Teaching Introductory Statistics:
From *dull* *to* *Dynamic!*

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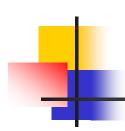*December 2, 2005*

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An Individual Exercise

Write down or remember your answers:

1. Think of something you *know how to do very well* and how you learned to do it.

2. What do you *know to be true* and how do you know it?

3. Recall an experience from childhood (age 6 to 10).

4. How would you explain the solution to this problem?

   A penny and a dime are each tossed. What is the probability that they both land "heads up"? (Assume the coins are fair.)
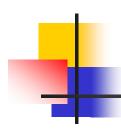
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Group Exercise
Discuss these questions

- Why should students study elementary statistics?

- What do you want students to remember a year or two after they take elementary statistics?

- What do you think students do remember a year or two after they take elementary statistics?

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Common Responses to Q1

Why students study elementary statistics:

- Should know how to interpret statistical studies in their life/profession (*consumers*)

- They will take additional statistics courses and need the basics first (*stepping stone*)

- They will conduct their own statistical studies (*producers*)
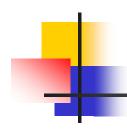
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Common Responses to Q2

What do you want students to remember a year or two after they take elementary statistics?

- How to interpret statistical studies - statistical signficance versus practical importance, etc (*educated consumer*)

- *The basic ideas* - what is a margin of error, how does hypothesis testing work, etc.

- How to conduct simple statistical procedures (*competent producer*)

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Common Responses to Q3

What do you think students do remember a year or two after they take elementary statistics?

- Some terms, like margin of error, p-value, median
- Interesting examples
- How hard the class was

Perhaps this is changing, but...

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What Can We Do Better?

Question 1:
Think of something you know how to do very well and how you learned to do it.

Sample responses:
Ride a bicycle, type, solve algebra problems, drive, juggle

Common Themes:
- Motivation – you probably thought it was important.
- Involvement – you probably learned by doing.
- Repetition – you probably practiced many times.
- Try, fail; try again, do better; try again, succeed – you probably went through a learning process.

What was *not* a theme:
"Someone told me how and then I knew"

What Else Can We Learn from Ourselves?

2. What do you *know to be true* and how do you know it?
3. Recall an experience from childhood (age 6 to 10).

Sample responses to Question 2:

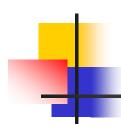I know I love my kids (wife, etc); I know everyone has to die someday; I know I like ice cream

Sample responses to Question 3:

Too long but common theme – emotional!

Common theme:

People trust and remember things better if they *experience* them and they have *emotion* involved.

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Recapping Common Themes

- **Motivation** *-why statistics is important*
- **Involvement -** *interaction of all sorts*
- **Repetition** *-practice, practice, practice*
- **Try, fail, try again, succeed -***self-discovery*
- **Experience –** *hands-on projects*
- **Emotion –** *laugh a little, have fun!*

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Motivation - *Why statistics is important*

Societies and businesses want to <u>have control</u> over things like:

- Reducing rates of cancer, heart attacks, and other diseases
- Growing better plants (pest resistant, high yield, etc)
- Determining what public service announcements help change behavior (smoking, safe-sex, etc)
- Deciding whether building a new lane on a congested road will increase or decrease congestion
- Releasing movies at the right time to get good attendance

Why Statistics is Important, continued

As individuals, we need to make <u>personal decisions</u>, like:

- What to eat to remain healthy
- Cost versus benefit for lifestyle changes (exercise, meditation, taking an aspirin a day, night-lights for children)

As intelligent, curious beings, we want <u>to understand</u> things like:

- Is ESP possible, and if so, under what conditions?
- How does memory work?
- Do left-handed people die at a younger average age?
- Does listening to classical music improve scores on intelligence tests?

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Why Statistics is Important, continued

As social, curious beings, we want to <u>know about other people</u>:

- Who are they planning to vote for in the next election?
- What television programs are they watching?
- Do they agree with President Bush about Iraq?
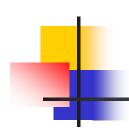- Do they think drugs like marijuana should be legal?

What other discipline can offer all that!?

Make sure your students understand the importance of statistics!

ASA Strategic Initiative GAISE

Guidelines for Assessment and Instruction in Statistics Education College Report

http://www.amstat.org/education/gaise

Special thanks to
Robin Lock
Jack and Sylvia Burry Professor of Statistics
St. Lawrence University
This and the next 5 slides are courtesy of Robin Lock

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GAISE College Group

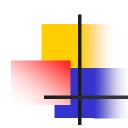|	
Joan Garfield	Univ. of Minnesota (Chair)
Martha Aliaga	ASA
George Cobb	Mt. Holyoke College
Carolyn Cuff	Westminster College
Rob Gould	UCLA
Robin Lock	St. Lawrence University
Tom Moore	Grinnell College
Allan Rossman	Cal Poly San Luis Obispo
Bob Stephenson	Iowa State
Jessica Utts	UC Davis
Paul Velleman	Cornell University
Jeff Witmer	Oberlin College

The Goal

Produce a set of recommendations and guidelines for instruction and assessment in introductory statistics courses at the undergraduate level.

