ASA-2013 1

Statistics Education: Steadfast or Stubborn

MILO SCHIELD
Augsburg College
Member: International Statistical Institute
US Rep: International Statistical Literacy Project
Director, W. M. Keck Statistical Literacy Project

August 5, 2013
Slides at www.StatLit.org/pdf/2013-Schield-ASA-6up.pdf

ASA JSM 2013 2

Survey

Have you EVER taught a traditional intro stats course where you SKIPPED OVER the following?

1. Difference b/t experiment & observation study ~10%
2. Random assignment controls for confounders ~20%
3. T-test: one or two population 5/50

where you SHOWED that Statistical Significance …

4. can be tested using confidence intervals ~60%
5. can be changed by controlling for a confounder 8/50
6. can be changed by the presence of bias 7/50
7. can be changed by re-defining group or measure 4/50

ASA JSM 2013 3

Three Claims; Two Questions

1. The introductory statistics course is essentially the same – in content – as it was 50 years ago.
2. Statistical education has ignored most of the content-changes proposed by the leaders in statistical education.
3. The introductory statistics course is essentially a math-stat (research methods) course.

Q. If these claims are true, why is this so? What does this mean for the future of stat-ed?

#1 ASA JSM 2013 4

1958 Intro Statistics Content: Little Change in 50 years

1958: Statistics in Psychology **(5th) Garrett+Woodworth:**
PART I: DESCRIPTIVE STATISTICS
1.The Frequency Distribution
2.Measures of Central Tendency
3.Measures of Variability
4.Cumulative Distributions, Graphic Methods and Percentiles
5.The Normal Distribution; Meaning and Importance of
6.Linear Correlation

PART II: INFERENCE AND PREDICTION
7. Regression and Prediction
8. The Significance of the Mean and of Other Statistics
9. The Significance of Difference between Means & other stats
10. Testing Experimental Hypotheses

#1 ASA JSM 2013 5

1966 Intro Statistics Content: Little Change in 50 years

1 Nature of Statistical Methods
2 Description of Sample Data
3 Probability
4 Frequency Distributions
5 Sampling
6 Estimation
7 Testing Hypotheses
8 Correlation
9 Regression

Paul Hoel: Elementary Statistics, 2nd ed. (1966):

#2 ASA JSM 2013 6

Early Calls for Change Ignored

1954 "Statistics courses are largely irrelevant—not just boring or technically difficult, but irrelevant" Ehrenberg

1966 "Great ideas of statistics lost in sea of algebra"
Drop t-test. Wallis & Roberts

1970 Disallow hyp-test in observ. studies. Selvin

1979 Only show test for proportions. Haack

1994 Drop hypothesis tests. MSMESB & Cryer

1997 Show effect sizes. Harlow, Mulaik & Steiger

#2

ASA JSM 2013 7

1997 Moore's "Big Ideas" Last part ignored!

Eight Big Ideas [re-arranged]:

1. Data beat anecdotes;
2. Association is not causation
3. The importance of study design
4. The omnipresence of variation
5. Conclusions are uncertain.

---

6. **Observation versus experiment**
7. **Beware the lurking variable** [confounding]
8. **Is this the right question?**

Stat-Literacy: what every educated person should know

#2

ASA JSM 2013 8

"Right Question" in *Concepts and Controversies*

Who is a smoker?

When estimating a proportion *p*, be sure you know what counts as a "success." The news says that 20% of adolescents smoke. Shocking. It turns out that this is the percentage who smoked at least once in the past month. If we say that a smoker is someone who smoked in at least 20 of the past 30 days and smoked at least half a pack on those days, fewer than 4% of adolescents qualify.

#2

ASA JSM 2013

2002 Joel Best's call for change ignored

1. **Every statistic is socially constructed** in the most operational sense of that term.
2. The social construction of statistics does not imply malevolence, negligence or even opportunism.
3. The social construction of statistics goes beyond chance, bias and confounding.*
4. Seeing that all statistics are socially constructed **is essential** to being statistically literate.

* See David Moore's: "Is this the right question?"

