

# Teaching Quantitative Research Skills Within an On-line Course

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# Outline

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- Motivation: Creating an “Introduction to Quantitative Research” course that addresses today’s data-rich society
- A flipped upper-level course:
  - Hands on: Learn by doing
  - Modular and Multidisciplinary
  - Low Math Prerequisite
  - Writing/Speaking Intensive
- Moving this course on-line and making it accessible for high school students

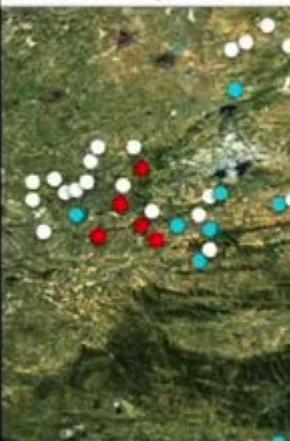
# Challenges in adapting to a data-rich society

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- Growing interest in data analysis
  - Technology has changed the discipline of statistics
  - Making decisions with data in an essential life skill

# Nate Silver

- Camps
- Camps with i
- Comparison



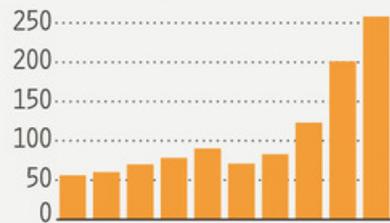
## Geek Chic

As data—and demands for data analysis—proliferate, so do students pursuing the field.

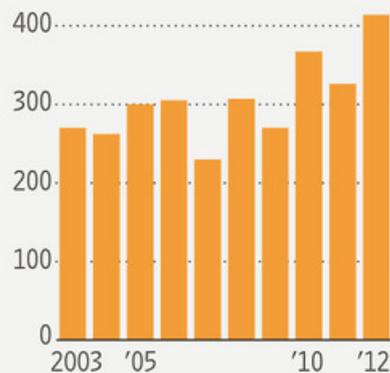
### Harvard University Statistics concentrators



### University of California, Berkeley Statistics majors, spring semester

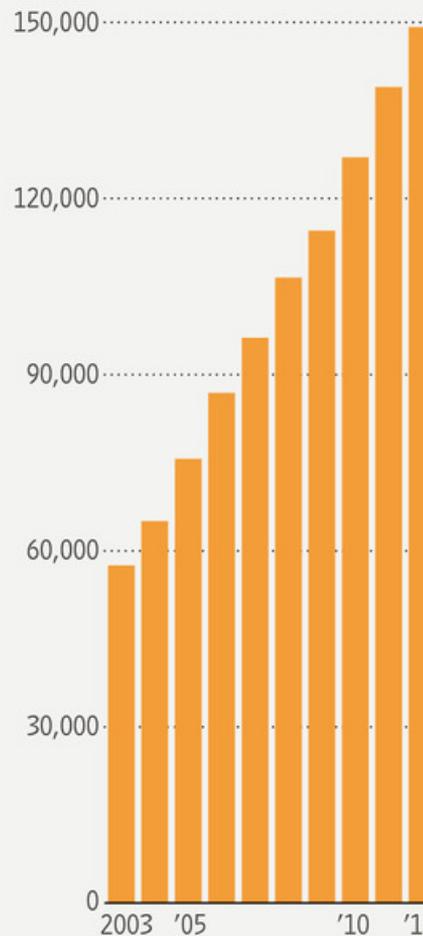


### Williams College Intro-statistics class enrollment



Sources: the schools; the College Board (AP exams)

### Advanced Placement tests taken in statistics



The Wall Street Journal



## The Sexiest Job of the 21st Century is Data Analyst

Chris Morris, Special to CNBC.com

Wednesday, 5 Jun 2013 | 1:00 PM ET



Graphic from an article appearing on March 2, 2013, on page A2 in the U.S. edition of The Wall Street Journal, with the headline: Data Crunchers Now the Cool Kids on Campus. [http://online.wsj.com/article/SB10001424127887323478304578332850293360468.html?mod=WSJ\\_hps\\_RightRailColumns](http://online.wsj.com/article/SB10001424127887323478304578332850293360468.html?mod=WSJ_hps_RightRailColumns)

# Challenges

# in society

are no longer  
statistical

curriculum is still  
of the twentieth

EDUCATION

- Student  
equipment  
method  
“We make  
preparation  
century”

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ESSAY

Why Most Published Research Findings Are False

John P. A. Ioannidis

Published: August 30, 2005 • DOI: 10.1371/journal.pmed.0020124

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When Should Potentially False Research Findings Be Considered Acceptable?

