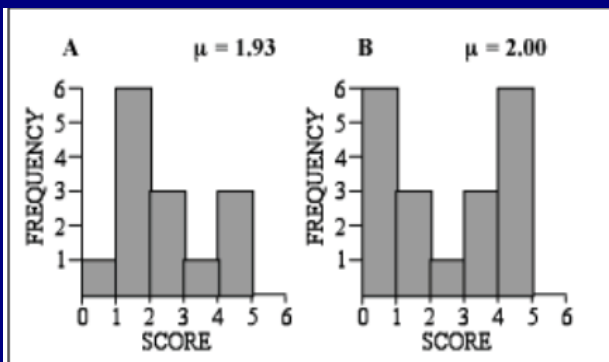
Answer – it depends on the students and the situation!

*...but remember that the students likely aren't getting a PhD in Mathematics or Statistics!*

# Concept vs. Procedure – StDev Example II

Conceptual question : For each pair of graphs, choose one of the following (you may reuse the same answer more than once):

- 1) A has larger standard deviation than B
- 2) B has larger standard deviation than A
- 3) Both have equal standard deviations



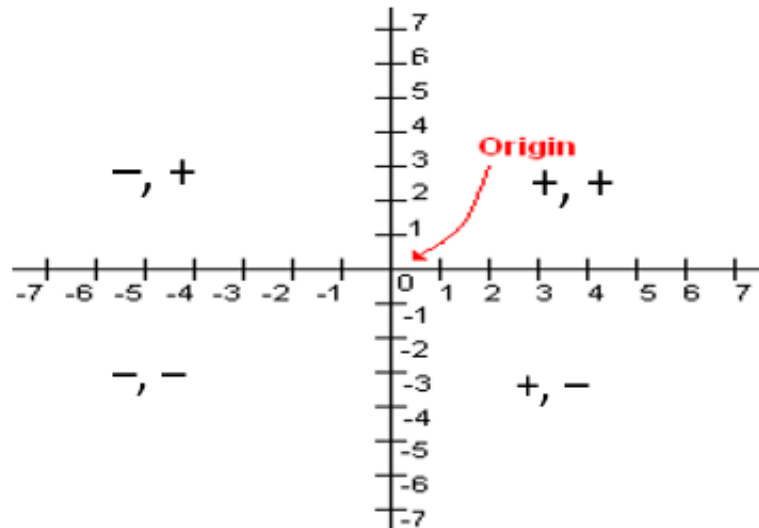
Think, Pair, Share...including what concept is being tested

# Concept vs. Procedure - Correlation

$$r = \frac{1}{n-1} \sum \left( \frac{x - \bar{x}}{s_x} \right) \left( \frac{y - \bar{y}}{s_y} \right)$$

is better than

$$r = \frac{\sum X_i Y_i - \frac{(\sum X_i)(\sum Y_i)}{n}}{\sqrt{\sum X_i^2 - \frac{(\sum X_i)^2}{n}} \sqrt{\sum Y_i^2 - \frac{(\sum Y_i)^2}{n}}}$$



# Beyond Calculation - Median

The ages of five people were gathered. The values of the first four were 18, 14, 16, 21. The value of the fifth could not be read. What are the possible values of the median of these five observations?

- a) 15
- b) 17
- c) 18
- d) somewhere between 14 and 16
- e) somewhere between 16 and 18

What is the misconception for each one?



# Concept vs. Procedure – Correlation II

A bank analyst wishes to determine whether there is a relationship between customers' average monthly credit card balance and the income stated on the original credit card application form. Which of the correlation coefficients below would show the strongest relationship between income and average monthly credit balance?

- a) 0.85
- b) 0.50
- c) -1.25
- d) -0.95
- e) 0.00
- f) I don't know

What is the misconception for each one?

# Conceptual Understanding - Resistance

The midhinge of a distribution is defined to be the average (mean) of the lower quartile and the upper quartile. The midrange of a distribution is defined to be the average (mean) of the minimum and the maximum. Which of these statistics is/are resistant to outliers?

- a) The midrange only
- b) The midhinge only
- c) Both the midrange and the midhinge
- d) Neither the midrange nor the midhinge

# Are You a Data Detective?



Data detectives use **PPDAC**

# What to Omit

## 1. Probability Theory

(I cover long-term likelihood and conditional probability (JITT))

## 2. Constructing Plots by Hand

## 3. Basic statistical measures (if taught earlier) – mean/median, histograms, scatterplots, etc.

## 4. Drills with tables

## 5. Advanced training of software programs (should be in later courses)

*ACTIVITIES:*

RANDOM RECTANGLES

and

GRAPHICAL DISPLAYS

# Activity - Random Rectangles

- 1) What is your best guess of the average area of the rectangles?

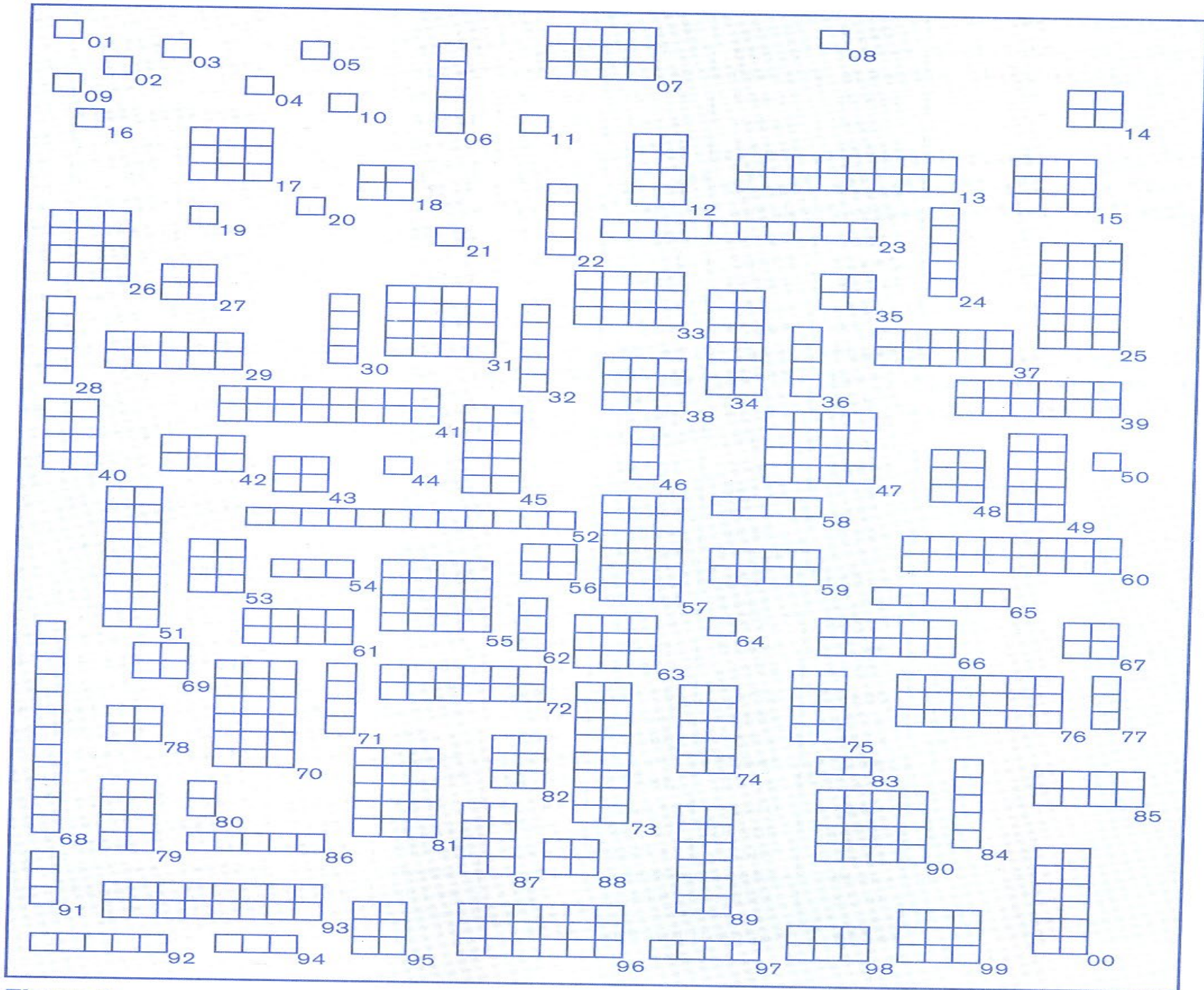
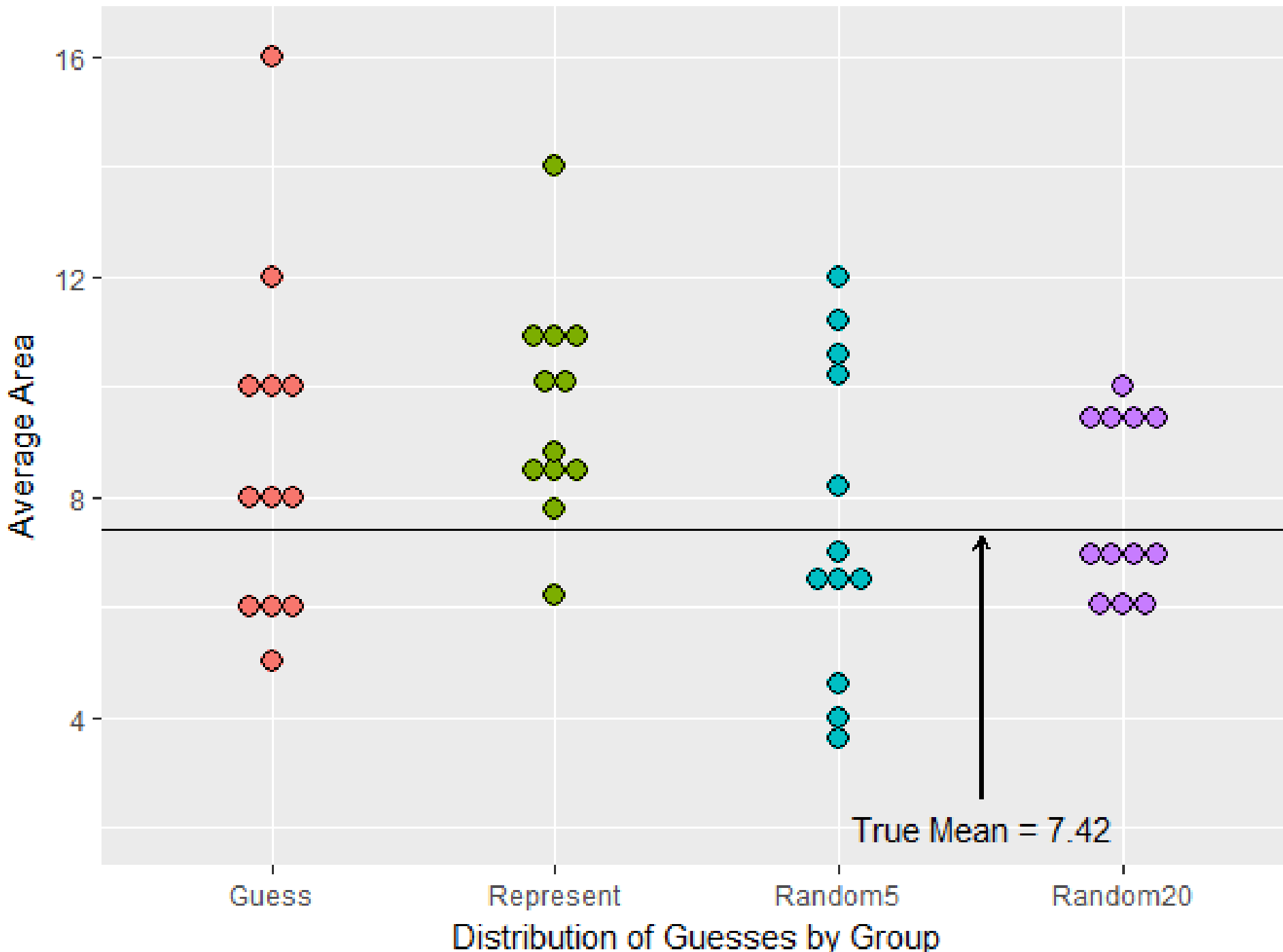


