Teaching Statistics To High-School Teachers

A discussion of the INSPIRE project
NSF grant ESI 0138807

The need

- Tremendous increase in demand for secondary level Statistics teachers
- Fueled in part by 1997 AP Statistics exam
- NCTM Standards (2000)
- Few teachers have background in Statistics beyond college mathematical stats courses.

Previous Efforts

- NCTM 2000 "Principles and Standards for School Mathematics"
- Quantitative Literacy (ASA/NSF)
- Data Driven Mathematics (ASA/NSF)

Integrates statistics into mathematics topiccs, such as algebra, geometry.

Math Integration falls short...

- cause-and-effect
- experimental design
- sampling variability
- survey design

Where do these fit into the algebra/geometry/calculus curriculum?

INsight into Statistical Practice, Instruction and Reasoning

- Teaches statistical content to beginning HS Stats teachers
- 1 Week workshop followed by year-long distance learning course
- Optional year-long "practicum" component

Designed so that participants

- actively participate in constructing their own knowledge
- practice what they are intended to learn
- confront their misconceptions
- work with real data in realistic context
- apply statistical analysis software to analyze and visualize data

Garfield, 1995 "How students learn statistics"

Participants

- 8 of 32 were teaching Stats for the first time
- Median # of years teaching Stats was 1
- All but one had math backgrounds
- Variety in attitudes towards and experience with computer technology
- Strong correlation between confidence in approach and comfort with computers

Workshop: CPSLO

- 32 participants, instructors met for 1 week at SLO in Summer 2003.
- Personal interactions foster community
- Cover topics difficult to cover on-line
- Only opportunity to demonstrate pedogagy

Management pages

- http://uclaextension.blackboard.com/?bbatt=Y
- Password protected
- Documents Area
- Discussion Area
- Navigation Tricky

Content Pages

- 15 Units, each corresponding to a chapter or main idea
- Each unit consists of 7 learning areas
- "Blackboard" handles discussions, grades, organization stuff
- http://inspire.stat.ucla.edu/unit_01

Technical Difficulties

- Emailing word files with graphics
- caststream
- Statistical Software
- Overall ease of use still awaiting evaluation.

Pedagogical Difficulties

- Group cohesion failed almost immediately
- Discussions were uninspiring
- Participants' pacing varied drastically
- Feedback erratic

Examples of Discussions

- Are SUVs safer than cars? Only 4 participants
- Design a simulation, and discuss the design
- Design and carry out experiment, discuss the experiment

Problems with Discussions

- Questions too vague or too precise
- Discussions not evaluated
- Time-zones and differing work schedules hinder discussions

Evaluation

- Workshop was felt to be important on a number of different levels. (95% agree or strongly agree w/s is critical.)
- Mixed opinions about level of preparation technically speaking before the coures
- (n = 21)

Course Units

- Large majority felt difficulty level was about right.
- 70% spent less than 5 hours per unit, and most worked less than 4 hours per week.

Impact on...

- knowledge: 29% said INSPIRE had "great" impact on knowledge, 67% said "impact", and 4% said "little".
- teaching: Great, 29%; Impact: 67%, Little: 4%
- confidence: 50%/42%/8%
- Students learning: 8%/88%/4%

Next Year

- New class just completed workshop in SLO
- Workshop featured more Fathom, computer work
- Quarterly "group chats" scheduled
- Bi-weekly discussions required
- Class starts August 16

Milestone Examples

Exploring Data	Describe our class
Bivariate	Classify midge flies
More bivariate	Fit linear model to predict API scores in CA
Collecting Data	Discuss news article
Probability Basics	Invent a contingency table that demonstrates independnece
Simulations	Birthday Match
Sampling Distributions	Use Max or Mean for detecting arsenic?

Cast

- Development: Floyd Bullard, Matt Carelton, Gretchen Davis, Rob Gould, Kim Robinson, Dan Teague, Katie Tranbarger
- Instructions: Floyd Bullard, Gretchen Davis, Robert Gould, Chris Olsen, Katie Tranbarger
- Workshop: Beth Chance, Mary Mortlock, Chris Olsen, Alan Rossman, Robin Lock, Tom Short
- Practicum: Carolyn Morgan, Judith O'Fallen
- PI's: Roxy Peck and Rob Gould

Beyond the Formula, August 2004

Robert Gould
Director, Center for Teaching of Statistics
UCLA

How Statisics Differs from Math

Teaching beyond mean, median, and mode

Premises

- Statistics is not mathematics.
- Statistics relies on mathematics, sometimes a lot, sometimes a little.
- Teachers with a background in math have a good foundation for beginning to learn Statistics but…
- Need additional tools to teach Statistics

What is Statistics?

- For our discussion, "the science of data".
- Depends heavily on "outside" fields for its development.
- Is therefore heavily collaborative
- Requires a statistician to integrate many diverse tools
- Requires teachers to adopt different approaches

What is (are) data?