Most Published Research

Abstract

Modeling the Framework for False Positive Findings

Bias

Testing by Several Independent Teams

Corollaries

Summary

There is increasing concern that most current published research findings are false. The probability that a research claim is true may depend on study power and bias, the number of other studies on the same question, and, importantly, the ratio of true to no relationships

Unreliable research

## Trouble at the lab

Scientists like to think of science as self-correcting. To an alarming degree, it is not

Jason Ford

The Economist

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Percolator  
Research that matters.

April 17, 2012 by Tom Bartlett

Is Psychology About to Come Undone?

If you're a psychologist, the news has to make you a little nervous—particularly if you're a psychologist who published an article in 2008 in any of these three journals: *Psychological Science*, the *Journal of Personality and Social Psychology*, or the *Journal of Experimental Psychology: Learning, Memory, and Cognition*.

Because, if you did, someone is going to

Brian Nosek

Percolator Writers

Tom Bartlett  
@tebartl  
Tom Bartlett is sciences.

<sup>1</sup>Suzanne Switzer and Nick Horton. (2007) "What Your Doctor Should Know about Statistics (but Perhaps Doesn't)." *Chance*. 20(1): 17-21.

<sup>2</sup>Cobb, G. (2007) "The Introductory Statistics Course: A Ptolemaic Curriculum?," *Technology Innovations in Statistics Education*: Vol. 1: No. 1, <http://www.economist.com/news/briefing/21588057-scientists-think-science-self-correcting-alarming-degree-it-not-trouble>

# Challenges in adapting to a data-rich society

- Students who take only an intro course are no longer equipped to apply the more relevant statistical methods in their own work<sup>1</sup>

“We may be living in the early twenty-first century, but our curriculum is still preparing students for applied work typical of the first half of the twentieth century<sup>2</sup>”

- Multiple barriers to courses involving data analysis
  - Calculus 1, 2, and 3, linear algebra
  - Two semesters of statistical theory

“Curricula in statistics have been based on a now outdated notion ...at every level of study, gaining statistical expertise has required extensive coursework, much of which appears to be extraneous to the compelling scientific problems students are interested in solving.<sup>3</sup>”

<sup>1</sup>Suzanne Switzer and Nick Horton. (2007) “What Your Doctor Should Know about Statistics (but Perhaps Doesn't).” *Chance*. 20(1): 17-21.

<sup>2</sup>Cobb, G. (2007) “The Introductory Statistics Course: A Ptolemaic Curriculum?”, *Technology Innovations in Statistics Education*: Vol. 1: No. 1,

<sup>3</sup>Brown, E., and Kass. R., (2009), “What is Statistics”, *The American Statistician*. May 1, 2009, 63(2): 105-110.

# Core Elements of the Course

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- Use **real** and **complex data** from multiple disciplines
  - Bridge the gap from smaller, focused textbook problems to real-world research questions
  - Active learning through inquiry-based case studies: Group work, reading primary literature, data collection and analysis (*just-in-time learning*)
- **Communicate** statistical ideas to others:
  - Read current articles from multiple disciplines
  - Describe how to set up designs and develop models
  - Present results through multiple modes

# Core Elements of the Course

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- Develop **statistical thinking** by emphasizing conceptual understanding instead of mathematical details or rote knowledge of procedures (*accessible to more students*)
- Follow national guidelines and successful reforms of other courses
  - Research-Like Experiences: “students conduct research in which **the outcome is not known** (even to the course instructor) and students have at least some **input into the research topic and design of the methodological approach.** <sup>\*</sup>”

# Core Elements of the Course: “Research-Like”

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- “A common ingredient of success is identifying a suitable research problem that uses a set of common tools (which can be taught to the students as a group) but can be subdivided to provide students with individual projects.
  - Often these parts are reassembled to derive more informative conclusions.
  - Well-designed projects also provide extensive opportunities for peer interaction and mutual support.\*”

# Core Elements of the Course: “Research-Like”

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- “These elements likely contribute to a student's sense of responsibility, of ownership of his or her piece of the project, and of the importance of his or her contribution to a broader picture\*”

The flipped classroom inverts traditional teaching methods, delivering instruction online outside of class and moving “homework” into the classroom.