Figure 1

# Activity - Random Rectangles

- 1) What is your best guess of the average area of the rectangles?
- 2) Choose five “representative” rectangles. Calculate their average area.
- 3) Choose five random rectangles (random.org or table of random digits). Calculate their average area.
- 4) Join together with 2-3 neighbors. Calculate their average area of the 15-20 rectangles (hint, the average of averages works here).





"The simple graph has brought more information to the data analyst's mind than any other device. "

- John Tukey

# Activity – Graphical Summaries

- This is one area where I reduce time spent on details
- See handout on [Graphical Summaries](#)
- Recall – to summarize numerical variables use **SOCS+IT**
  - **S**hape – symmetric or skewed (left or right / positive or negative), # modes
  - **O**utliers
  - **C**enter – median or mean (approximate)
  - **S**pread – how disperse are the data points
  - +
  - **I**nteresting?
  - **T**ake home message

# Activity on Sampling

Stars in the Sky (Activity B)

# (Updated) Schedule

- Thursday August 4, 1-3pm
  - Introductions & Overview
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  - Review / Questions from first day?
  - Bias and Multivariate Thinking
  - Technology for Teaching Statistics
  - Assessment
  - Magic of Statistics
  - Resources

# Statistical Anagrams

clue	answer	clue	answer
dome	mode	maiden	
said rule		anger	
level curb		maples	
meet irises		rain cave	
true oil		cool terrain	
next premise		tour skis	
salsa request		fenced icon	
its logic		in a limbo	
poisons		persona	
dust tents		trap oily bib	

from CAUSEweb's [Fun Resources](#) (search for “puzzles”)

# Cartoon

- from [CAUSEweb](#)'s section on [Fun Resources](#)
- Discussion
  - What statistical concept is used?
  - Why is the cartoon funny?

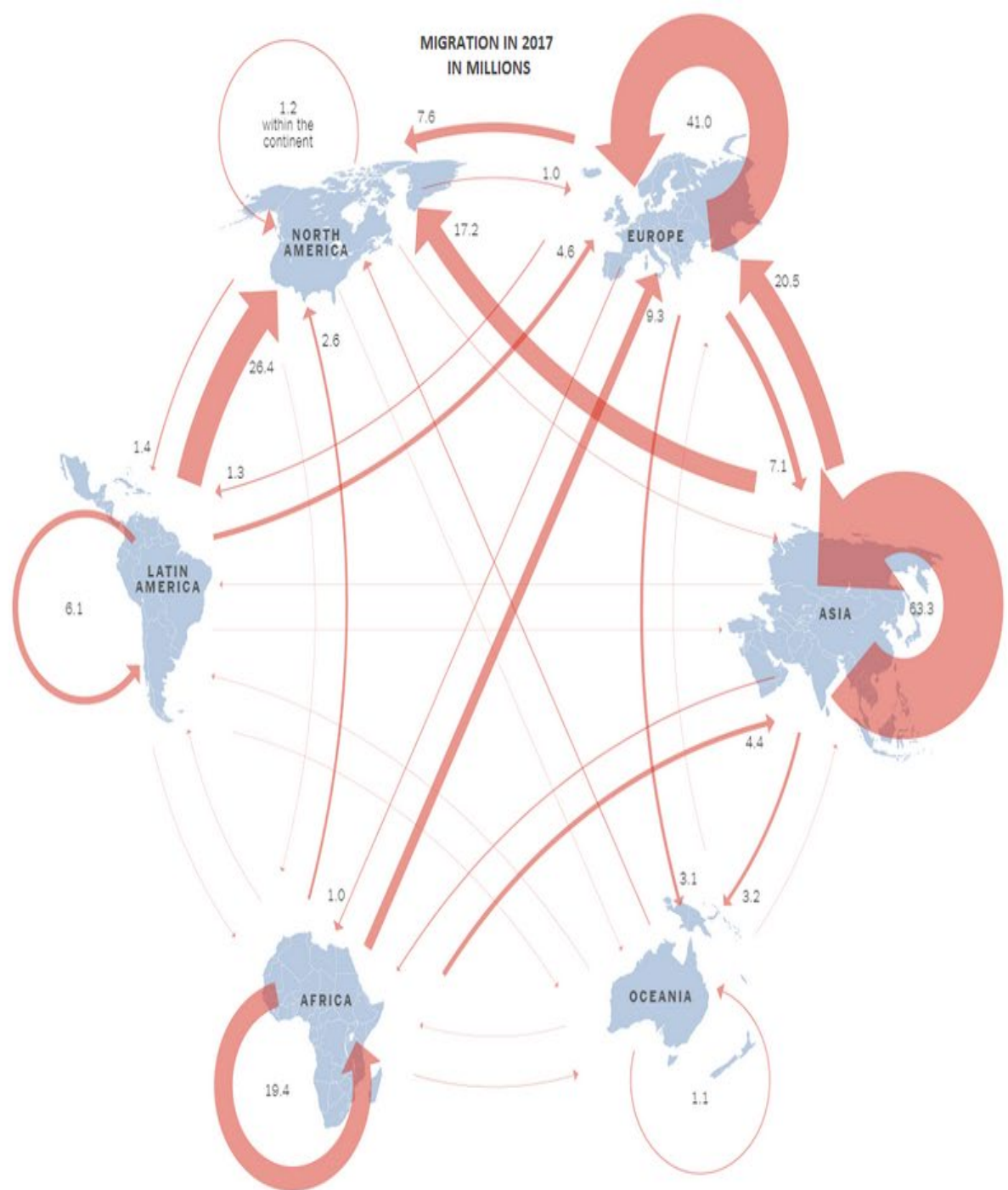


## What's Going On in This Graph? | Sept. 12, 2018

Look closely at this graph, and join the moderated conversation about what you and other students see.

Sept. 11 • By THE LEARNING NETWORK

*What do you...  
Notice?  
Wonder?*



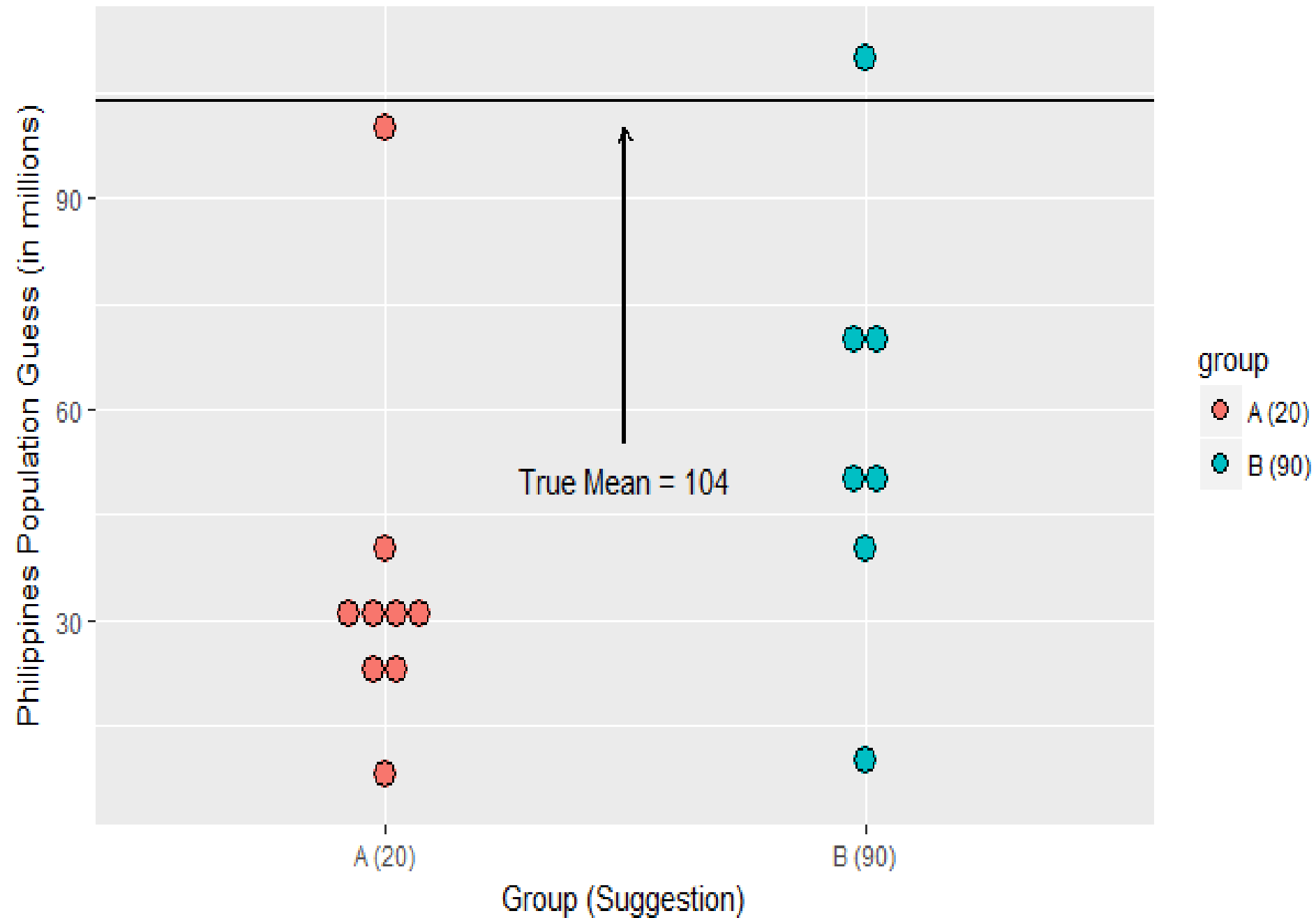


BIAS  
and  
MULTIVARIATE  
THINKING  
(CONFOUNDERS)

# Activity - Population Estimation

- What is your best guess for the population of the Philippines?
- Record and review these
- This is an example of bias!

