

Real data, Experiential learning, Writing and Authentic Assignments Archbald and Newmann 1988, Angelo and Cross, 1993, Crowley 1993, Garfield, 1994 and Chance 1997 Butler, 1998 Cites a lack of or improper applications of statistical concepts in the workplace Wild and Pfannkuch, 1999 Do we really know how to teach students to think like statisticians and solve problems? ...and so many more!

Why CAOS? Garfield, 2000 Large-scale survey of statistics instructors → Evidence of widespread reform → No quality assessment to measure impact of reform Enter the ARTIST CAOS exam for assessing statistical literacy delMas, Garfield, Ooms and Chance, 2007 Results not altogether encouraging, increased difficulty interpreting boxplots understanding important design principles (bias, randomization) concepts related to probability, sampling variability and inferential statistics.

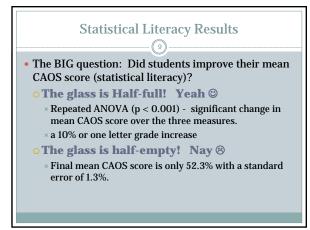
Wild and Pfannkuch (1999) Is the glass is Half-empty? All we can do is assign projects and hope that something develops. OR Is the glass is Half-full? Maybe we just need to advocate for a second course of a nonmajor statistics course.

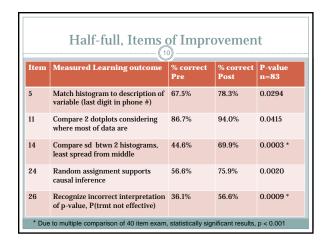
The present study asks 1. Is there significant improvement in statistical literacy of basic introductory level concepts (as measured by the ARTIST CAOS exam) following a 2nd course in Business Statistics? and 2. Are there significant changes in student attitudes toward statistics following a 2nd course in Business Statistics?

Study Purpose

• Business Students were observed through two semesters of Business Statistics taking the same instructor for both courses. Data measured: • Beginning of Fall 2007 (pre 1st course of stats) • Beginning of Spring 2008 (pre 2nd course, post 1st course) • End of Spring 2008 (post 2nd course) • Students were given: • ARTIST CAOS (mandatory) exam as part of their lab grade * Extra credit was given to those who improved their post score • Offered the SATS survey as extra credit for their lab grade

Repeated ANOVA Equality of mean exam score over 3 repeated times Equality of mean attitude for the six attitude components Post-Hoc analysis for multiple pair-wise comparisons Question analyses Question by question paired t-tests between pre and post in the second semester only to see which questions: improved, stayed the same or worsened in comprehension.





Half full or half empty?
• Nine items in which more than 60% of the students scored correctly on both pre and post tests
 Description of approx bell-shaped histogram *
 Match histogram to description of variable (like #5) *
× Wrist circum ~ bell-shaped
scores from an easy quiz, skewed
 Compare 2 groups using dotplots (like #11) *
onsidering where most of data are is valid comparison
× Comparing extremes is not valid
 Consistent results are better for estimating *
 Interpreting relationships from scatterplots *
o Can recognize a valid probability stmt of a CI
* Consistent findings of delMas et al

Broken glass, Increased misconception					
Item	Measured Learning outcome	% correct Pre	% correct Post	P-value n=83	
27	Recognize incorrect interpretation of p-value, P(trmt is effective)	49.4%	37.3%	0.029	
32	Understanding sampling error is used to make inference about sample mean. (1-sample t-test)	16.9%	8.4%	0.026	
33	Understanding that a distn with med>µ is likely left-skewed, graph given sample stats	27.7%	14.5%	0.010	
37	Understanding how to simulate data to find probability of observed value.	16.9%	9.6%	0.067	

Shattered glass



- More than ½ of the students missed 10 items on both the pre and post test.
 - Interpreting boxplots
 - O Data to histogram
 - o Important design principles and purpose of simulations
 - Sampling variability
 - Making proper inferences
- One in five students actually decreased understanding on 6 items of the test.
 - Boxplots, valid interpretations of p-value, graphing a population from sample stats and applying a rejected H0

How can I show my face in public?



 Consistent results with delMas et al using 760 subjects from around the globe

The difference is, this is after a second course in Business Statistics. So what do we do in a second course of 'intro', non-majors statistics

Lots of hypothesis testing

Lots of test statistics

Lots of standard errors

lots of p-values

Do how to the student 'FEEL'



The six attitudes (SATS) components observed over the 3 time periods indicate:

- **1. Affect** I will like statistics NS
- **2.Effort** I plan to study
 - NS
- **3.Interest** I am interested in stats p=0.005
 - p=0.043
- 4.Value Stats is useful5.Difficulty Stats is easy
- p=0.009
- **6.Cognitive** I can learn stats

NS

Post Hoc Comparison Student Attitudes



Interest

Significantly reduced interest following the 1^{st} semester, and did not gain interest throughout 2^{nd} semester (though no further drop)

Value

Though not significant following the 1^{st} semester, the gradual drop became significant following the 2^{nd}

Difficulty

Perceived difficulty became significant only in the 2^{nd} semester.

Attitudes (SATS) and Performance (CAOS)



 Is there a relationship between improvement the on the CAOS assessment and changes in how they 'feel' towards statistics?

Of the six attitude components, only 'effort' showed a significant relationship with CAOS scores.

Those that reported an increase in effort in the second semester revealed a significant association with decreased performance on the CAOS exam as indicated by a Chi-Square analysis.

Indications



- Some of the 'historically' important learning objectives, students may have already mastered.
- o GAISE is lower education is hard at work!
- Some of the important learning objectives, they are failing to understand even after taking the course.
 - Self-reported increased effort did not result in increased literacy
- Students reported a loss of interest ff the 1st course
- Remained disinterested in the 2nd course
- o Valued statistics less in 2nd course
- Found it more difficult