## THE INVERSION

**The Traditional Classroom**  
Teacher's Role: Sage on the Stage



**The Flipped Classroom**  
Teacher's Role: Guide on the Side



# The Flipped Classroom

DURING



Students practice applying key concepts with feedback

Catch students at the moment of uncertainty

Students prepare to participate in class activities

BEFORE



Out of Class

Students check their understanding and extend their learning

AFTER



What is a flipped classroom? (in 60 seconds);  
[http://www.youtube.com/watch?feature=player\\_embedded&v=r2b7GeuqkPc](http://www.youtube.com/watch?feature=player_embedded&v=r2b7GeuqkPc)

# What Should be Flipped?

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“The Internet, online textbooks, online lectures, ... provide access to endless amounts of content, much of it free. Students can discover information on their own and find the answer to a question within a matter of seconds. What they can't always do on their own is ***analyze, synthesize, and experience the process of engaging in higher levels of critical thinking***. This is when they need to do the messy work of learning, evaluating, and critiquing. This also is when they need your structure and guidance, but not your answers. They have to make meaning for themselves. This is a ***'flippable moment'***.”

--Dr. Barbi Honeycutt, North Carolina State University.

# What Should be Flipped?

- 1) **Essentials:** What are the most critical parts of the course that students need to know before they can move forward?

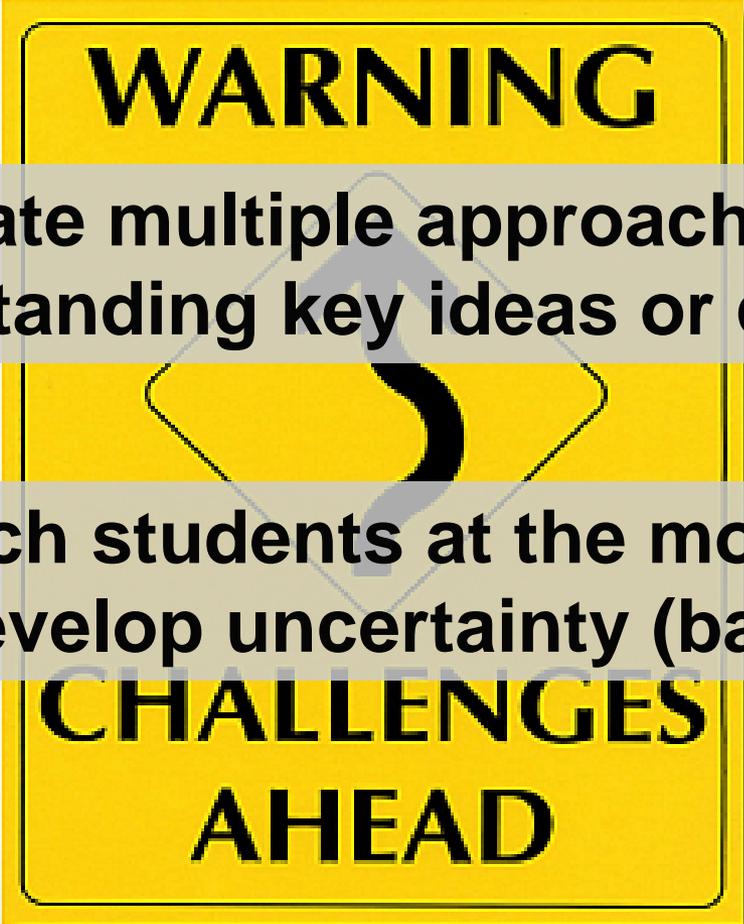
**Start with the QUESTIONS, not the TOPICS**

What is your vision of your learners at the end of their contact with you?