# Exploring Bias in Leading Questions for Philippines Population Size



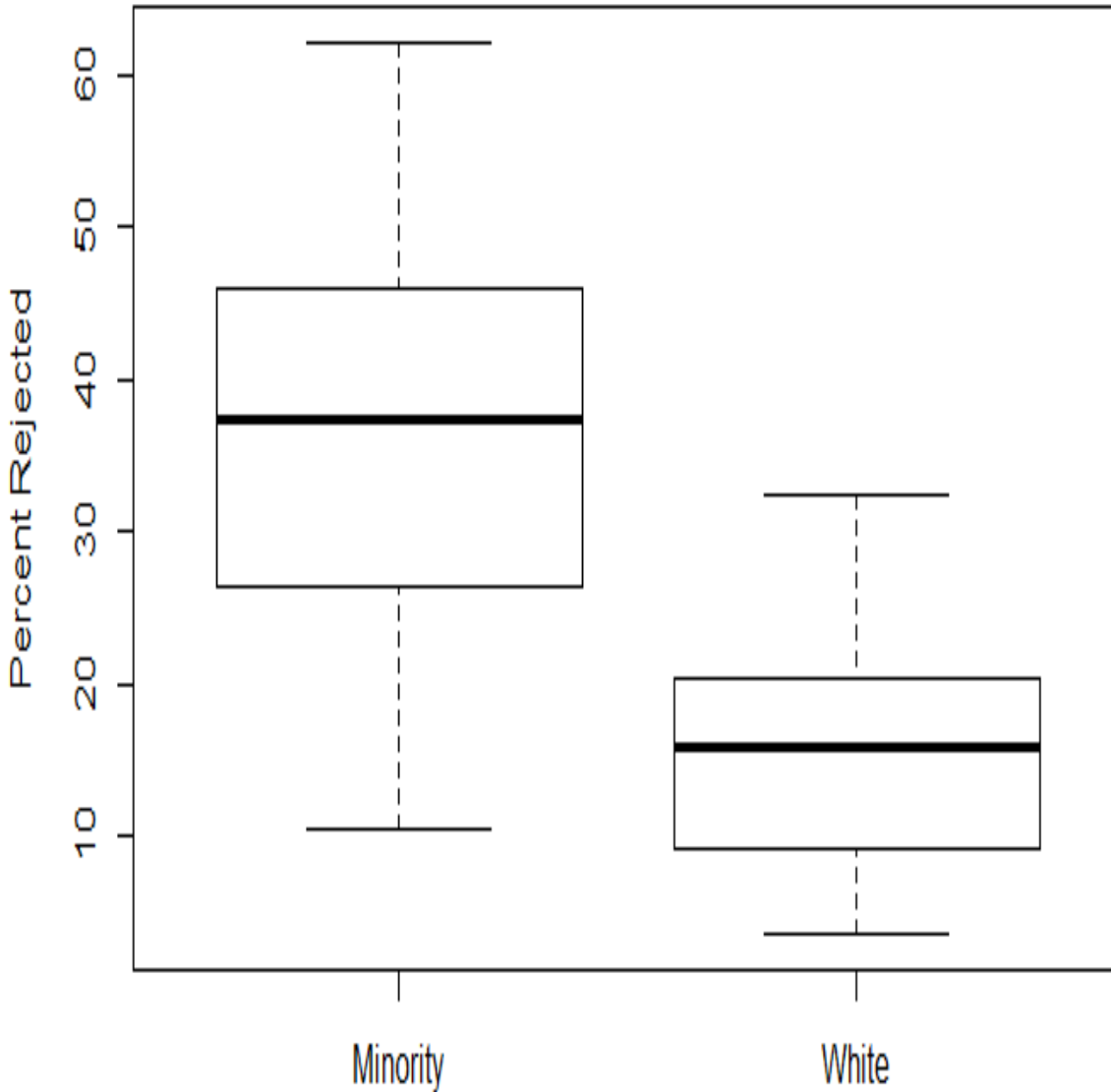
# Bias – In Practice

- Ideally...
  - ...eliminate bias completely
- Hopefully...
  - ...reduce bias as much as possible
- At a minimum...
  - ...identify the direction of the bias and comment on how that influences your conclusions

# Multivariable Thinking

**Confounder (Confounding Variable)** – A confounding variable is a variable that is related to the explanatory variable and the response variable and changes the observed relationship between the two. A potential confounder is any variable related to the explanatory and response variables. Non-experiments are very susceptible to confounders.

## Boxplot of Mortgage Rejection Rate



## Questions:

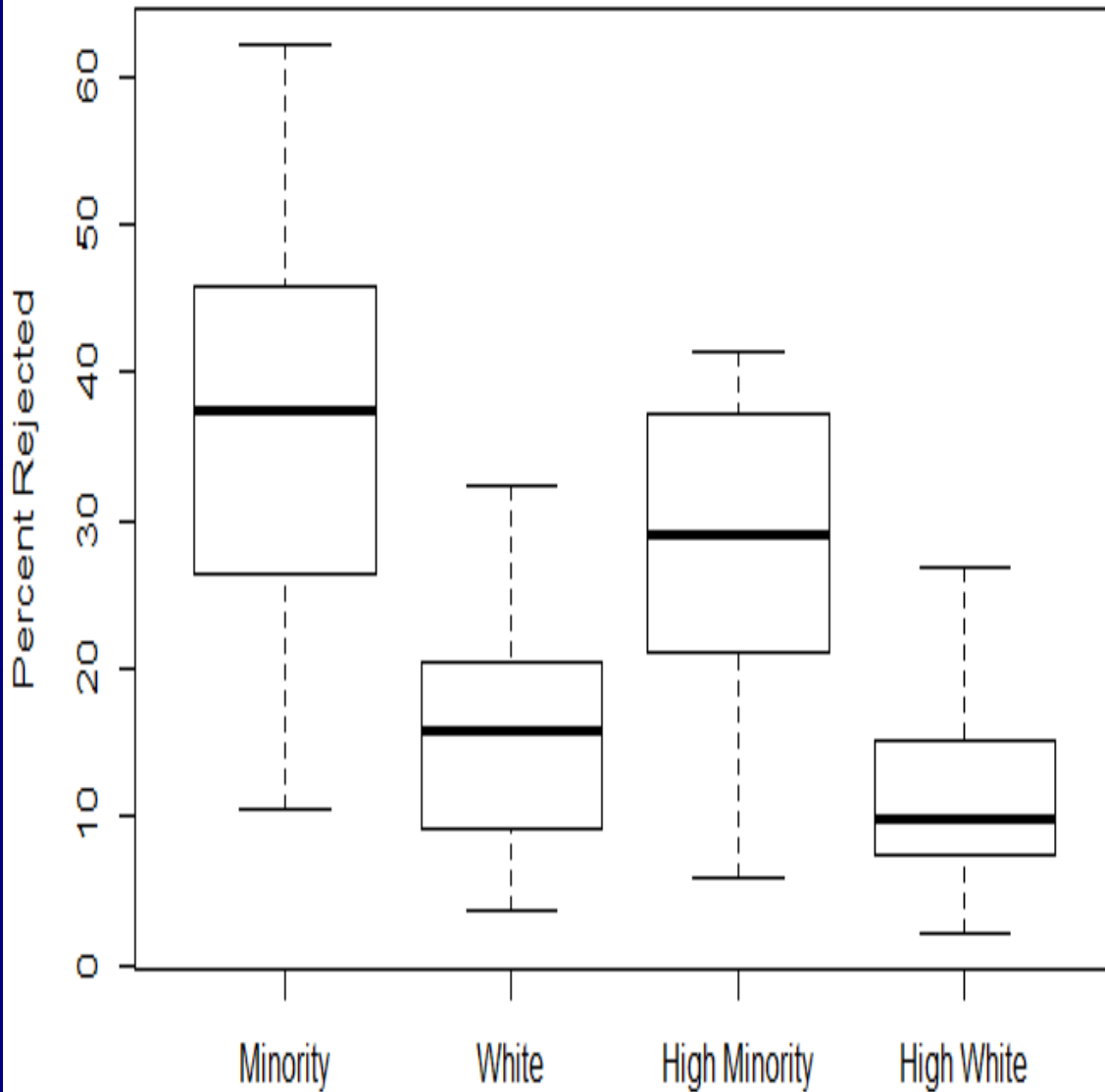
1) Describe the mortgage rejection rates.

2) Why might there be a different rejection rate between Whites and Minorities? List all possible confounders (and sources of bias, but here let's focus on confounders).

3) Additional questions to Consider:

- Is this model appropriate? What assumptions are necessary? (two-sample t-test)
- How bad is it if the assumptions are violated?
- What **alternative methods** exist if there are problems with the assumptions being met?
- Are there measurement issues? bias?

Boxplot of Mortgage Rejection Rate



Questions:

1) Describe the relationship now, controlling for SES.

2) Have we explained the difference away yet?

