Dan Brick,
CISC Dept,
University of St. Thomas

Slightly RADICAL Ideas To Help Students Interpret Introductory Statistics

Milo Schield
Dept. of Business Admin.
Augsburg College
www.StatLit.org

AUDIENCE

Non-majors in a one-semester course and the first course for potential stat majors.

Both groups are better served by having a first course with a stronger foundation in the practical aspects of statistics and less emphasis on the technical aspects of inference.

GOALS

Students should see that "explaining variation" in a response variable is a most useful 'thread' from the logic of comparisons of counts, ratios, comparisons of ratios and pairing, through ANOVA and multiple regression.

Students should be able to make **an intelligent critique** of statistical information provided in newspaper articles, other courses, reports at work, and statistical studies so as to **assess the credibility** of the conclusions.

Students should be able to appropriately display graphically, and **verbally interpret**, relationships involving any combination of nominal and interval scaled predictor and response variables

Students should be able **to comment on** such issues as appropriate measurement, sampling frame bias, other non-sampling error concerns, possible confounding variables and practical significance. Students should know how to select a 'good' sample, and how to collect 'useful' data.

Students should know how to utilize software to analyze real data and know how to verbally describe what the data is telling them. Students should know how to utilize software to make appropriate inferences, and be able **to verbalize the implications** of the results.

Five Things We Can Drop

1. **All hand calculations**
2. **Most of probability including independence**
3. **Binomial and normal approximation**
4. **T-test and F-test tables, degrees of freedom, pooling**
5. **Chi-Square Test**

(Students need to understand the thought and computational process of inference, but the specifics of the computations in these contexts take up time better spent on other topics).

Contact, More Information:

DgBrick@StThomas.edu or Schield@Augsburg.edu.
For further information, check out www.StatLit.org

BAYES' CONFIDENCE

A practical soft-Bayesian interpretation of confidence:

A 95% confidence interval has:

- **a 95% chance of including the population parameter**
- **a 95% chance of being a correct statement**

This approach treats the level of confidence as a subjective probability. This gets past unhelpful philosophical and semantic issues. See Schield (1997).

BAYES' SIGNIFICANCE

A practical soft-Bayesian approach to hypothesis tests:

- **(1 minus the Pvalue): the confidence the Alternate is true** when the Null and Alternate are equally likely.
- **The confidence the research hypothesis is true is more than (1 minus the Pvalue)** when the Alternate is more likely to be true than the Null.

ARGUMENT BY EXAMPLE:

1a. Null is $\mu \le 500$; Alternate is $\mu > 500$
1b. Xbar = 530. SE = 20. Ztest = (530 - 500)/20 = 1.5
1c. Pvalue = P(Z > Ztest) = 6.68%

2a. One-sided confidence interval on Xbar for $\mu > 500$
2b. Lower limit: Z = (500–Xbar)/SE = (500–530)/20 = -1.5
2c. Confidence that $\mu > 500$ = P(Z > -1.5) = 93.32%

3a. Pvalue is the same as "lack of confidence" that $\mu > 500$
3b. (1-Pvalue) is synonymous with confidence that $\mu > 500$
See Schield (1996) for alternate derivation.

INFORMAL SIGNIFICANCE

A difference between two sample medians is statistically significant if:

- n > 3 and the sample ranges do not overlap
- n > 9 and the interquartile ranges (IQR) do not overlap
- n > 36 and the medians are outside the IQR of the other group. For more, see Schield, M. (2005).

BIAS

Bias is important, but there is no test or measure for bias. So students often are not asked to work problems.

But we can ask students:

- *Which kind of bias is more/most likely and why?*
- *Which way is bias most likely to shift things?*
- *How much bias would change an observed association?*

Recommendations

Incorporate literacy-based materials such as those in Utts' *Seeing Through Statistics* or in Moore's *Concepts or Controversies*. Have students

- estimate the influence of plausible sources of bias.
- estimate the influence of confounders on associations
- interpret statistical significance using informal inference.
- interpret margin of error and confidence intervals.
- interpret statistical significance and p-values.
- estimate confounder influence on statistical significance.

References

Schield, M. (1996). Using Bayesian Inference in Classical Hypothesis Testing. 1996 ASA Proceedings of the Section on Statistical Education. pp. 274-279. www.statlit.org/pdf/1996SchieldASA.pdf

Schield, M. (1997). Interpreting Statistical Confidence. 1997 ASA Proceedings of the Section on Statistical Education. pp. 137-142. www.statlit.org/pdf/1997SchieldASA.pdf

Schield, M. (2006). Presenting Confounding and Standardization Graphically. *STATS Magazine*, American Statistical Association. Fall 2006. pp. 14-18. www.StatLit.org/pdf/2006SchieldSTATS.pdf

Schield, M. (2005). Statistical Literacy and Chance. 2005 ASA Proceedings of the Section on Statistical Education. [CD-ROM] 2302- 2310. See www.statlit.org/pdf/2005SchieldASA.pdf

Terwilliger, J. and M. Schield (2004). Frequency of Simpson's Paradox in NAEP Data. Presented at AERA. At www.statlit.org/pdf/2004TerwilligerSchieldAERA.pdf

CONFOUNDING

Confounding is a big issue in observational studies where randomized assignment is impossible.

Of the students in majors that require statistics (business, social sciences, history, psychology, health sciences and biology), 60% are in majors where observational studies are common. All students should study multivariate thinking.

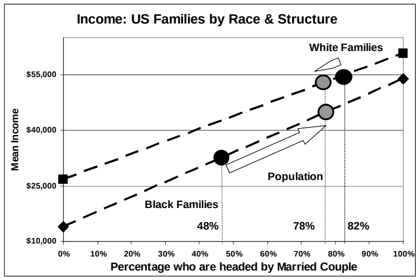
Confounding is common:

- The 2006 annual death rate per thousand in the US (9) is higher than that in Vietnam (6), Mexico (5) or Saudi Arabia (3). The confounder is the different mix of ages.
- US SAT scores were flat (540) from 1981 to 2002. But they increased for every subgroup: whites (8%), blacks (9%), Asians (27%), Mexicans (7%), Puerto Ricans (18%) and American Indians (7%). The confounder is the relative increase in non-whites.
- Terwilliger and Schield (2006) found that up to 10% of statistically-significant differences between state NAEP scores were reversed after controlling for a confounder.

Students must know the difference between experiments and observational studies, and the implications for establishing cause-and-effect (with particular emphasis on the importance of confounding variables).

STANDARDIZING

Confounding can be introduced with binary predictors and confounders. A graphical approach illustrates this big idea.



Standardizing allows for comparisons on a common or standard basis. In this case, most of the black-white income gap can be "explained by" differences in family structure. For more examples, see Schield (2006)

This technique can be used to show how controlling for a confounder can change a statistically-significant result into one that is statistically-insignificant (and vice versa).