

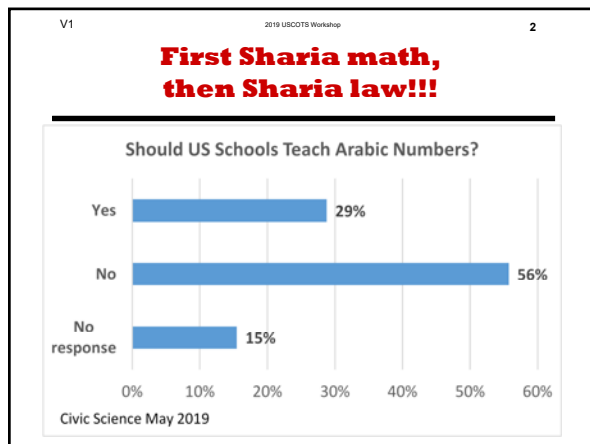
V1 2019 USCOTS Workshop 1

Teaching Statistical Literacy

Chapter 1
by
Milo Schield

Half-Day Workshop
USCOTS May 16, 2019

www.StatLit.org/pdf/2019-Schild-USCOTS-slides1.pdf



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Working Moms; Better Kids

23% more \$

<http://money.com/money/5272659/working-moms-better-kids/>

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Outline

Introduction:

- A1. Who takes intro statistics
- A2. SAT level of our students by college
- A3. Math level of our students by major

Exp vs. Obs: What kinds are relevant?

- A3. Kinds of influence on statistics
 - How common are these influences?
- A4. Grammar: Association vs. causation

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Goals of this Workshop

1. Present my view of statistical literacy
2. Expose you to lots of new ideas
3. Present a coherent structure for teaching
4. Show the importance of English grammar
5. Show simple ways of handling significance
6. Show simple ways of handling confounding
7. Show how confounding changes significance
8. Role-model analyzing studies

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Fraction of 4-year Undergrads that take Intro Stats?

57%

Schild (2016, IASE)

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Fraction of Course Gain that Stat Students Lose in 4 Months

50%

Tintle et al, 2013

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Student Attitudes Toward Stats

Of those taking Stat I:

- less than 1% take *Stat II* (10-yrs @ U. St. Thomas)
- less than 0.2% major in statistics (nationwide).
- most see less value in statistics after the course than they did before. Schield and Schield (2008).
- too many say “Worst course I ever took” [anecdotal]

www.amstat.org/misc/StatsBachelors2003-2013.pdf 1,135 stat majors in 2013 at 32 colleges www.StatLit.org/pdf/2015-Schild-UST-Enroll-in-Statistics.pdf

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What fraction of 4-Yr Intro Stat students are taught outside Math?

50%

Estimates by Schield (2015, Statchat)

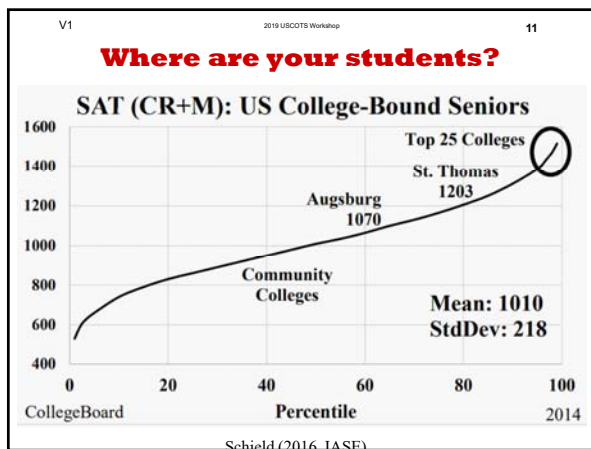
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Who takes Intro Statistics at Four-Year Colleges?

Table 1: Distribution of Majors in Stat 101

%	Major
38%	Business or Economics
19%	Social Science or History
13%	Health
10%	Psychology
9%	Engineering
9%	Biological Science
2%	Math or Statistics
100%	All students in these majors

Schild (2016, IASE). Inferred from data in 2012 US Statistical Abstract.



