TEACHING THE SOCIAL CONSTRUCTION OF STATISTICS

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Best (2001) asserts that "all statistics are socially constructed." This paper investigates three questions. (1) Is Best's thesis true? (2) If so, should this fact be taught in introductory statistics courses? (3) If so, what general principles involving the social construction of statistics can be taught that don't rely on detailed knowledge of a particular subject? Isaacson (2011) notes that the social construction of statistics is readily presented by asking students "Where do statistics come from?" Results of a small survey show that statistical educators are seriously divided on whether this topic should be taught. Examples of questions and principles used in teaching Statistical Literacy at Augsburg College are presented. This paper argues that the Isaacson question, "Where do statistics come from?" is fundamental to statistical education and should be at the center of any course titled "statistical literacy". If there isn't time to teach this material in introductory statistics courses, then statistical educators should support offering a separate statistical literacy course in order to cover this important topic.

KEYWORDS: Statistical literacy

INTRODUCTION:

Joel Best (2001) clearly stated and persuasively argued that "All statistics, from the best to the worst, are socially constructed. All statistics are products of choices and compromises that inevitably shape, limit, and distort the outcome." And he argued that this fact is the most important influence on any statistic and that "numeracy education needs to address social construction". Best (2008) and Schield (2007).

Any statement that asserts "all" is highly suspect. So the first part of this paper attempts to support this claim. Given that all statistics involving real things are socially constructed, the second part of this paper investigates whether this should this be taught in college statistics courses. Assuming that it should, the third part of this paper presents ways of teaching this idea that have been student tested.

1. ARE *ALL* STATISTICS SOCIALLY CONSTRUCTED?

Consider statistics involving human consciousness: ideas, goals, values and benefits. These idea-based statistics are most likely to be socially constructed. Here are some examples:

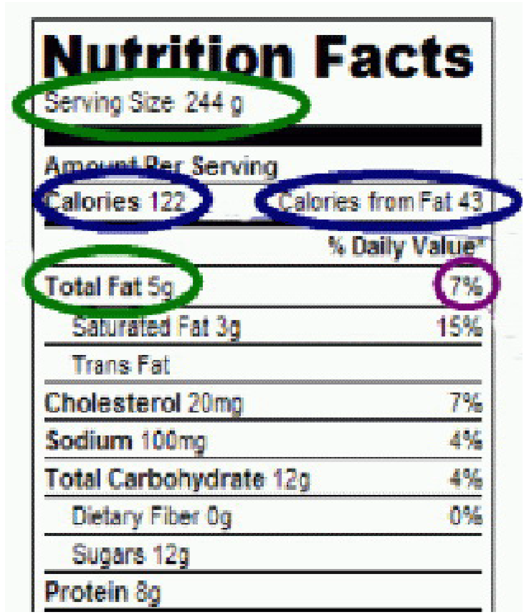
According to a recent report on the abuse of children by Catholic priests, "less than 20% of the sexual abuses of children by priests involved pedophilia**.**" The John Jay Report (2004). One wonders why this isn't 100%. But if we define a pedophile as "an adult who sexually abuses pre-pubescent children and pre-pubescent is defined as being less than 11 years old, then the 20% claim becomes plausible.

Other statistics about the human condition such as poverty, unemployment, elderly and disabled are obvious candidates for being socially constructed. These ideas don't exist in reality like animals, plants and inanimate matter. They are – by their very nature – socially constructed by human beings.

What about statistics involving the biological aspects of people? Consider something as simple as height. Research shows that our height varies every day: highest on awakening, lowest at bedtime. As Wikipedia notes, "The height of each person can change in the short-term depending on factors such as the amount of exercise done directly before measurement, or the time elapsed since lying down for a significant period of time."

What about statistics involving the animal kingdom? Consider this recent press release titled "What is the loudest animal on earth?" You might expect an elephant or lion or whale. The article claimed it was a pond insect (Corixdae). How can an insect be louder than a lion? In the body of the article they said it was the "loudest animal relative to its body size."

What about statistics involving inanimate matter? Consider 2% low-fat milk. This sounds like a very straightforward statistic. But there are at least three different ways to calculate the fat in milk. The first is by weight: 5 grams in a total serving size of 244 grams gives 2%. The second is by calories: 43 calories from fat out of 122 calories per serving gives 35%. A third is to compare the calories from fat in a serving of milk with the recommended daily limit of 387 calories (43 calories out of (65 grams of fat times 9 calories per gram of fat) gives 7%. Note that the 2% is much lower than the 35% because so much of milk is water.