#2

ASA JSM 2013 10

2013 Tintle et al will be ignored for intro course

Confounding and **variation** are **the two**:

- substantial hindrances to drawing conclusions from data
- major themes of statistical analysis

Title: Challenging the State of the Art in **Post-Introductory Statistics**: Preparation, Concepts, and Pedagogy

By Nathan Tintle, Beth Chance, George Cobb, Allan Rossman, Soma Roy, Todd Swanson & Jill VanderStoep.

http://www.statistics.gov.hk/wsc/IPS032-P1-S.pdf

#3

ASA JSM 2013 11

Intro statistics is essentially math-stats

Math studies patterns & structure.
Math-stat studies random variability;
Statistics should study variability in context!

Certainty ------- Variability -------

Math Calculus	Probability; Discrete; Math-Stats	Statistics; Data-analysis

------- Ideal world --------- Context Reality

Why?

ASA JSM 2013 12

Is Statistical Education Steadfast or Stubborn?

Introductory statistics courses ignores context.

Context is determined by

- what is taken into account (controlled for)
- what is ignored (confounding)
- how groups are defined
- how quantities are measured

Steadfast vs. stubborn:
What is statistical education's essential topic?

ASA JSM 2013 13

What are Statistics' *Core Concepts?*

Most important concept (% of respondents):

96% Variation

82% Association vs. causation

77% Randomness and statistical significance

75% Data: experiment vs. observational study

71% Sampling distribution

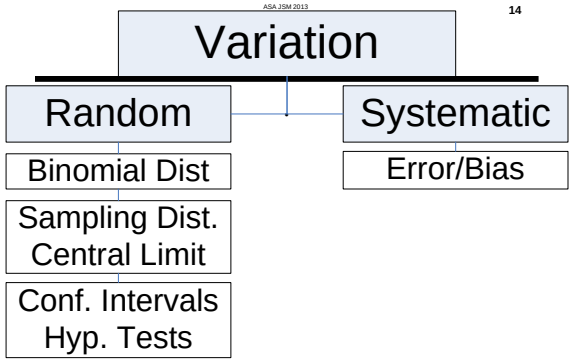
64% Hypothesis tests

63% Confidence Interval

63% Random Sample

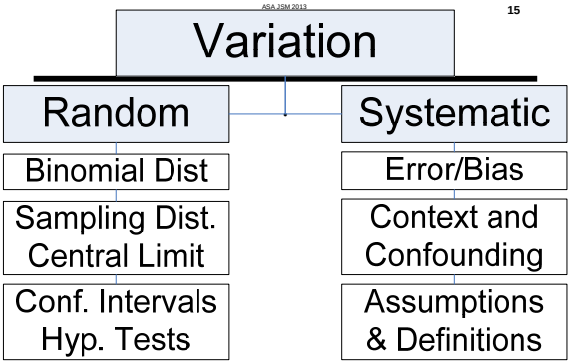
McKenzie Survey (2004)

ASA JSM 2013 14



Introductory Statistics: Now

ASA JSM 2013 15



Statistics: Future

#2

ASA JSM 2013 16

2004 Schield: Survey IASE Sweden

Presented a graphical technique showing the influence of a binary confounder on the association between a binary predictor and a ratio outcome. Two questions:

Q1. Should students be shown that statistical significance can be influenced by a confounder?
* Strongly agree (8), agree (7), neutral/indifferent (1).

Q2. Should introductory statistics should teach students more about confounding even if that means less time for statistical significance?
* Strongly agree (0), agree (7), neutral (4), disagree (5).

ASA JSM 2013 17

The Real Core of Statistical Education

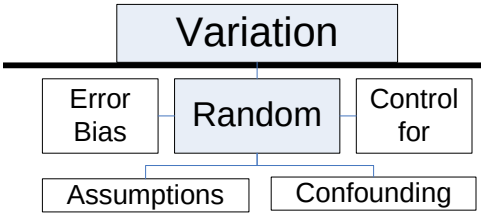
Variation is the genus of our core idea

But **Random Variation** is the essential idea.

'Confounding' was absent in McKenzie's survey

"To be successful in changing introductory statistics, any proposed change must uphold **random variation** and **statistical significance** as the core ideas – the crown jewels – of statistics education."

ASA JSM 2013 18



Introductory statistics must be extended to study all sources of variation: assumptions, confounding and bias. Must show how all sources of variation can influence statistical significance.