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SAT Math Percentile by Major

SAT MATH	PERCENTILE	MAJOR
613	80%	Math/Stats
585	72%	Physical Sciences
579	70%	Engineering
554	62%	Comp. Science
551	61%	Biological
550	61%	Social Sciences
522	51%	Business
522	51%	English Lang/Lit
506	46%	History
498	43%	Communication
489	40%	Psychology
482	38%	Education

Business Insider (2014), College Board (2015)

SAT Math Scores:
Average by Student Major

Percentiles of all those taking the Math SAT

Schild (2016, IASE)

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GAISE 2016 Update

The real world is complex and can't be described well by one or two variables.

If students do not have exposure to simple tools for disentangling complex relationships, they may dismiss statistics as an old-school discipline only suitable for small sample inference of randomized studies.

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GAISE 2016 Update

Multivariable thinking is critical to make sense of the observational data around us

- *learn to identify observational studies*
- *learn to consider potential confounding factors*
- *use ... stratification ... to show confounding*

This report recommends that students be introduced to multivariable thinking, preferably early in the introductory course and not as an afterthought at the end of the course.

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Most Important Topics: Student Choices

Rank	The most important topics in Statistical Literacy for Managers
1	Take CARE: Confounding, Assembly, Randomness and Error/bias
2	Confounding
2	Hypothetical thinking: plausible confounders, plausible definitions
4	Statistics are more than numbers. They include the context
5	Association-causation (Luck-skill) including the grammar
5	Bias: Placebo, Single blind; double blind
5	Named Ratios and Ratio grammar; Percent, Percentages, Rates
5	Read tables and graphs

Schiold (2016, ASA)

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**A-B-C Words:
A = Association**

Statistical association is not the same as Basketball Assoc.

Association words assert association explicitly or describe associations involving fixed conditions or unrepeatable events.

Association: Height is *associated* with age in children
Obesity is *correlated* with (related to) diabetes.

Prediction: Graduating from high school *predicts* success in life.

*Comparisons: People with degrees earn *more than* those without
Whites have a *higher* risk of suicide *than* blacks.

*Co-variation: *As children get older*, their weight *increases*.

* Manipulation is impossible, or treatment or outcome cannot be repeated.
Schiold (2018, SL4DM)

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**A-B-C Words:
C = Causation**

Causation words assert causation, sufficiency or contra-factual

Causation: A bomb *caused* the fire. Insomnia is a side *effect*.
Lightning *resulted in* a fire. Spark results in a fire.

Sufficient: The more X you do, the more Y *you will get*.
*Prevent, stop, end, start, kill, produce, cure, avoid, ban, quit, block, ward off, stave off, cancel, hinder, or eliminate.*⁶

Contra-factual: Those who do X *will get* more Y *than if they had not done X*.

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**A-B-C Words:
B = Between**

Between words describe association but imply causation

Verbs: Red wine *cuts* cancer risk. TV *ups* kids' risk of flunking.
Gene X *increases* health risk. Smoking *raises* asthma risk.

Connectors: Nuts *linked to* cancer. Trauma *tied to* heart disease.

Contributor: Diet *contributes to* diabetes. Age is *factor* in infertility

Nouns: Spinach is *asthma protector*. Bad water is a *killer*.

Logicals: Anxiety increases *due to (because of)* high stake testing

*Compare: People who take antidepressants have fewer migraines
Asthma attacks more likely for smokers *than* non-smokers.

*Covariation: As teacher pay *increases*, student scores increase.
The more hours worked, the *more likely* a promotion

*Manipulation is possible, and treatment and outcome are repeatable.

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A-B-C Words: Distribution in Headlines

Of the 2,000 news headlines analyzed⁶,
71% involved A, B or C.

Of those headlines involving A, B or C,

- **86% were "between" claims,**
- 11% sufficiency, 3% causation, 3% association.

6. Schield and Raymond (2009).

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Association is not causation

This statement is ambiguous. It can mean:

- 1 Association is not sufficient to prove causation
- 2 Association provides no evidence for causation.