3) Are these models appropriate? What assumptions are necessary? (ANOVA or Multiple Regression, NICE, Multicollinearity)

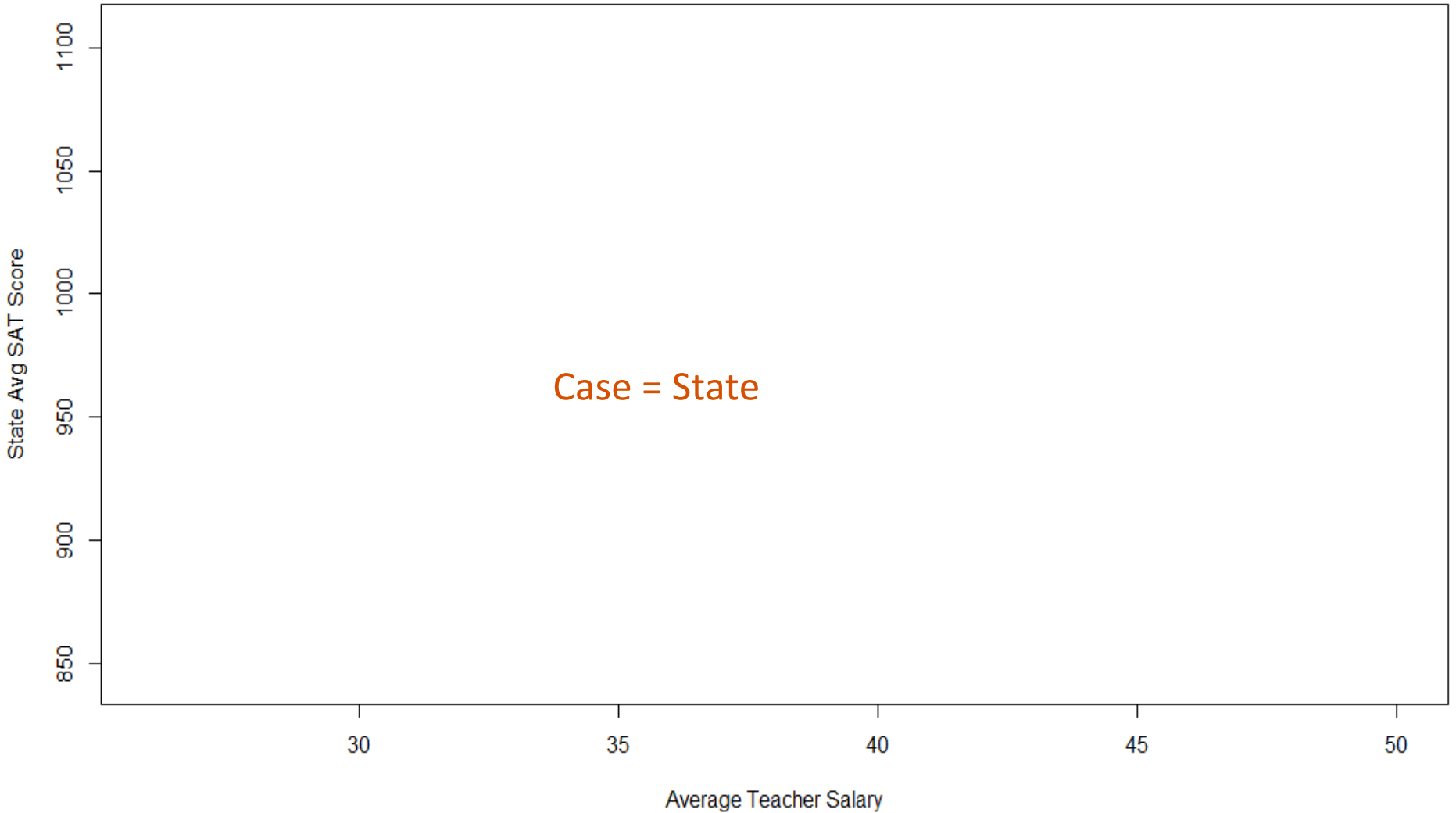
# Methods for Dealing with Confounders

- Stratification
  - Make the confounder categorical (group numeric values)
  - Examine the relationship between the explanatory and response variables by each level of the confounder
- Modeling
  - Control or adjust for the other factors mathematically
- Sherlock Holmes quote:
  - “When you have eliminated the impossible, whatever remains, however improbable, must be the truth.”
- Quasi-experimental methods
  - More sophisticated models, like propensity score methods



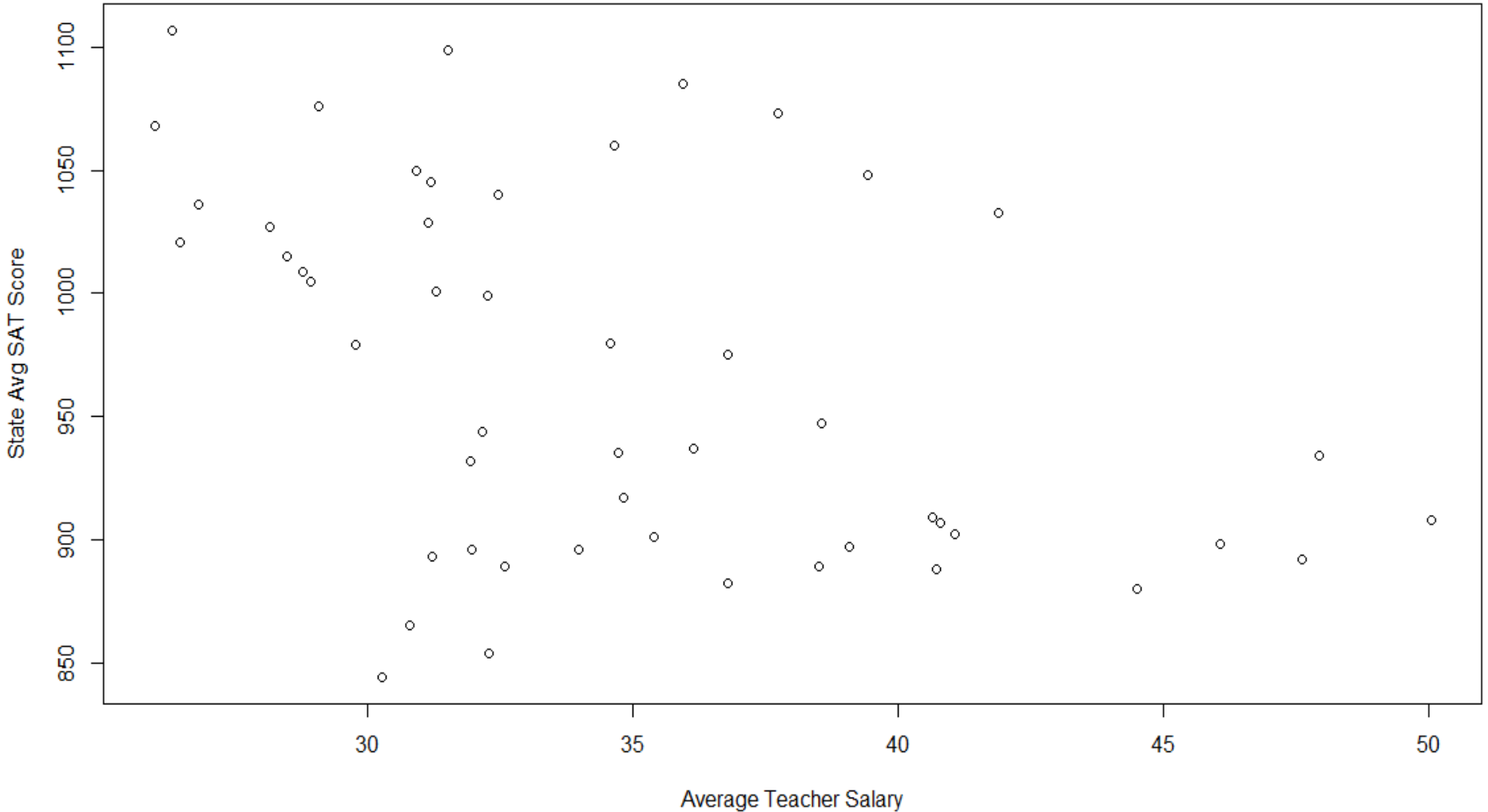
# Sat Score & Teacher Salary

Plot of SAT Score by Teacher Salary



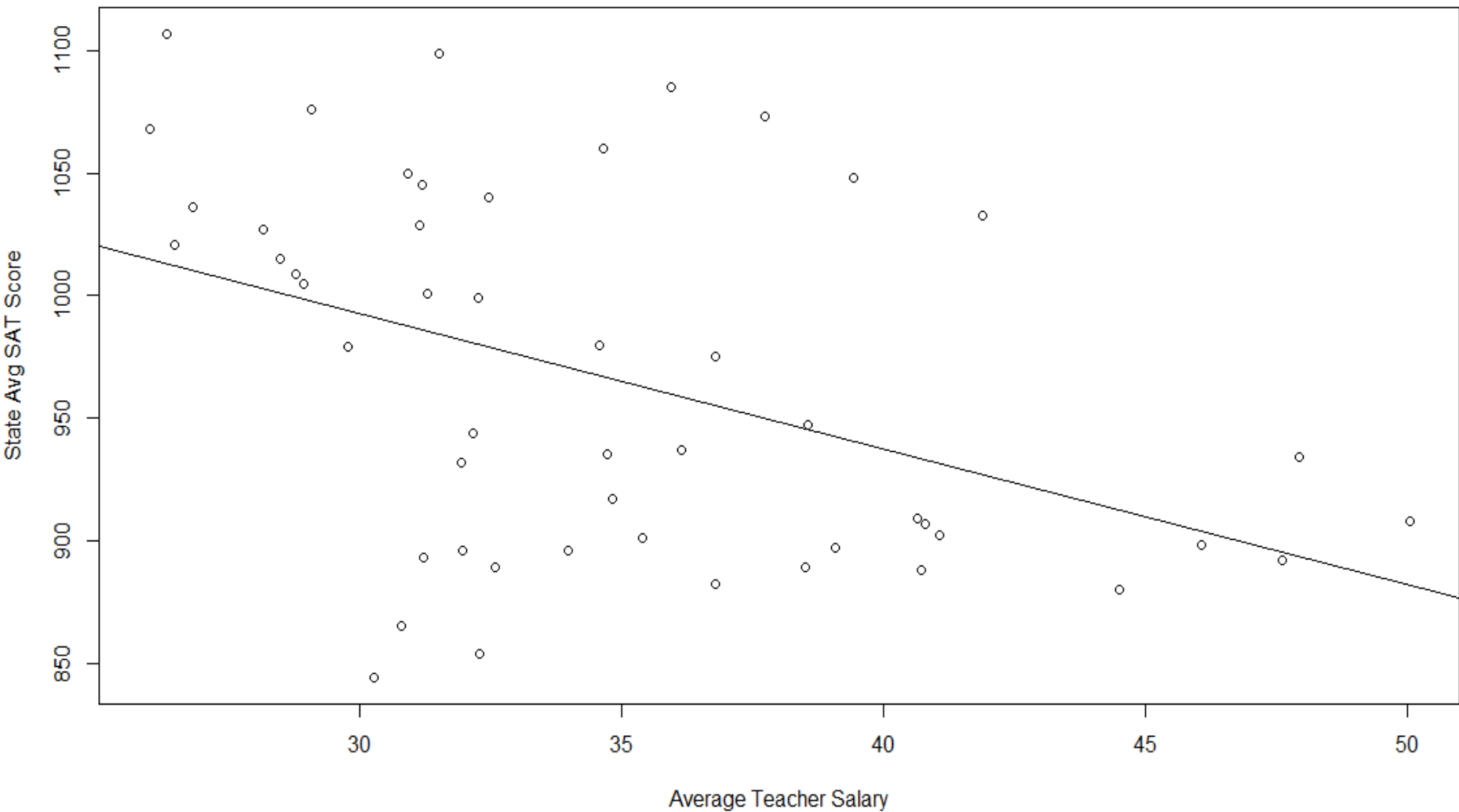
# Sat Score & Teacher Salary

Plot of SAT Score by Teacher Salary



# Sat Score & Teacher Salary

Plot of SAT Score by Teacher Salary



# SAT & Salary – (Simple) Regression

Summary of Fit	
RSquare	0.193497
RSquare Adj	0.176695
Root Mean Square Error	67.88929
Mean of Response	965.92
Observations (or Sum Wgts)	50