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The Many Flavors of Introductory Statistics

Consumer ⟷ Producer

Discipline-specific ⟷ General

Large lecture ⟷ Small class

Year ⟷ Semester ⟷ Quarter ⟷ Block

H.S. (AP) ⟷ Two year college ⟷ Four year college ⟷ University

Challenge in Writing Guidelines

Give sufficient structure to provide real guidance to instructors.

Allow sufficient generality to include good practices in the many flavors.

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Four Part Report

- Introduction and History
- Goals for Students in an Introductory Course: *What it Means to be Statistically Educated*
- Six *Recommendations* for helping teachers achieve those goals
- Appendix of *Examples and Suggestions*

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Six Recommendations

1. Emphasize statistical literacy and develop statistical thinking

2. Use real data

3. Stress conceptual understanding rather than mere knowledge of procedures

4. Foster active learning in the classroom

5. Use technology for developing conceptual understanding and analyzing data

6. Integrate assessments that are aligned with course goals to improve as well as evaluate student learning.

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Recommendation #1

Emphasize statistical literacy and develop statistical thinking.

- **Statistical literacy**: understanding the language and ideas of statistics

- **Statistical thinking**: the thought process statisticians use to answer a scientific question with data

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Suggestions for Teachers

Model statistical thinking for students.

Present examples as questions that need an answer.

Example (from *Mind On Statistics*, Utts/Heckard):

Question of interest:

Do men lose more weight by dieting or by exercising regularly? Study done at Stanford, used overweight male volunteers, randomly assigned to one year of diet or exercise. Lost more weight with diet.

Useful for illustrating:

- Types of studies (experiment vs. observational study)
- Design of randomized experiments
- When cause and effect can be concluded (or not)
- How to do hypothesis tests, from start to finish
- How to construct and interpret a confidence interval

More Suggestions

- Give students practice developing and using statistical thinking. This should include open-ended problems and projects.

- Give students plenty of practice with choosing appropriate questions and techniques, rather than telling them which technique to use and merely having them implement it.

Choosing the appropriate parameter

TABLE 13.2 The Parameters and Types of Data Used for Inferences About Them

Variable Type (Parameter Type)	One Sample (No Pairing)	Paired Data	Two Independent Samples
Categorical (Proportions)	p	none	$p_1 - p_2$
Quantitative (Means)	μ	μ_d	$\mu_1 - \mu_2$

From *Mind on Statistics,* Utts/Heckard

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Recommendation #2
Use Real Data

See my website →**Statistics Links** → **Examples and Information about Polls, Statistical Studies, etc** for links to 34 websites with examples, data sets, applets, etc.:

http://anson.ucdavis.edu/~utts/statlinks.html

Some other Sources for real data:

- Textbooks, including CDs that come with them
- Websites such as
  - www.pollingreport.com **(recent polls on numerous topics)**
  - **"Dazzle" – data and storage library:**
  - lib.stat.cmu.edu/DASL/
  - **Journal of Statistics Education data archive:**
  - www.amstat.org/publications/jse/jse_data_archive.html

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Recommendation #3

Stress conceptual understanding rather than mere knowledge of procedures.

- Most introductory courses contain too much material.
- If students don't understand the important concepts, there's little value in knowing a set of procedures.
- If they do understand the concepts well, then particular procedures will be easy to learn.
- Concepts should be integrated throughout the course, not taught separately.

Concepts: Two Sources of Recommendations

GAISE Section titled *Goals for Students in an Introductory Course: What it Means to be Statistically Educated*

American Statistician Article: *What Educated Citizens Should Know About Statistics and Probability*

-Jessica Utts, May 2003, *American Statistician*

Let's look at some suggestions for what to include...

Students should recognize:

- How to determine the population to which the results of statistical inference can be extended, if any, based on how the data were collected.
- How to determine when a cause and effect inference can be drawn from an association, based on how the data were collected (e.g., the design of the study)
- That words such as "normal", "random" and "correlation" have specific meanings in statistics that may differ from common usage.
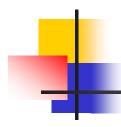- Common sources of bias in surveys and experiments.