Teachers may intend #1; students often hear #2.

A better statement would be:
Association is evidence of causation somewhere.

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Association is not causation

No idea has stifled the growth of statistical literacy as much as the endless repetition of the words "correlation is not causation".

This phrase seems to be primarily used to suppress intellectual inquiry -- by encouraging the unspoken assumption that correlational knowledge is somehow an inferior form of knowledge.

John Myles White (2010):
www.johnmyleswhite.com/notebook/2010/10/01/three-quarter-truths-correlation-is-not-causation/

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Studies are the Primary Unit of Analysis

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Harvard Case Studies: Title or Abstract

#	INFERENCEAL	CONTROL/CONFOUND
22	"clinical trial" 18	2,263 control
7	"statistical significance"	234 "control of" 200
4	"statistically significant"	113 "take (ing) into account"
3	"standard error"	30 "compensate (ing) for"
1	"sampling error"	19 "control (ed, ing) for"
1	"margin of error"	18 confound (er, ing)
1	"prediction interval"	17 "adjust(ed, ing) for"
1	p-value	3 "sampling bias"
0	"sampling distribution"	0 "alternate explanation"
0	"confidence interval"	0 "common cause"
0	"null hypothesis"	0 "effect modifier"
0	"reject the null"	0 "Simpson's paradox"
0	"random assignment"	0 "hurling variable"

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Statistical Literacy : An Overview

Statistics are numbers in a context
Association is not causation

RANDOMNESS and CAUSATION	CONFOUNDING and CAUSATION
Chance, independence and sampling distributions	Comparisons, ratios, models and study designs
Margin of error, hyp tests & statistical significance	Epidemiological causation (Bradford-Hill)
Random assignment and causation (Fisher: RCT)	Confounder conditions for nullification (Cornfield)

v0.7 Conditional probability, medical tests and Bayesian reasoning
Coincidence, Simpson's Paradox and regression to the mean

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Stat Literacy studies Stats as Evidence in Arguments

The Point or the Target

The more disputable the point, the stronger the evidence must be.

Statistic As Evidence

“All Statistics are Socially Constructed”
So, “Take CARE”!!

Statistics may be influenced by:

C	A	R	E
Context	Assembly	Randomness	Error

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Statistical Literacy : Assembly

Living with AIDs

All (1,000)	White (non-Hispanic)	Black (non-Hispanic)	Hispanic
434	150	186	78

Q1. Which group is largest?
Consolidate White (Non-Hispanic) with Hispanic.

Q2. Which group is largest?

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Statistical Literacy : Randomness

Five non-quantitative Topics:

1. Regression to the Mean
Sport Illustrated Cover
2. Statistically significant
3. Chance-Related Mistakes:
Three Door problem; Birthday problem
 - Better than chance
 - Unlikely to be chance

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Statistical Literacy : Error/Bias

Three kinds of error

1. Subject/respondent error:
2. Researcher/measurement error:
3. Sampling error:

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Statistical Literacy : Assembly

Child Abuse Statistics

Each year, more than 7,000 children in Minnesota are confirmed to be victims of physical or sexual abuse, emotional maltreatment, or neglect.

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Statistical Literacy : Recommendation

More college students (over half) take intro statistics than any other course (except English).

One-size fits all is no longer viable. Statistics education must support Stat 101 and 100/102.

Statistics education should (1) support different flavors for different majors, and (2) agree on the contributions of statistics to human knowledge.

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Willful Ignorance

The past success of statistics has depended on vast, deliberate simplifications amounting to willful ignorance.

This very success now threatens future advances in medicine, the social sciences, and other fields.

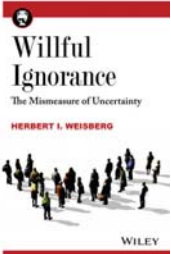
Limitations of existing methods result in frequent reversals of scientific findings/recommendations, to the consternation of scientists and the public.

Herbert I. Weisberg

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Willful Ignorance **Herbert Weisberg**

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