Analysis of Variance				
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	53077.82	53077.8	11.5162
Error	48	221229.86	4609.0	<b>Prob &gt; F</b>
C. Total	49	274307.68		0.0014*

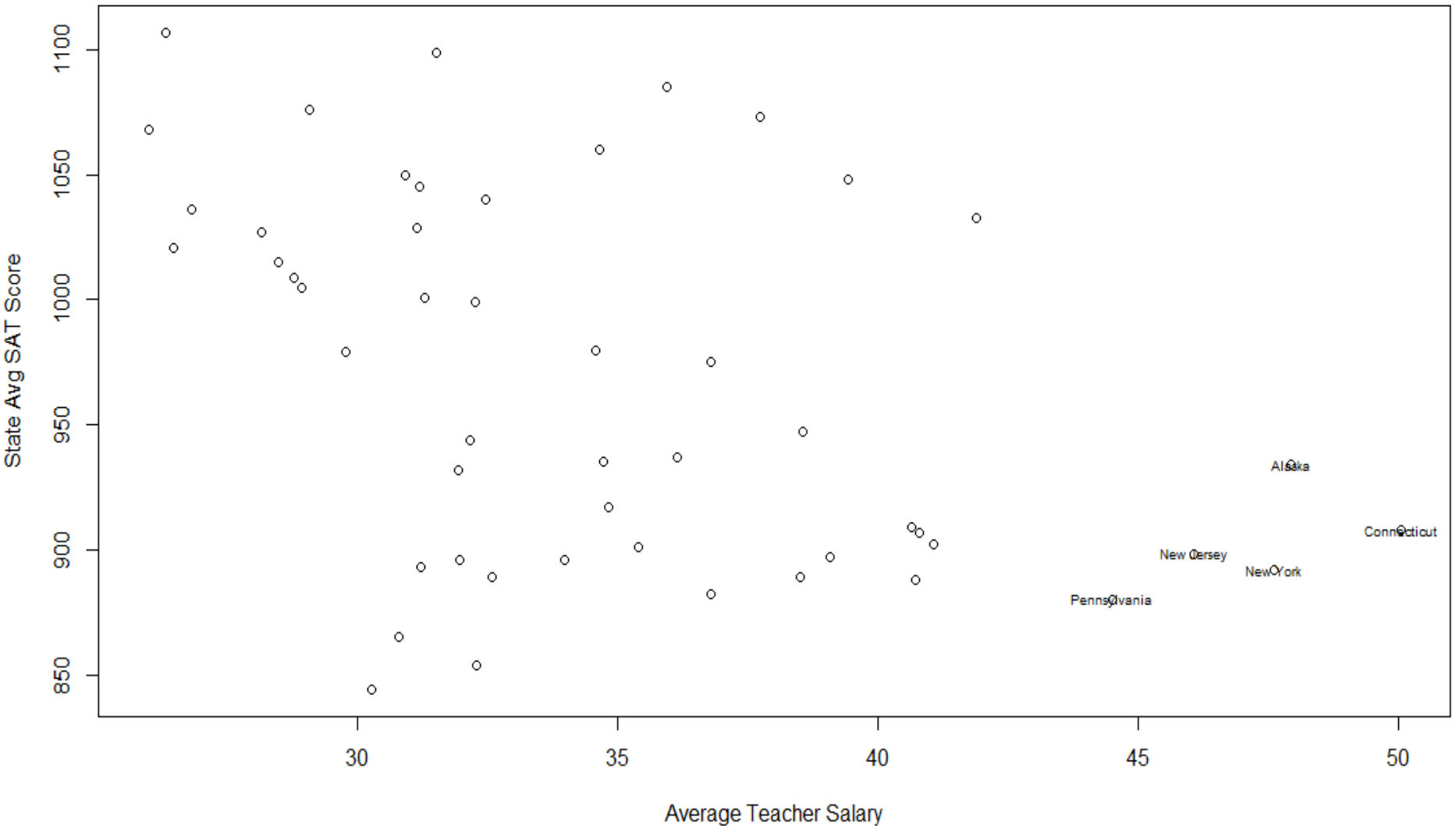
  

Parameter Estimates				
Term	Estimate	Std Error	t Ratio	Prob>  t
Intercept	1158.8588	57.65939	20.10	<.0001*
salary	-5.539615	1.632391	-3.39	0.0014*

$$\text{SAT} = 1159 - 5.5 \text{ Salary}$$

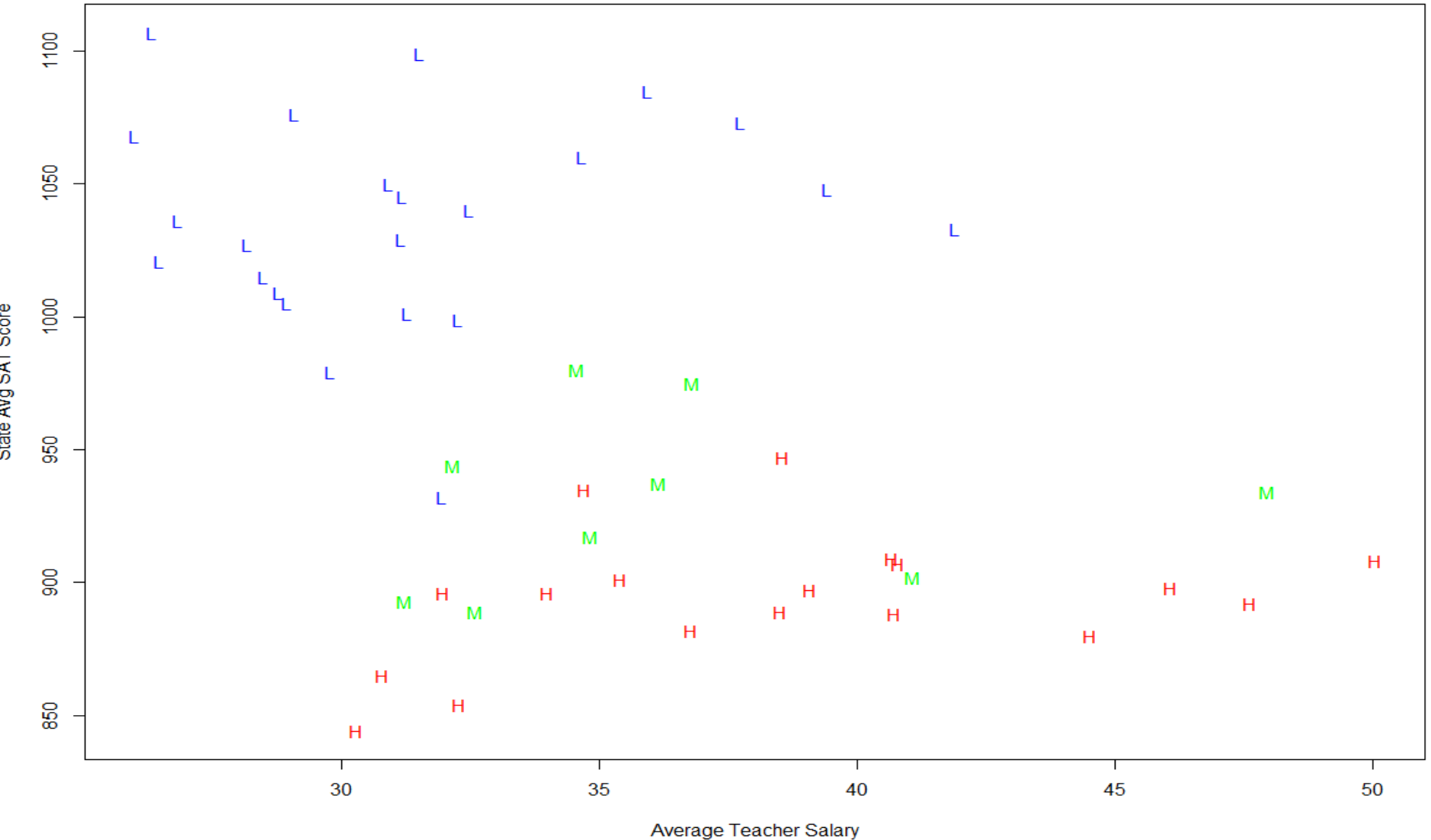
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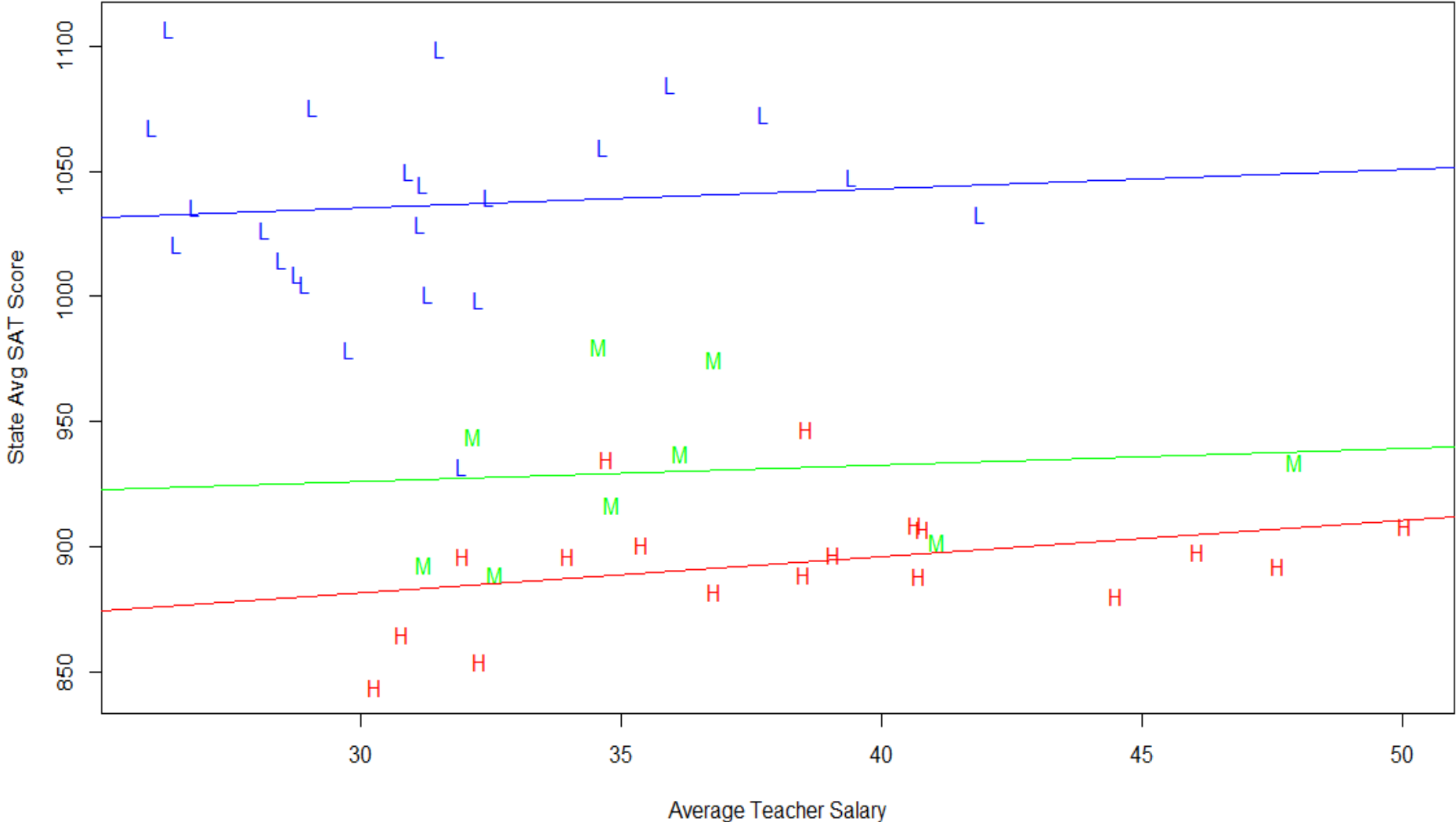
# Sat Score & Teacher Salary