Students should understand why:

- Random *sampling* allows results of surveys and experiments to be extended to the population from which the sample was taken.
- Random *assignment* in comparative experiments allows cause and effect conclusions to be drawn.
- Association is not causation.
- Statistical significance does not necessarily imply practical importance, especially for studies with large sample sizes.
- Finding no statistically significant difference or relationship does not necessarily mean there is no difference or no relationship in the population, especially for studies with small sample sizes.
- Data beat anecdotes.
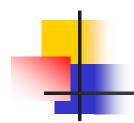- Variability is natural and is also predictable and quantifiable.

Students should know:

- How to interpret statistical results in context.
- How to critique news stories and journal articles that include statistical information, including identifying what's missing in the presentation and the flaws in the studies or methods used to generate the information.
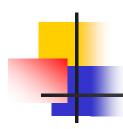- When to call for help from a statistician.

Recommendation #4

Foster active learning in the classroom.

Types of active learning include:

- Group or individual problem solving, activities and discussion.

- Lab activities (physical and computer-based).

- Demonstrations based on data generated on the spot from the students.

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Some Basic Principles

- Activities don't have to be physical, but they have to require *thinking*!! Activities with a prescribed "menu" of steps are not much use.

- Activities probably won't have one "right" way to do them... it's the thought process that counts!

- Activities should mimic a real-world situation. They should not seem like "busy work." For instance, if you use coins or cards to conduct a binomial experiment, explain some real-world binomial experiments that they could represent.
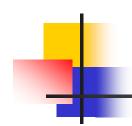
Some Ideas for Involving Students

IN CLASS
- Thought Questions
- Hands-on Projects

AT HOME OR IN COMPUTER LAB
- Computer Applets

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If you were faced with the following alternatives, which would you choose?

- A gift of $240, guaranteed.
- A 25% chance to win $1,000 and a 75% chance of getting nothing.

Which do you think is more informative when you are given the results of a study: A confidence interval or a *p*-value? Why?

Ideas for Using Thought Questions

1. **Listen, understand, interpret with partner**:

Students work in pairs, A explains to B, then B explains A's answer to the class.

Let's try it! – Choose a partner, and discuss

Question 4 (from earlier in talk):

How would you explain the solution to this problem?

A penny and a dime are each tossed. What is the probability that they both land "heads up"? (Assume the coins are fair.)
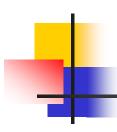
Using Thought Questions - continued

- Lesson learned from this activity:

There are multiple ways to address much of what we teach. Students learn differently. When possible, discuss multiple ways to address a problem.

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Ideas for Using Thought Questions

2. Group work – discuss privately then publicly

Each group discusses a question, then reports to class. The rest of class comments. You can have all groups discussing the same question, or a variety.
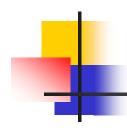
3. Students prepare in advance, then discuss

Randomly call on a student to answer at start of class. Questions should be about material for the day but not require advance study of it.

4. Individual reflection

Turn in answer, read some of them, and discuss. Can use as part of grade.

Hands-on Projects

Some examples I use:

- *Estimating the probability of animal eye landing so that it's staring at you.*

- *Collecting and summarizing data of various types.*

Two sources for in-class projects:

- *Seeing Through Statistics, 3rd edition Activities Manual - 10 projects (Utts, 2005, Brooks/Cole)*

- *Instructors' CD for Mind On Statistics, 3rd edition – 35 projects (Utts/Heckard, 2006, Brooks/Cole)*

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Computer Applets

- Most useful for work at home or in small groups in computer lab.
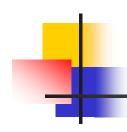- Excellent for teaching concepts.

Example: Correlation Applet

- From *CyberStats*
- Also on CD for *Seeing Through Statistics* and *Mind on Statistics* (Utts, Heckard)
- Many applets on the web, free access – good resource is:

  http://members.aol.com/johnp71/javastat.html

  Links to over 600 useful statistics webpages!

Demonstration of applet (if time)

- Place points on scatter plot to achieve target correlation

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Conclusions and Advice

Conclusion:

Statistics classes don't have to be boring!

Advice:

There are lots of resources out there for making your course more dynamic – learn and enjoy!

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Some Websites of Interest

GAISE Reports:

- http://www.amstat.org/education/gaise

Recent polls on numerous topics

- www.pollingreport.com

"Dazzle" – data and storage library:

- lib.stat.cmu.edu/DASL/

Journal of Statistics Education data archive:

- www.amstat.org/publications/jse/jse_data_archive.html

American Statistician paper:

- http://anson.ucdavis.edu/~utts/AmerStat2003.pdf

Good Resources for Statistics Teachers:

- http://anson.ucdavis.edu/~utts/statlinks.html