Is the glass half full or half empty?

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ASSESSING STATISTICAL LITERACY AND ATTITUDES FOLLOWING A SECOND COURSE OF BUSINESS STATISTICS

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The Reform Movement

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- Focused primarily with the Intro 1-semester course
- Enter the GAISE guidelines
  - Emphasis on **statistical literacy** and demonstration of **statistical thinking** in final report, authentic assessment.
  - Use of **real data**
  - Foster **active learning** and stress conceptual understanding.
  - Use of **technology** to summarize and analyze
  - Use **assessments to improve** and **evaluate student learning**.

Evidence of changes in pedagogy

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- ***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?

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- 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)

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- 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 non-major statistics course.

Study Purpose

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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 Design

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- 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

Statistical Analyses

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- 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.

Statistical Literacy Results

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- The BIG question: Did students improve their mean CAOS score (statistical literacy)?
  - **The glass is Half-full! Yeah ☺**
    - Repeated ANOVA ($p < 0.001$) - significant change in mean CAOS score over the three measures.
    - a 10% or one letter grade increase
  - **The glass is half-empty! Nay ☹**
    - Final mean CAOS score is only 52.3% with a standard error of 1.3%.

Half-full, Items of Improvement

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Item	Measured Learning outcome	% correct Pre	% correct Post	P-value n=83
5	Match histogram to description of variable (last digit in phone #)	67.5%	78.3%	0.0294
11	Compare 2 dotplots considering where most of data are	86.7%	94.0%	0.0415
14	Compare sd btwn 2 histograms, least spread from middle	44.6%	69.9%	0.0003 *
24	Random assignment supports causal inference	56.6%	75.9%	0.0020
26	Recognize incorrect interpretation of p-value, P(trmt not effective)	36.1%	56.6%	0.0009 *

* Due to multiple comparison of 40 item exam, statistically significant results, $p < 0.001$

Half full or half empty?

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- 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) *
    - considering where most of data are is valid comparison
    - Comparing extremes is not valid
  - Consistent results are better for estimating *
  - Interpreting relationships from scatterplots *
  - Can recognize a valid probability stmt of a CI

* Consistent findings of delMas et al

Broken glass, Increased misconception

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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

* Due to multiple comparison of 40 item exam, statistically significant results, $p < 0.001$

Shattered glass

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- More than ½ of the students missed 10 items on both the pre and post test.
  - Interpreting boxplots
  - Data to histogram
  - 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?

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- 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'

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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
4. **Value** – Stats is useful p=0.043
5. **Difficulty** – Stats is easy p=0.009
6. **Cognitive** – I can learn stats NS

Post Hoc Comparison Student Attitudes

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- **Interest**

  Significantly reduced interest following the 1st semester, and did not gain interest throughout 2nd semester (though no further drop)
- **Value**

  Though not significant following the 1st semester, the gradual drop became significant following the 2nd
- **Difficulty**

  Perceived difficulty became significant only in the 2nd semester.

Attitudes (SATS) and Performance (CAOS)

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- 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

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- Some of the 'historically' important learning objectives, students may have already mastered.
  - 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
  - Valued statistics less in 2nd course
  - Found it more difficult.

The challenge of 'Letting Go'

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- USCOTS '09 – 'Letting go to grow'

Let go of concepts

- Students now bring into the course
- They are not grasping in a single semester and which 'who cares' in the workplace. Cobb, USCOTS '09

Stoking the fire

- How can we increase interest and value?
- Maybe by letting go of some of the 'meaningless' drudgery, the fire will glow brighter.

Conclusion

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Half-Empty?

or

Half-Full?