Plot of SAT Score by Teacher Salary by Fraction

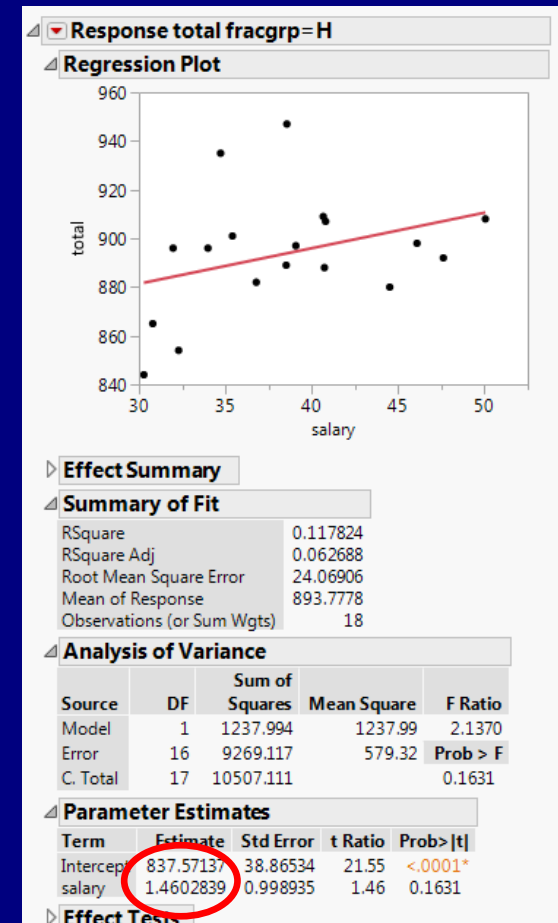
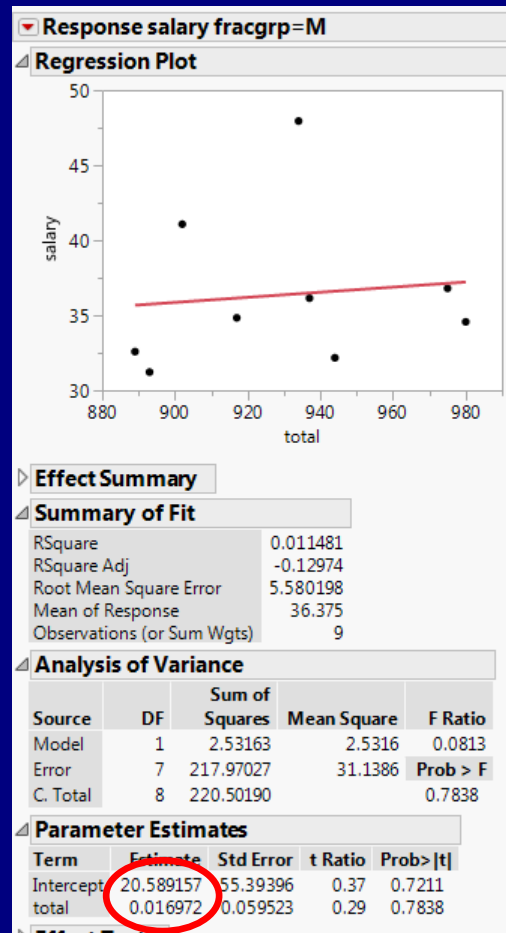
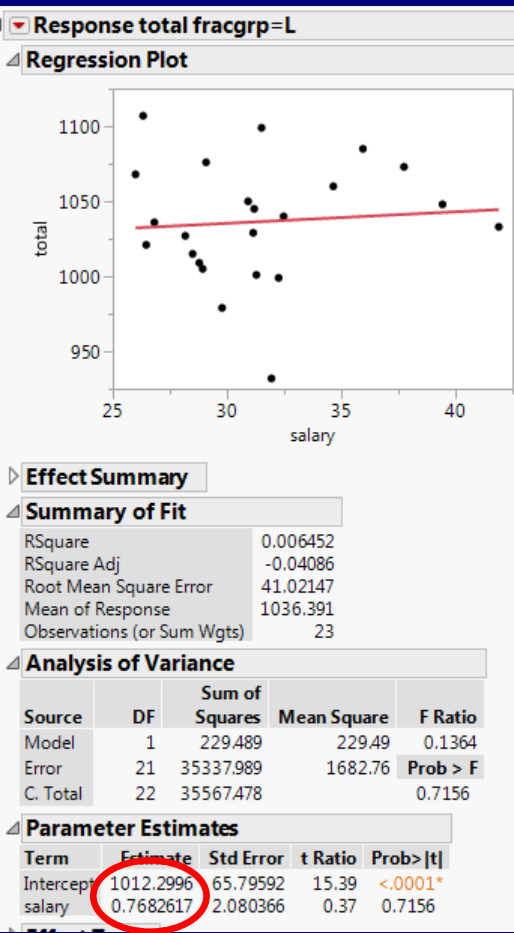


# Sat Score & Teacher Salary

Plot of SAT Score by Teacher Salary by Fraction



# SAT & Salary – Stratified Regressions





# SAT & Salary – Multiple Regression

A multiple regression combines the stratified regression into one equation  
This one (with main effect only) combines the slopes into a single estimate

Parameter Estimates				
Term	Estimate	Std Error	t Ratio	Prob>  t
Intercept	6.8833342	22.2371	0.31	0.7583
total	0.0236159	0.021432	1.10	0.2762
FracGrpM	7.5262117	3.01405	2.50	0.0162*
FracGrpH	10.499313	3.440696	3.05	0.0038*

$$\text{SAT} = 7 + 0.024 \text{ Salary} + 7.5 \text{ FracGrpM} + 10.5 \text{ FracGrpH}$$

# SAT & Salary – w/Interactions

A multiple regression combines the stratified regression into one equation  
This one (with interaction effects) allows each slope to differ

Parameter Estimates				
Term	Estimate	Std Error	t Ratio	Prob>  t
Intercept	-3.972649	23.86276	-0.17	0.8685
total	0.0359652	0.023611	1.52	0.1348
FracGrpM	6.2159025	3.341735	1.86	0.0696
FracGrpH	13.544073	4.315539	3.14	0.0030*
(FracGrpM-0.18)*(total-965.92)	0.0085735	0.060003	0.14	0.8870
(FracGrpH-0.36)*(total-965.92)	0.0722875	0.055931	1.29	0.2030

$$\text{SAT} = -4 + 0.036 \text{ Salary} + 6.2 \text{ FracGrpM} + 13.5 \text{ FracGrpG} + 0.0086 f(\text{FracGrpM}, \text{Salary}) + 0.072 f(\text{FracGrpM}, \text{Salary})$$

# A Case of Discrimination in California

- **Discrimination in Services to the Disabled**  
(from the *Journal of Statistics Education*)
- Data Set: Random sample of 1,000 clients of California Department of Developmental Services
- Variables:
  - Annual expenditure for support to individual and family
  - Gender
  - Ethnicity
  - Age Cohort (based on amount of financial support typically required during a particular life phase) (0 – 5 years, 6 – 12 years, 13 – 17 years, 18 – 21 years, 22 – 50 years, over 50 years)

# Annual Expenditure on Services to Disabled

- Court case in California. Is there discrimination?

Gender	Average of Expenditures (\$)
Female	\$ 18,130
Male	\$ 18,001
<b>All Consumers</b>	<b>\$ 18,066</b>

**Table 2.** Average Expenditures by Gender

Ethnicity of Consumers	Average of Expenditures (\$)
American Indian	\$ 36,438
Asian	\$ 18,392
Black	\$ 20,885
Hispanic	\$ 11,066
Multi Race	\$ 4,457
Native Hawaiian	\$ 42,782
Other	\$ 3,317
White non-Hispanic	\$ 24,698
<b>All Consumers</b>	<b>\$ 18,066</b>

**Table 1.** Average Expenditures by Ethnic

Many groups only have a few people in them, so let's focus on two large groups – Hispanic and White (non-Hisp)

What might explain the difference in expenditure by Ethnicity?