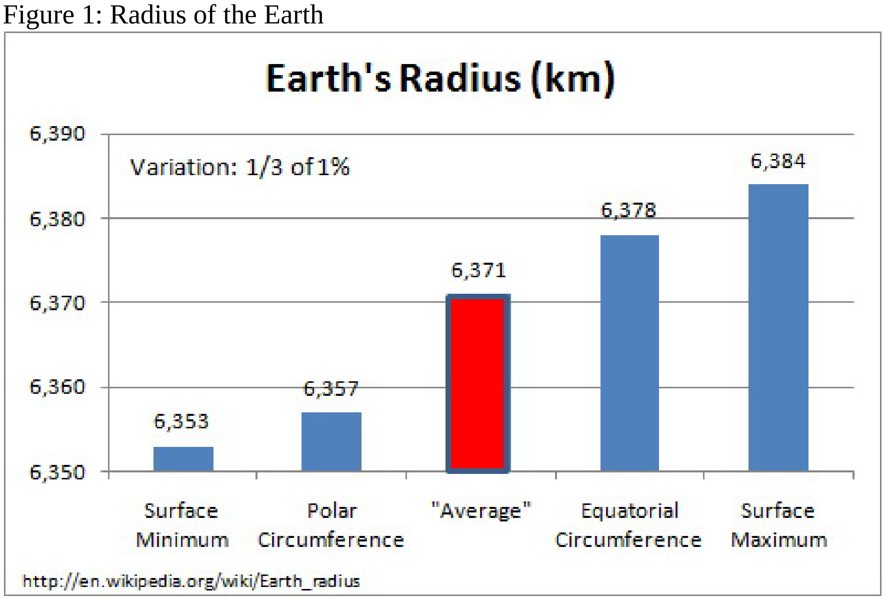


The percentage of fat in milk is socially constructed in another way. The 2% milk certainly has less fat than whole milk with 3.5% to 5% fat depending on the type of cow. If whole milk has 5% fat, then 2% milk has 60% less fat.

But this means that whole milk is 95% fat-free and 2% milk is 98% fat free. Switching from whole milk to 2% milk is an increase of slightly more than 3%. In fact, "95% fat-free" makes whole milk sound very "low-fat" all by itself.

Now consider a natural instance of inanimate matter. Consider the radius of the Earth. Figure 1 illustrates different ways of measuring that radius since the earth is not a perfect sphere. Here again, human beings have to make a choice.

Figure 1: Radius of the Earth



This kind of problem applies to all heavenly bodies where there is no formal requirement that they be perfect spheres.

Finally, consider those physical constants that are treated as though they were absolute values allowing no room for human construction. Consider the speed of light. Someone had to decide whether this was the speed of light in water, in air or in a vacuum. Someone had to determine whether the speed of light varied with the frequency or wavelength involved. Someone had to determine whether the speed of light varied with the ambient temperature or pressure of the medium.

2. SHOULD INTRO STATS TEACH THAT ALL STATS ARE SOCIALLY CONSTRUCTED?

Assume that all statistics are socially constructed is a fact – an essential fact – about all statistics. The next question is whether introductory statistics course should teach this. Last spring, a group of Minnesota college statistical educators were presented with this question.

At that meeting, Isaacson (2011) argued that the social construction of statistics is an essential component of a basic question: "*Where do statistics come from*?"

> *Many introductory statistics textbooks begin with the near-biblical premise "There is Data" as if they are pre-existing facts and then concentrate on the language, mechanics and science of statistical calculations. Most of these same textbooks completely ignore the fundamental question about the origin of statistics and the critical yet often subjective decisions (i.e. choices of population, sample, measures, definitions, categories, etc.) that can greatly impact the data and values eventually calculated.*
>
> *Saying that "Statistics Come from Data" seems to be a common answer from both beginning introductory statistics students and their textbook authors. What is wrong with starting with data? To say that "Statistics Come from Data" is similar to saying "Babies Come from Hospitals". While it is generally true and an appropriate answer for some audiences, it leaves out a whole lot of the interesting part of the story.*
>
> *As educated, statistically literate citizens of our society, students must learn to consume and critique the statistics others present to us in their efforts to sell, persuade and convince. Focusing on the question "Where Do Statistics Come From?" gives the student a set of tools to develop their critical thinking regarding numbers and statistics.*

Isaacson (2011) argued that statistical educators should start their class with the question, "Where do statistics come from?" Common answers from 242 students included data or numbers (53%), calculations (15%), data collection (7%) and other sources (18%). Only 7% indicated a question of interest by an individual or group.

A proper answer to the "Isaacson question" would include not just the question of interest. It should include the identification of the target population, the sampled population, the type of sampling, and the size of the sample. It should also include how the qualitative variables and the quantitative measures were defined and how subgroups were grouped into new categories.