- David Moore: "Numbers in context."
- Context includes What, Where, When, Why, How? (DeVeaux & Velleman)
- Numbers?

8 Extra-mathematical Themes (in the Stats curriculum)

1. Inference
   - Causal and Estimation
2. Graphical Tools
   - When and where
3. Calculation of Statistics
   Intepretation and application instead

Extramathematical…

4. Science
   - weighs evidence, does not prove
5. Data Collection
   - Conclusions
   - Structure
6. Data Management
   - Quality
   - Storage and Retrieval
7. Computer

8. Consult

Case Study

The Issue: Can parents who are exposed to lead at work inadvertently increase the level of lead in their children's blood?

Original study appeared in
D. Morton, et al. (1982), "Lead Absorption in children of employees in a lead-related industry," American Journal of Epidemiology, Vol. 155, pages 549-555

Case Study to appear in Cyberstats, an on-line statistics text published by Cybergnostics, Inc (www.cyberk.com).

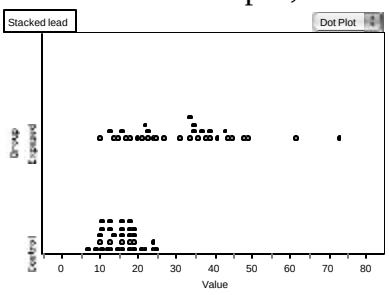
Means and SDs differ, but so what?

Stacked lead

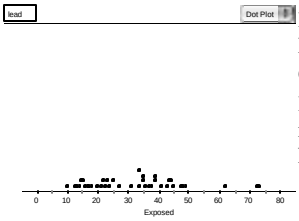
		Value
Group	Control	15.878788 4.5398071
	Exposed	31.841049 14.412065
Column Summary		23.859918 13.307173

S1 = mean ( )
S2 = stdDev ( )

Graphs show interesting difference in shapes, but…



So what?



Medical experts say levels above 40 dangerous

Levels above 60 require immediate hospitalization

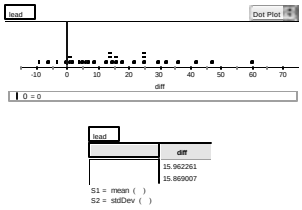
Where are we now?

- We've established that a true medical problem exists.
- Parents' exposure at the battery factory is only one possible explanation, though.
- Other explanations…

Other explanations are…

- Neighborhood environment
- Age
- And so children were "paired" based on neighborhood and age.
- Therefore we examine the differences between each pair.

Exposed minus Control



Is Chance a reasonable explanation?

- Tricky! Data are not a random sample.
- Subjects were not randomly assigned to treatment.
- Difficult to say exactly what the population is that we are making inferences about.
- But…let's make some gentle assumptions.

Non-parametric Test

- Assume that in the absence of a 'battery factory effect', the exposed child's level is just as likely to be above as below the exposed child's level.
- Thus we'd expect about half, or 16, of the observed differences to be negative.
- In fact, we see only 4 such differences.
- The chances of seeing 4 or fewer negative differences is quite small, and so…

Conclusion?

- If we believe in our probability model, then Chance is not a plausible explanation for the difference.
- But does this mean that parents ' exposure is the only explanation remaining?
- Hygiene habits also recorded and an association existed.

The Themes revisited

Inference

Just what constitutes the population is an interesting question, given the means by which the data were collected. We are also asked to infer about a causal mechanism, and this is impossible with these data, although insights can be made.

Graphical Tools

- I used dot-plots throughout.
- Other choices include histograms, boxplots, and others?
- But important to acknowledge that the graphs told us more than the numerical summaries.

Calculation

- Numerical summaries required "outside" information to be interpretable
- We needed to know what "dangerous" lead levels were.

Statistics is a science

- And science cannot prove
- But we can accumlate evidence
- Discount theories
- Propose further investigations
- Science informs the analysis and the data collection

Data Collection

- Analysis was shaped by knowledge of how the data were collected.
- Our ability to make inferences also affected.

Others

- Data Management
- Computer
- Consulting

Teacher Preparation

Practice!Practice! Practice!

With Real Data Sets (bag of datasets)
With Computers
With Collecting Data
With choosing and applying tools

A bad homework problem

- Pairs of children had their blood lead levels measured. One child in each pair had a parent whose work exposed the parent to lead. Below are the differences between the potentially exposed child and a control child. Is there a statistically significant difference in the lead levels?

Miscellaneous Questions

- Should we recruit secondary statistics teachers from outside mathematics?
- Challenge: find a medical study that uses randomization and a random sample!
- The local middle school adopts a new math curriculum and claims math scores have improved. What statistical analyses can we do to support/refute?

Some References

- Moore, David S. (1988) "Should mathematicians teach statistics (with discussion), College Math. Journal 19, 3-7.
- Cobb, George W., Moore, David S., (1997) "Mathematics, Statistics, and Teaching", American Mathematicaly Monthly 104, 801-824