Using Activity- and Web-Based Materials in Post-Calculus Probability and Statistics Courses

Allan Rossman (and Beth Chance)
Cal Poly – San Luis Obispo
arossman@calpoly.edu

Goals

- To generate productive thought and discussion about appropriate
  - Goals
  - Content
  - Pedagogy

  of an introductory statistics course for mathematically inclined students

Goals (cont.)

- To introduce you to curricular materials that aim to help prepare you to:
  - Present a course that provides a more balanced introduction to statistics for mathematically inclined students
  - Infuse a post-calculus introductory statistics course with activities and data
  - Model recommended pedagogy and content for future teachers of statistics

Format

- Activity sessions will consist of working through activities/investigations
  - Please be willing to play the role of student
  - Investigations chosen from throughout course to illustrate guiding principles
  - More “lecture” than with my students
  - Implementation suggestions offered along the way

Features of Statistics Education Reform

- Active Learning
- Conceptual Understanding
- Genuine Data
- Use of Technology
- Communication Skills
- Interpretation in Context
- Authentic Assessment

Products of Statistics Education Reform

- Textbooks
- Activity Books
- Lab Manuals
- Books of Data Sources
- Books of Case Studies
- On-line Books
- Journals
- Dynamic Software
- Java Applets
- Web Sites
- Project Templates
- Assessment Instruments
- Workshops

What's the Problem?

- Vast majority of reform efforts have been directed at the "Stat 101" service course
- Rarely reaches Mathematics or Statistics majors
  - Option A: Take Stat 101
  - Option B: Standard Prob and Math/Stat sequence

What's the Problem?

- Option A
  - Does not challenge students mathematically
  - Rarely counts toward major
- Option B
  - Does not give balanced view of discipline
  - Fails to recruit all who might be interested
  - Leaves prospective K-12 teachers ill-prepared to teach statistics, implement reform methods
  - Does not even prepare assistants for Stat 101!

Is This Problem Important?

"The question of what to do about the standard two-course upperclass sequence in probability and statistics for mathematics majors is the most important unresolved issue in undergraduate statistics education."

- David Moore

Is This Problem Important?

"The standard curriculum for mathematics majors allows little time for statistics until, at best, an upper division elective. At that point, students often find themselves thrust into a calculus-based mathematical statistics course, and they miss many basic statistical ideas and techniques that are at the heart of high school statistics courses."

- CBMS MET report (ch. 5)

Is This Problem Important?

"In most teacher preparation programs appropriate background in statistics and probability will not be provided by simply requiring a standard probability-statistics course for mathematics majors. It is essential to carefully consider the important goals of statistical education in designing courses that reflect new conceptions of the subject."

- CBMS MET report (ch. 5)

My Project (with Beth Chance)

To develop and provide a:

Data-Oriented, Active Learning, Post-Calculus Introduction to Statistical Concepts, Applications, Theory

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Principle 1

- Motivate with real studies, genuine data
  - Statistics as a science
  - Wide variety of contexts
  - Some data collected on students themselves

Principle 2

- Emphasize connections among study design, inference technique, scope of conclusions
  - Issues arise in chapter 1, recur often
  - Observational study vs. controlled experiment
  - Randomization of subjects vs. random sampling
  - Inference technique follows from randomization in data collection process

Principle 3

- Conduct simulations often
  - Problem-solving tool and pedagogical device
  - Address fundamental question: “How often would this happen in the long run?”
  - Hands-on simulations usually precede technological simulations
  - Java applets
  - Small-scale Minitab programming (macros)

Principle 4

- Use variety of computational tools
  - For analyzing data, exploring statistical concepts
  - Assume that students have frequent access to computing
    - Not necessarily every class meeting in computer lab
  - Choose right tool for task at hand
    - Analyzing data: statistics package (e.g., Minitab)
    - Exploring concepts: Java applets (interactivity, visualization)
    - Immediate feedback from calculations: spreadsheet (Excel)

Principle 5

- Investigate mathematical underpinnings
  - Primary distinction from “Stat 101” course
  - Some use of calculus but not much
  - Will assume familiarity with mathematical ideas such as function
  - Example: study principle of least squares in univariate and bivariate settings
  - Often occurs as follow-up homework exercises

Principle 6

- Introduce probability “just in time”
  - Not the goal
  - Studied as needed to address statistical issues
  - Often introduced through simulation
  - Examples
    - Hypergeometric distribution: Fisher’s exact test for 2x2 table
    - Binomial distribution: Sampling from random process
    - Continuous probability models as approximations

Principle 7

- Foster active explorations
  - Students learn through constructing own knowledge, developing own understanding
  - Need direction, guidance to do that

Principle 8

- Experience entire statistical process over and over
  - Data collection
  - Graphical and numerical displays
  - Investigate sampling/randomization distribution
  - Apply inference procedure
  - Communicate findings in context
  - Repeat in new setting
    - Repeat in new setting
      - Repeat in new setting…

Content- Chapter 1

- Comparisons and conclusions
  - Categorical variables
  - Two-way tables
  - Relative risk, odds ratio
  - Variability, confounding, experimental design, randomization, probability, significance
  - Fisher's exact test

Content- Chapter 2

- Comparisons with quantitative variables
  - Visual displays
  - Numerical summaries
  - Randomization distribution
    - Significance, p-value, …

Content- Chapter 3

- Sampling from populations and processes
  - Bias, precision
  - Random sampling
  - Sampling variability, distributions
  - Bernoulli process and binomial model
    - Binomial approximation to hypergeometric
  - Significance, confidence, types of errors

Content- Chapter 4

- Models and sampling distributions
  - Probability models, including normal
  - Approximate sampling distribution for sample proportion
    - Normal approximation to binomial
  - Sampling distribution of sample mean
    - *t*-procedures
  - Bootstrapping

Content- Chapter 5

- Comparing two populations
  - Categorical variables
    - Two-sample z-test
    - Approximation to randomization distribution
    - Odds ratio
  - Quantitative variables
    - Two-sample *t*-test
    - Approximation to randomization distribution

Content- Chapter 6

- Association and relationships
  - Chi-square tests
  - Analysis of variance
  - Simple linear regression

Why this sequence?

- Spiral through entire process over and over
- Start with comparisons
  - More scientifically interesting
  - Observation vs. experiment early
- Start with categorical variables
  - Easy, natural to work with
  - Lead to mathematically interesting analyses
- Change one thing at a time

Course Materials- Structure

- Investigations
  - Can be adapted for variety of teaching styles
- Exposition
  - Study conclusions, discussion, summaries
- Technology explorations
- Detours for terminology, probability
- Practice problems
  - Help students to assess their understanding
  - Expand their knowledge

Course Materials- Status

- Preliminary version to be published by Duxbury in August
  - Hot-off-the-press version in your binders
  - Companion website: www.rossmanchance.com/iscam/
- Next year: polishing, refining, developing resource materials
  - Homework problems/solutions, teachers' guide, powerpoint, practice problem solutions to appear on web
  - Include more worked out examples
- Please share your suggestions

Questions?