The statistical educators were also briefed on how Schield (2010) organized the social construction of statistics under four headings: *Context* (influence of what is – and is not – controlled for), *Assembly* (influence of definitions of groups and measures), *Randomness* (influence of chance) and *Error* (influence of bias).

As background it was argued that Statistical educators don't generally teach that statistics can be influenced by human choices in *Assembly*: choices such as definitions of groups/measures, choices in the kind of comparison (# more vs. % more) or choices in presentation (pie chart vs. bar graph). Statistical educators do teach that statistics can be influenced by the choice of the mean versus the median. But they seldom go beyond that.

The argument went like this. Checking assumptions is a critical activity in modeling. Often times the assumptions used in analyzing data influence – if not determine – the results. This talk argues that statistics have the same status as models: they both are sensitive to choices (assumptions) that influence – if not determine – the results.

One of the five elements of the AACU Quantitative Literacy Rubric (2009) is the "ability to make and evaluate important assumptions in estimation, modeling, and data analysis." This focus on assumptions in data analysis could be extended to include the formation of categories, measures and summary statistics. While statistical educators may have little to say about which data formation assumptions are best, they can highlight how choices in group definitions, quantity measures, ratio denominators and other context determiners can influence the resulting statistics.

Once students are aware of "Where do statistics come from?" and the many choices made in generating a statistic, statistical education should focus on two auxiliary topics: (1) More focus on the *context* – what was and was not taken into account by ratios, comparisons, comparisons of ratios and models. (2) More focus on *assembly*: how groups and measures are defined.

After the presentation, the eleven statistical educators were surveyed on seven questions. Here are the questions and the survey results. See the Appendix for details.

Table 1: Survey Questions and Summary Results (Agree, Neutral and Disagree)

Statistical educators …

Q1. *should leave these auxiliary topics for a later course.* A majority (55%) disagreed; only 27% agreed.

Q2. *should extend intro stats to include factors taken into account (context).* A majority (55%) agreed; 18% disagreed.

Q3. *should extend intro stats to include where do statistics come from (meaning to include assembly: how groups and measures are defined).* A near-majority (45%) disagreed; 27% agreed.

Q4. *should extend intro stats to include both of the above.* The group was split: 40% agreed; 40% disagreed. As might be expected the pattern for this question is somewhere between the positive pattern in Q2 and the negative pattern in Q3.

Q5. *should support a separate statistical literacy course.* A majority (56%) disagreed; only 11% agreed. Note: Several local supporters of a separate statistical literacy course either were not present (Kaplan) or did not vote (Schield and Isaacson).

Q6. *should extend modeling to include epidemiological models, rates and percentages.* The group was split: 36% agreed; 36% disagreed.

Q7. *should extend "assumptions" to include all choices influencing a statistic*. The group was split: 36% agreed; 36% disagreed.

After the survey was completed, some of the respondents were asked their reasons for not extending introductory statistics to include factors taken into account (Q2). One respondent said that if students were to recognize the sensitivity of many statistics to what is taken into account they might have "less respect for our discipline." Some may wonder if this is an example of what sociologists call *mystification*: the idea that professions often find it useful to keep non-professionals awed – and in line. The same respondent was asked for reasons why we should not extend introductory statistics to include "Where do statistics come from?" The respondent noted that measurement was a separate discipline from statistics and statistical educators should not presume to be experts in these non-statistical areas.

So, a slim majority of the faculty support increasing the focus on *context* and disagree with offering a separate statistical literacy course. The group was seriously divided – no majority position – on either side of any of the other questions.

This simple survey did not investigate why respondents disagreed. Some may have thought the topic was inappropriate regardless of venue. Others may have thought the topic appropriate somewhere but not in introductory statistics. Still others may have thought there were no general principles to be taught.

Despite the negative results of this survey, this author believes that both *context* and *assembly* can and should be taught as involving general principles. If there isn't time in introductory statistics (which already has too much to cover) to teach these topics, then they should certainly be taught in a separate statistical literacy course.

3. HOW SHOULD THE SOCIAL CONSTRUCTION OF STATISTICS BE TAUGHT?

Assuming that the social construction of statistics should be taught in introductory statistics or statistical literacy, how should it be taught? Recall the survey respondent who pointed out that statistical educators are not subject-matter experts (SMEs). That is an excellent point. And even if some statistical educators were subject matter experts, they don't have time to educate their students to that level in introductory classes.

There are many general principles illustrating the social construction of statistics that can be taught without requiring students to be subject-matter experts. They typically involve the use of ordinary English rather than algebraic formula.