*- Leslie Owen Wilson*

# What Should be Flipped?

**2) Challenges:** What are the most difficult concepts within the course?



**Create multiple approaches to understanding key ideas or concepts**

**Catch students at the moment they develop uncertainty (bad habits)**

**CHALLENGES  
AHEAD**

# What Should be Flipped?

## 3) Boredom: When do students tend to tune out?



**Create situations that challenge students to investigate in order to answer their own questions**

**Create space to imagine, practice, and struggle so they become invested in the problem.**

# Flipped Example: Case Studies

- Students read the initial 3-5 page case study, conduct a simple analysis and answer preliminary questions before class.
  - Detailed software instructions provided
  - Class time is used to interpret and discuss the statistical results
- Give students an opportunity to modify the research question; they get to ask questions they care about
  - When students have input into the research process and the outcome is not known a priori to either the students or the instructors, the study becomes real to the students in very new ways
  - This greater level of investment encourages greater student learning and a passion for knowing how to find a solution to their study

# Flipped Example: Case Studies

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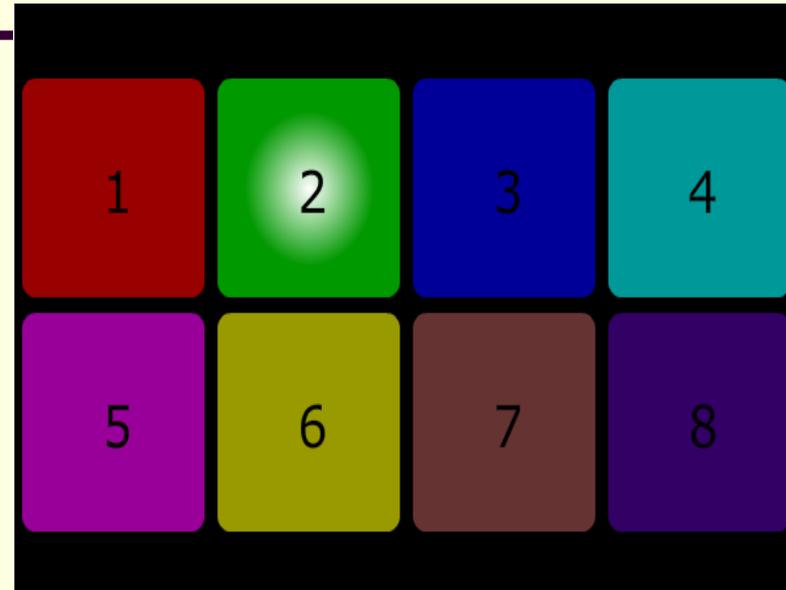
Can a new drug reduce the spread of schistosomiasis?

- Before class, read the 3-5 pages, graph the data and find summary statistics.
  - A waterborne disease that affects 200 million people worldwide and can cause death
  - Currently only one drug effectively treats this disease (issues with drug resistance)
  - Promising new drug has been tested on a small sample of mice, can we tell if it is effective?
- This is a small and highly skewed dataset, so a two-sample  $t$ -test is not appropriate. What can we do to determine if there is a difference between groups?
- ***Students come to class wanting to know how to find the answer***

# Unit 2: Memory

## Introductory Case Study

- Memorathon game: players attempt to remember sequences of buttons
- How long of a sequence can students in your class remember?
- Read the article by Surprenant, A. M. (2001).
- Play the game and develop your own research hypothesis



# Unit 3: Multiple Regression

## Introductory Case Study

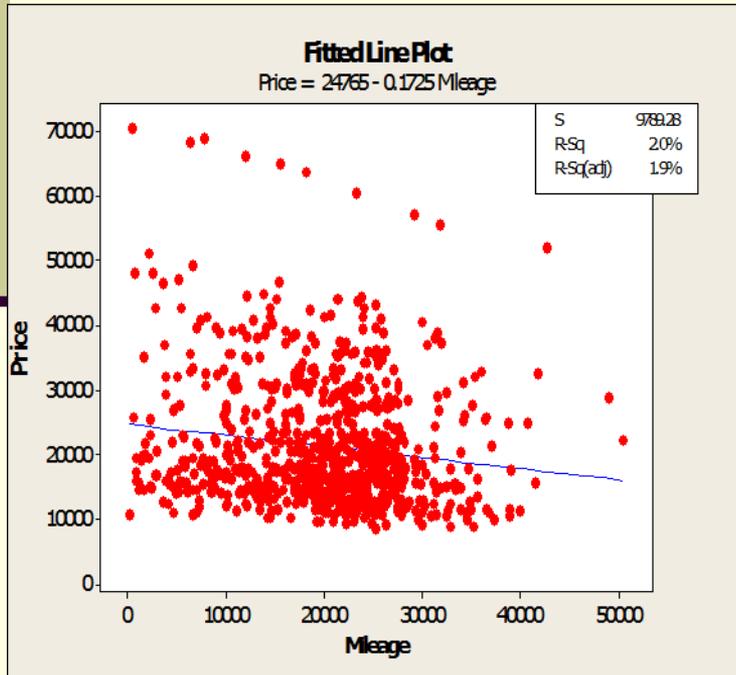
- Build a multiple regression model for 2005 General Motors (GM) cars
  - Price = 24723 - 0.17 Mileage
  - Slope coefficient ( $b_1$ ):  $t = -4.09$  (p-value = 0.0001)
  - R-Sq: 2.0%