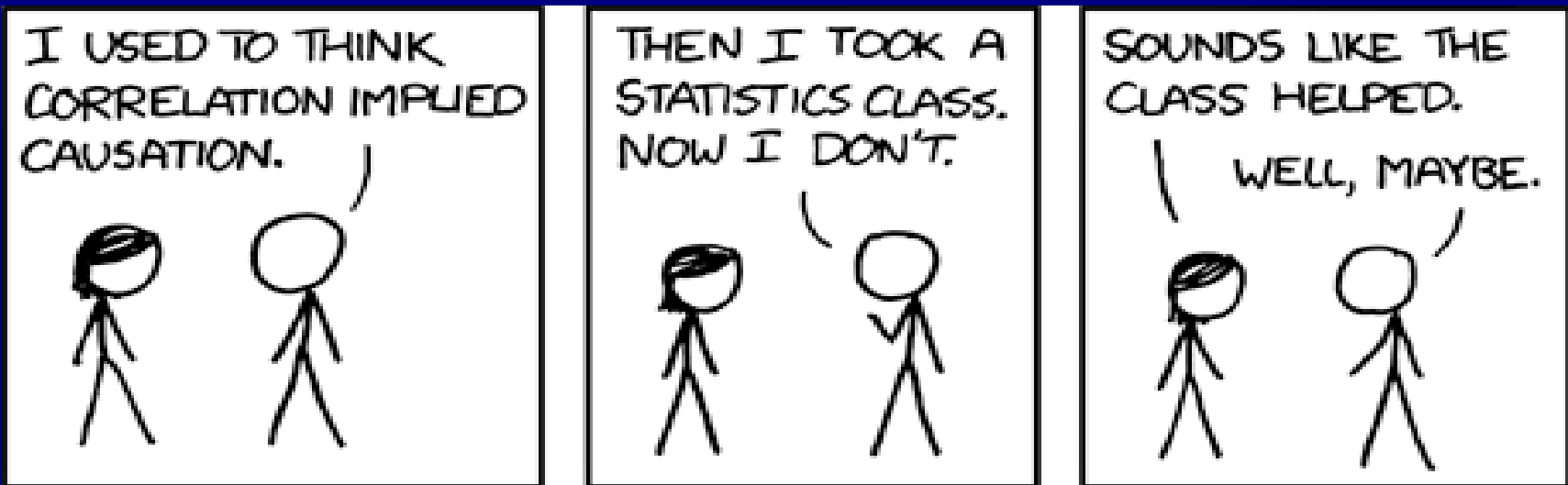
# (Joint) Expenditure by Ethnicity & Age

<b>Age Cohort</b>	<b>Hispanic</b> (avg. of expenditures)	<b>White non-Hispanic</b> (avg. of expenditures)
0 – 5	\$ 1,393	\$1,367
6-12	\$ 2,312	\$2,052
13-17	\$ 3,955	\$3,904
18-21	\$ 9,960	\$10,133
22-50	\$ 40,924	\$40,188
51 +	\$ 55,585	\$52,670
<b>All Consumers</b>	<b>\$11,066</b>	<b>\$24,698</b>

**Table 6.** Average Expenditures by Ethnicity and Age Cohort

# Multivariate Thinking

Correlation does not imply causation! (xkcd)



Correlation doesn't imply causation, but it does waggle its eyebrows suggestively and gesture furtively while mouthing 'look over there'.

# Confounder Activity

**For each of the following, identify the confounder:**

- Shoe size and vocabulary among children?
- As crime rates increase, so does ice cream sales, so let's stop selling ice cream!
- The number of speeding tickets that a student has is less than that of his/her parents.
- Typically, students do worse on exam problems that they spend a lot of time on.
- There is a strong positive relationship between # of TVs per house and life expectancy (by country)
- The mortality rate in the US is higher than most other North/South American countries
- The more children a woman has, the lower her risk of breast cancer.
- Do storks really bring babies?
- Bonjour Paris Lecole  
(<https://www.youtube.com/watch?v=tS55WeYwPfA>)

# MAGIC OF STATISTICS



# The Magic of Statistics...Revealed

Guess the color of the card!



# Probability and Independence

- Define “success” as guessing right
- What is the probability of “success”?
  - Bayesian vs. Frequentist
- What is the probability of getting all  $n$  right?

$$P(X = n) = p^n$$

- Does the guess of one student affect the next student?
  - Does the probability of “success” change?
  - Series of reds often forces the next guess to be black

# Binomial Distribution

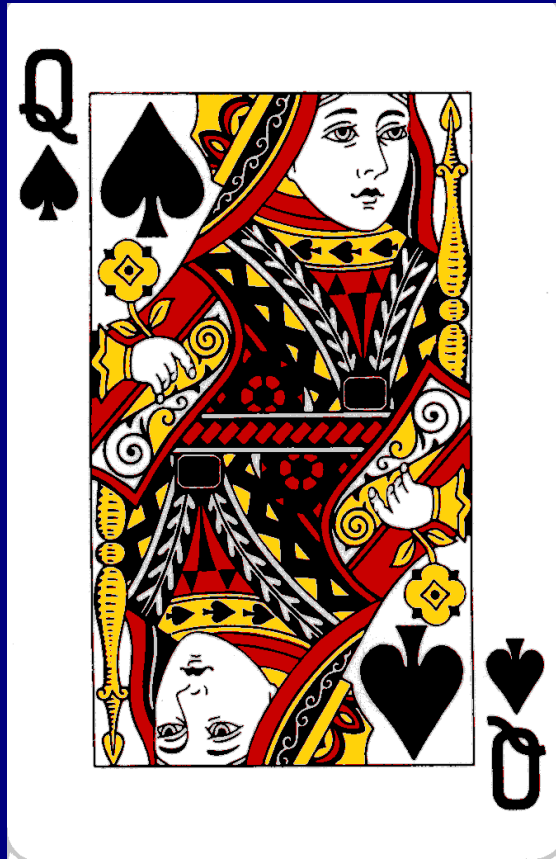
- Recall requirements
  - Dichotomous event
  - Independence
  - N trials
  - Constant probability of success (50%)
- What is the probability of getting n-1 out of n right?

$$\begin{aligned}P(X = n) + P(X = n - 1) \\&= p^n + \binom{n}{n-1} p^{n-1} (1-p) \\&= p^n + np^{n-1} (1-p)\end{aligned}$$

# Hypothesis Testing

- If the true probability of “success” is 50%, what is the chance you get all  $n$  right?
  - This is the p-value!
  - $P(\text{get this result or more extreme} \mid \text{null hypothesis is true})$
- In the end, you don't need to understand how the trick works, just that your guesses were likely not random
  - This is how hypothesis testing often works in the real world – you don't know data generation mechanism

Oh, and by the way...



YOU GOT  
THE QUEEN  
OF SPADES  
WRONG!

# Calculated Probabilities (P-values)

N	Basic Trick	Single Error	Single Error Prediction
1	1 in 2	1	1 in 48
2	1 in 4	3 in 4	1 in 64
15	1 in 32,768	1 in 2,048	1 in 98,304
20	1 in 1 million	1 in 49,932	1 in 2.4 million
25	1 in 34 million	1 in 1.3 million	1 in 62 million
30	1 in 1.1 billion	1 in 35 million	1 in 1.7 billion

# “Out of this World”

- One of the top ten tricks
  - Rated by magicians from around the world
- Created in 1942
- Uses a regular deck of cards
- Single prediction modification shown to me by Larry Smith
- Used by America’s Got Talent 2015 Winner!



# The REAL Magic!

- It makes students enjoy statistics class!
  - Many mention that “he does cool magic tricks” on course evaluations
    - (Although it’s the only one I use!)
  - Students love engagement with activities



TECHNOLOGY USE  
in  
STATISTICS  
EDUCATION

# Technology Options in Stat Ed

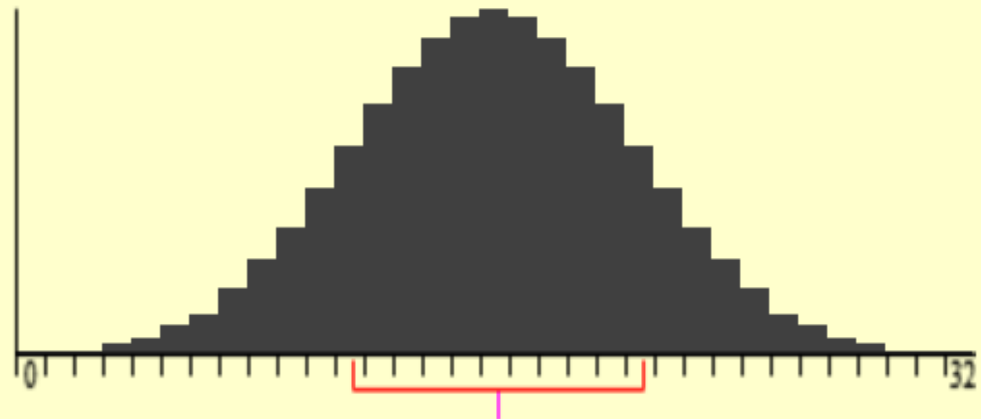
- Graphing calculators
- Statistical analysis software:
  - [R](#), [SAS](#), [SPSS](#)<sup>§</sup>, [StatCrunch](#)<sup>§</sup>, [Minitab](#)<sup>§</sup>, [JMP](#)<sup>§</sup>, Python
- Statistics modeling/simulation:
  - [TinkerPlots](#), [Fathom](#), [Gapminder](#), [CODAP](#), [StatKey](#)
- Applets:
  - [Rossman/Chance](#), [ArtOfStat](#), [STApplet](#)

# Applets for Teaching Statistics Concepts

- CI – Exploring coverage probability - [ArtOfStat](#) / [RossmanChance](#)
- Sampling Distribution - [Rice](#) / [ArtOfStat](#) / [RossmanChance](#)  
See Activities C
- Correlation - [ArtOfStat](#) / [istics](#) / [RossmanChance](#)
- Learning Regression – [RossmanChance](#)
- Power - [ArtOfStat](#)
- Guess the p-value – [RossmanChance](#)
- Simulation-based Inference – [StatKey](#) / [RossmanChance](#)  
– [Smelling Parkinson's](#) (from Doug Tyson)

mean= 16.00  
median= 16.00  
sd= 5.00  
skew= 0.00  
kurtosis= 0.00

Parent population (can be changed with the mouse)

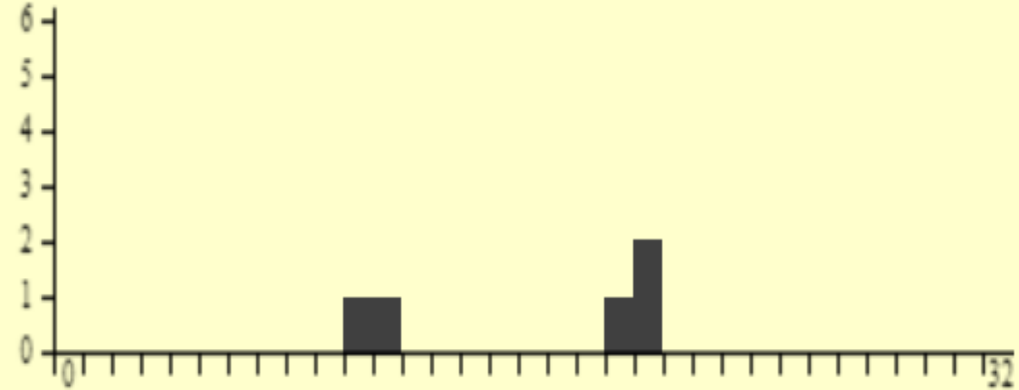


Clear lower 3

Normal ▾

Reps= 5  
range= 10.00

Sample Data



Sample:

Animated

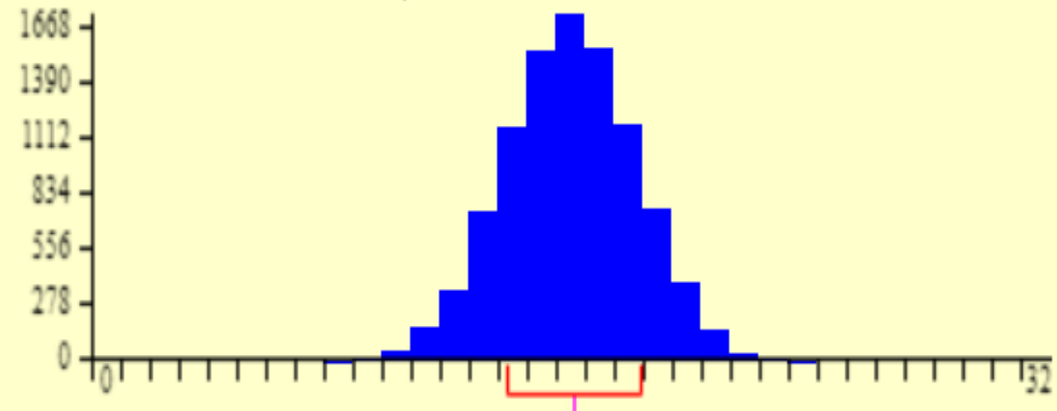
5

10,000

100,000

Reps= 10001  
mean= 16.00  
median= 16.00  
sd= 2.28  
skew= -0.01  
kurtosis= -0.04

Distribution of Means, N=5



Mean ▾

N=5 ▾

Fit normal

# Simulating Confidence Intervals

## Method

Proportions

Binomial

Wald

$\pi$

n

Intervals

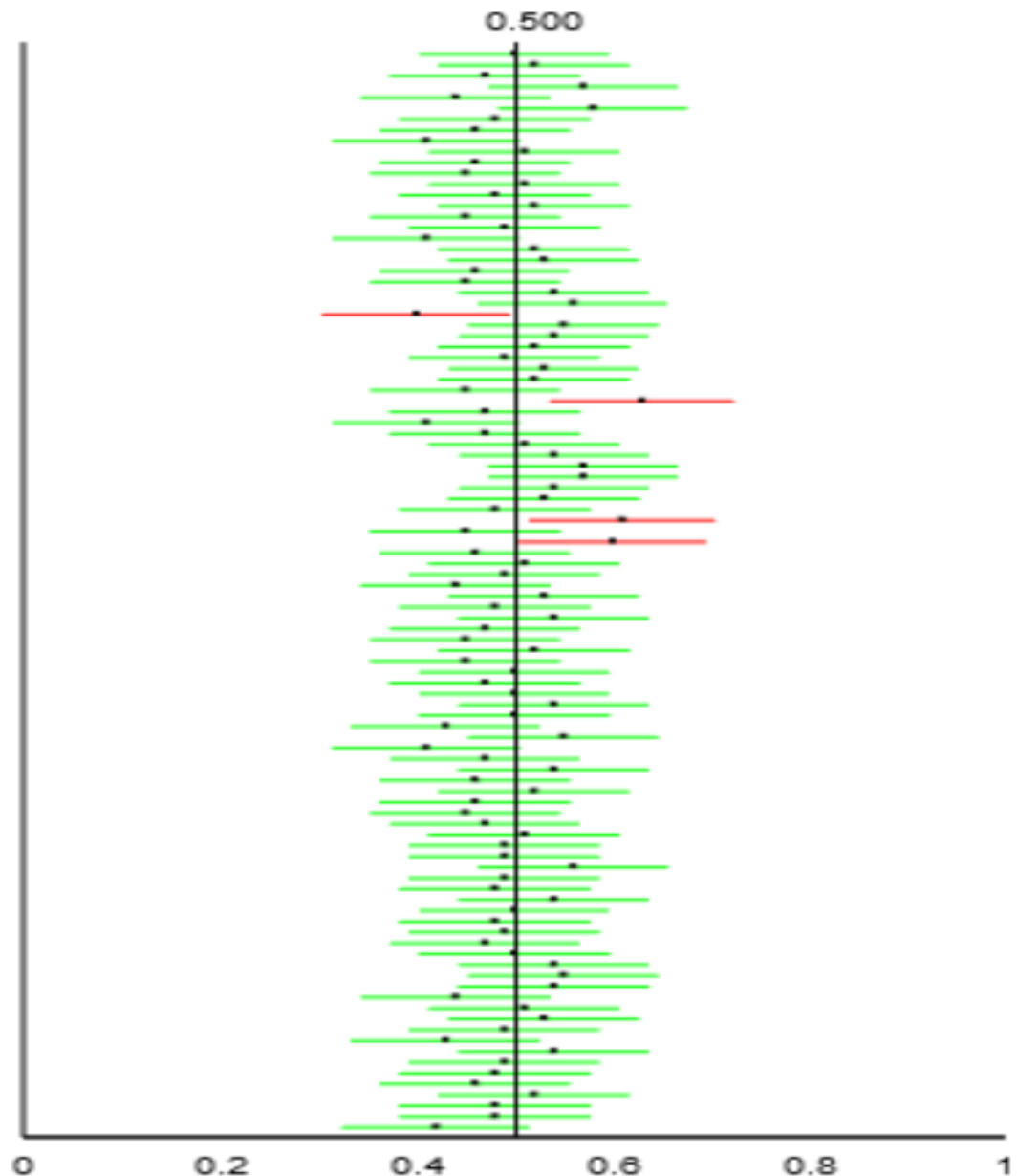
Conf level  %

Intervals containing  $\pi$

96 / 100 = 96.0%

Running Total

97 / 101 = 96.0%



Select data

### Enter data

footlength	height
32.0	74
24.0	66
29.0	77
30.0	67
24.0	56
26.0	65
27.0	64
29.5	70
26.0	62

(Explanatory, Response)

Use Data

Clear

n = 20

Show descriptive statistics:

### Explore lines

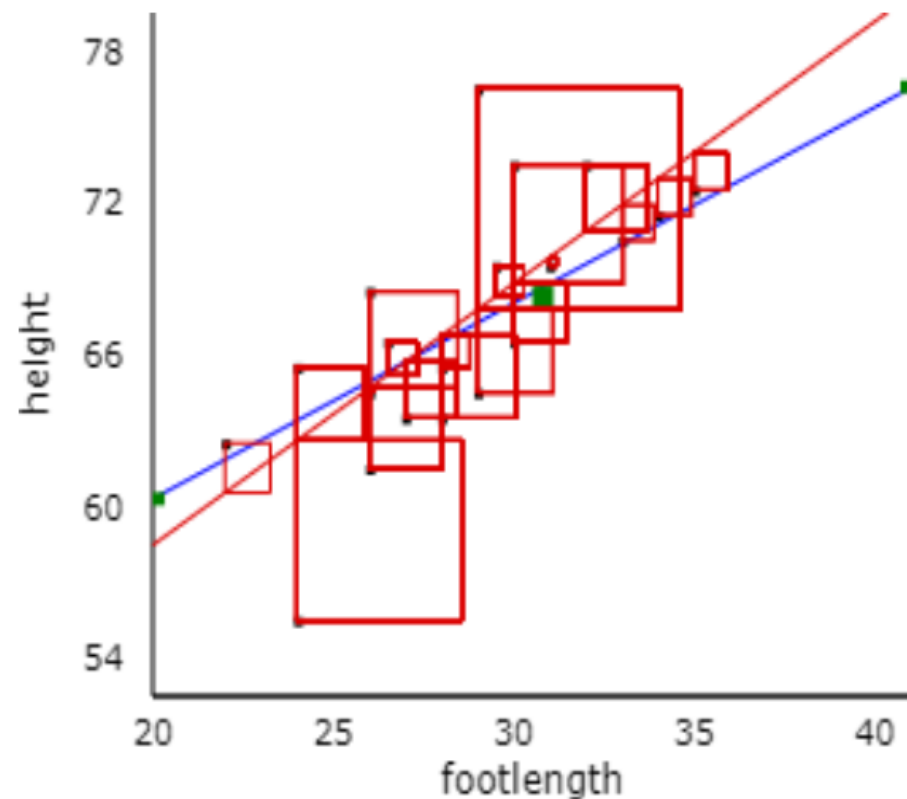
Show Movable Line:

$$\text{height}^{\wedge} = 45.34 + 0.77 \times \text{footlength}$$

Show Residuals:

Show Squared Residuals:

### Results



Show data options:

Show Regression Line:

$$\text{height}^{\wedge} = 38.30 + 1.03 \times \text{footlength}$$

Show Residuals:

Show Squared Residuals:

# Projects in Intro Stat

- See Activities E

# Resources

<http://tinyurl.com/StatEdResources>

Full URL:

<https://www1.villanova.edu/villanova/artsci/mathematics/cse/TeacherResources.html>

Feel free to ask me questions in the future...



# YOUR Hopes for the Workshop

- What engineering students (my largest enrollment) might need to know from statistics, and how to defend that information to my colleagues
- General techniques, language, useful examples
- I want to learn how to use and integrate real world data and situations into statistics courses.
- Useful methods for helping students understand / appreciate real world statistics applications.
- The teaching methods/idea that would make my current approaches more effective
- I'd like to learn about how students are being engaged in learning statistics today in a world that feels quite a bit different than when I was exposed to it.
- How to prepare well to teach Statistics
- What students would be comfortable with in terms of how in depth I should be mentioning theory or advanced programming concepts.
- Tips to help technology-averse students succeed in an R-based course.
- Techniques to make my statistics class more engaging for students.
- Options for in-class activities.
- What 'data-driven' should mean in an intro stats course
- Engaging and Crucial Content
- How to teach statistics better.

# Change is Hard!

*If you would attain to what you are not yet, you must always be displeased by what you are.*

*For where you are pleased with yourself there you have remained.*

*Keep adding,*

*keep walking,*

*keep advancing.*

*~Saint Augustine*