ASA JSM 2013 19

Influence of Context on Statistical Significance

Context: what is taken into account, confounders, assumptions in defining groups and measures & bias

Q1. Can we show how context can influence statistical significance??? **ABSOLUTELY!!!**

Q2. Can it be done with minimal math and time?

ABSOLUTELY!!! Do everything with tables and confidence intervals. Non-overlap means statistical significance. See 2013 ASA paper for examples.

ASA JSM 2013 20

Influence of Bias on Significance

Response bias: Men likely to overstate income

$5,000 is the 95% margin of error

Income	Men	Women	Diff	Overlap	Stat. Sig
Stated	$62,000	$51,000	$11,000	No	Yes
Actual	$53,000	$51,000	$2,000	Yes	No

Sample bias: Rich less likely to do surveys

$3,000 is the 95% margin of error

Income	Men	Women	Diff	Overlap	Stat. Sig
Responders	$53,000	$51,000	$2,000	Yes	No
Population	$62,000	$55,000	$7,000	No	Yes

ASA JSM 2013 21

Influence of Assembly on Significance

Two definitions of "bullying"

Middle-school kids 5% is the 95% margin of error

BULLYING	Boys	Girls	Diff	Overlap	Stat.Sig
1) Physical only	40%	10%	30%	No	Yes
2) Physical & Social	42%	40%	2%	Yes	No

Two ways to combine subgroups to form groups

6% is the 95% margin of error

Fishing	Dislike	Neutral	Like	% who like*	% who like**
Men	30%	30%	40%	40%	70%
Women	50%	20%	30%	30%	50%
			Overlap	Yes	No
			Statistical significance	No	Yes

* Exclude neutral

** Include neutral

ASA JSM 2013 22

Conclusion #1

To present statistics as *numbers in context*, the introductory statistics course must be redesigned.

The intro course needs much more focus on big ideas:

- **Context** (what is controlled for; confounders), **assumptions** (definitions) and **bias** are big ideas for non-statisticians.
- **Randomness** and **statistical significance** are big ideas for statisticians.
- **Seeing how confounding, assumptions and bias can influence statistical significance should be central for a "statistics-in-context" course**.

ASA JSM 2013 23

Conclusion #2

Thesis: Adding systematic sources of variation to introductory statistics will

- improve student retention of key ideas,
- improve attitudes on the value of studying statistics,
- uphold context – not variability – as the essential difference between statistics and mathematics.

Since this can be done with minimal math and very little time, the introductory statistics course should be re-designed as a "statistics-in-context" course!

ASA JSM 2013 24

References

ASA (2012). GAISE Report.

Ehrenberg, A. S. C. (1976). We must preach what is practised: a radical review of statistical teaching. *Journal of the Royal Statistical Society*, Series D, 25(3),195–208.

Haack, (1979). Statistical Literacy.

McKenzie, Jr., John (2004). Conveying the Core Concepts. ASA Proceedings of the Section on Statistical Education. www.statlit.org/pdf/2004McKenzieASA.pdf

Moore, D. (1997). Statistical Literacy and Statistical Competence in the 21st Century [slides]. www.statlit.org/pdf/1997MooreASAslides.pdf

Moore, D. (1998). Statistical Literacy and Statistical Competence in the 21st Century [slides]. www.statlit.org/pdf/1997MooreASAslides.pdf

Moore, D. (2001). Statistical Literacy and Statistical Competence in the 21st Century [slides]. www.statlit.org/pdf/1997MooreASAslides.pdf

Moore, D. S. (1997). New pedagogy and new content: the case of statistics. Int. Statistical Review, 65,123-165. www.stat.purdue.edu/~dsmoore/articles/PedagogyContent.pdf

Morrison, D.E. & Henckle, R.E. (1970). *The Significance Test Controversy*. Chicago Aldine

Pearl, D., Garfield, J., delMas, R., Groth, R., Kaplan, J. McGowan, H., and Lee, H.S. (2012). Connecting Research to Practice in a Culture of Assessment for Introductory College-level Statistics. www.causeweb.org/research/guidelines/ResearchReport_Dec_2012.pdf

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

Tintle, Chance, Cobb, Rossman, Roy, Swanson & VanderStoep (2013). Challenging the State of the Art in **Post-Introductory Statistics**: Preparation, Concepts, and Pedagogy. ISI.