Teaching Quantitative Research Skills Within an On-line Course

Dr. Shonda Kuiper
Grinnell College

June 13, 2014
http://web.grinnell.edu/individuals/kuipers/stat2labs
Outline

• 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

• Growing interest in data analysis
  o Technology has changed the discipline of statistics
  o Making decisions with data in an essential life skill
Challenges in adapting to a data-rich society

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

• Students who take only an intro course are no longer equipped to apply the more relevant statistical methods.

“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.”

Challenges in adapting to a data-rich society

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\(^1\)

> “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\(^2\)”

• 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 “Curricula in statistics have been based on a now outdated notion … at every level of study, gaining statistical expertise has required extensive coursework, much of which appears to be extraneous to the compelling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.\(^3\)”


Core Elements of the Course

• 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

- 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**.”

“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”

• “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”

* Cynthia A. Wei and Terry Woodin Undergraduate Research Experiences in Biology: Alternatives to the Apprenticeship Model, CBE Life Sci Educ, Vol. 10, 123–131, Summer 2011
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

- **LECTURE TODAY**
- Homework: Reading and questions due tomorrow

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

- **ACTIVITY TODAY**
- WATCH lecture online tonight!
The Flipped Classroom

BEFORE
Students prepare to participate in class activities

Out of Class
Students check their understanding and extend their learning

DURING
Students practice applying key concepts with feedback

AFTER
Catch students at the moment of uncertainty

What is a flipped classroom? (in 60 seconds);
http://www.youtube.com/watch?feature=player_embedded&v=r2b7GeuqkPc
What Should be Flipped?

“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

Understanding by Design, by Grant Wiggins and Jay McTighe
http://www4.uwsp.edu/education/lwilson/curric/backdesignoverview.htm
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)
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
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

http://web.grinnell.edu/individuals/kuipers/stat2labs/
Unit 3: Multiple Regression

Introductory Case Study

- Build a multiple regression model to predict the price of 2005 General Motors (GM) cars based on mileage.
  - Price = 24723 - 0.17 Mileage
  - Slope coefficient ($b_1$): $t = -4.09$ (p-value < 0.01)
  - R-Sq: 2.0%

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

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

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
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

- **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

- 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

Textbook:
http://www.pearsonhighered.com/kuiper1einfo

Games and other Resources:
web.grinnell.edu/individuals/kuipers/stat2labs

Videos:
http://www.screencast.com/users/Stat2labs