Time and space to struggle with core ideas

e of

## Review Questions

- What happens to Price as Mileage increases?
- Since  $b_1 = -0.17$  is small can we conclude it is unimportant?
- Does mileage help you predict price? What does the p-value tell you?
- Does mileage help you predict price? What does the R-Sq value tell you?
- Are there outliers or influential observations?



# The On-line Course

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## Week

- 1- 4: Unit 1: Randomization and Permutation Tests (Schistosomiasis)  
Unit 2: Making Connections: The 2-sample t-test, Regression and ANOVA  
(What Impacts Memory?)  
Project: Three Page Memo to University President  
(Gender Discrimination Among University Faculty)
- 5 -9: Unit 3: Multiple Regression (Estimating Car Prices)  
Unit 4: Designing Experiments (How to Get the Best Microwave Popcorn)  
Project: Webpage (Economic Growth in Developing Countries)
- 10-14: Unit 6: Categorical Data Analysis (Space Shuttle Challenger )  
Unit 7: Logistic Regression (Detecting Cancer through Fine Needle  
Aspiration)  
Final Project: PowerPoint Presentation (Climate Change Models,  
College Rankings, Housing Prices, Encryption Speeds)

# The On-line Course

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## Each Unit/Chapter Contains

- Daily textbook readings with guided instructions for assignments and 2-3 short video lectures
- Online quizzes and discussion boards (1-2 times a week)
- Small group online meetings (weekly through Google Hangouts)

Three small group projects

# The On-line Course

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## Monday, Sept 30

Submit Questions C2) 17,19-27 from the textbook

With your group, make and submit final edits your three page memo to the faculty dean in your **Project 1: Faculty Discrimination**.

Select a time to meet with me (you will get an email invitation). We will discuss:

- the discrimination project
- any questions about chapter 2, particularly normal probability plots and transformations, so please attempt Thursday's assignment before our meeting.

## Tuesday, Oct 1

- Watch the video 180 degrees, then take the Project 1 Quiz.
- Submit a minimum of two comments or questions in the Chapter 2 Discussion Questions.

## Thursday, Oct 3

- Read Sections 2.8 and 2.9
- Watch the video on Normal Probability Plots
- Submit Questions C2) 28,30,32 from the textbook
- Fill out the Project 1 peer evaluation form.

# The On-line Course: Challenges

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- Time
  - Making video lectures and modifying course material
  - Ensuring all students are on task
  - School breaks and Time Zone issues
  - Software problems
- Not all students designate appropriate time to the course (all students have a site director)
- Engagement and accountability with some students
- Slower Pace

# The On-line Course: What has worked well

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- Global Online Academy support / tech support
- Extremely bright students
- Good connections with some students
- Developed many new skill sets
- Benefits to brick-and-mortar classes
  - Interactive, **inquiry-based studies** that teach students **complex statistical concepts** early in their education.
  - Address the **changing needs and learning styles** of students
  - Active learning/unique research question in a real context fosters a **sense of engagement** and encourages students to go deeper than the assignment requires

# Resources

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Textbook:

<http://www.pearsonhighered.com/kuiper1einfo>

Games and other Resources:

[web.grinnell.edu/individuals/kuipers/stat2labs](http://web.grinnell.edu/individuals/kuipers/stat2labs)

Videos:

<http://www.screencast.com/users/Stat2labs>