When talking about *Context*, statistical educators can educate students on how statistics are influenced by choices in deciding what related factors are – and are not – taken into account. Students should recognize the various linguistic signs of comparisons, ratios (e.g., per, percent, rate) and comparisons of ratios (e.g., more likely). Students should be aware of what "taking into account" means and why failing to control for plausible confounders matters.

When talking about *Assembly*, statistical educators can educate students on how statistics are influenced by choices in defining groups and measures. The definitions of groups and measures can be grouped under three categories:

- *Formal*: Need almost no knowledge of ideas: Fewer tall smokers than smokers…
- *Material*: Need detailed knowledge of ideas: More autistic boys than autistic girls…
- *Between*: Need some knowledge of ideas: Women live longer than men on average.

By focusing mainly on *formal definitions*, statistical educators can readily make the point that statistics are easily influenced by social construction in the definition of groups or measures.

Augsburg's Statistical Literacy course for students in non-quantitative majors has focused primarily on *context* and *assembly*. Recall that *context* identifies all the influences on a statistic that involve a comparison, the phrases "after taking into account" or "after controlling for", or any kind of model. *Assembly* identifies all the influences on a statistic that involve how the group or measure was defined and how the summary data was presented. See Schield (2010).

The following examples focus on *assembly* in defining groups, they involve general principles and the definitions are predominately formal so no particular knowledge is needed.

- *Compare Formal Definitions involving Counts: Criteria-based.* Examples: Which count/total is larger? (1) US population; US male population? (2) Not employed; Not employed and looking for work? (3) Use of physical force; Use or threat of physical force?
  Principles involving counts or totals: (a) "And" phrases and modifiers restrict the options and give a smaller total. "Or" phrases increase the options and give a larger total. Beware of "and" conjunctions that really mean "or." E.g., the number of juniors and seniors.
- *Compare Formal Definitions involving Counts: Frequency-based.* Examples: Which count is bigger? (1a) Smoker: smokes *more than* five cigarettes a day vs. (1b) Smoker: smokes *more than* two cigarettes a day. Which count is bigger? (2a) Sober: consume *less than* 3 drinks in past week. (2b) Sober: consume *less than* 1 drink in past week.
  Principles involving one-sided ranges: If "more than X" (a minimum), then a larger X gives smaller count. If "less than X" (a maximum), then a larger X gives bigger count.
- *Compare Formal Definitions involving Counts: Duration-based.* Examples: Which count is bigger? (1a) Smoker: smoked in the past 2 weeks. (1b) Smoker: smoked in the past 4 weeks. Which count is bigger? (2a) Sober: No alcohol in past 2 weeks. (2b) Sober: No alcohol in past 4 weeks.
  Principles involving time periods in the past: If "Event-exists in *any* of the past X periods" is the criteria, then a bigger X results in a bigger number. If "event-free in *all* the past X periods" is the criteria, then a bigger X results in a smaller number.
- *Compare Formal Definitions involving Ratios: Compare Numerators.* Which ratio is largest? (1a) Percentage of US citizens who are adults, (1b) Percentage of US Citizens who are adult males, (1c) Percentage of US citizens who are adults or are males? Which ratio is largest? (2a) The US death rate due to suicide, (2b) the US death rate, or (2c) the US death or emigration rate.
  Principles for comparisons of numerators: "And" phrases and modifiers restrict and result in smaller ratios. "Or" phrases increase options and result in larger ratios.
- *Compare "Between" Definitions involving Rates: Compare Denominators.* Here a minimal knowledge of the ideas is needed to answer these questions. Examples: Which ratio is

bigger? (1a) US birth rate: per 1,000 adults or (1b) US birth rate per 1,000 women? Which ratio is bigger? (2a) Percentage of US oil imports that are from OPEC, or (2b) Percentage of US oil usage that is from OPEC.

- *Compare "Between" Definitions involving Rates: Compare Numerator-Denominator Switches*. A minimal knowledge of the ideas is needed to answer these questions. Examples: Which ratio is bigger? (1a) Percentage of auto accidents that involve a death or (1b) Percentage of auto deaths that involve an accident. Which ratio is bigger? (2a) Accidental death rate per 1,000 US males or (2b) Male-death rate per 1,000 US accidents. Which ratio is bigger? (3a) Percentage of US adult prisoners who have low IQ or (3b) Percentage of US low-IQ adults who are prisoners. Which ratio is bigger? (4a) Percentage of US males who are in the military or (4b) Percentage of the US military who are male.

The point of identifying principles isn't so much as to teach the principles which students may easily forget. The point is that by identifying these principles, statistical educators may pick problems that students can work without being subject-matter experts.

CONCLUSIONS

Statistical educators can teach the influence of *context* (taking into account or controlling for the influence of a related factor) on a statistic by focusing on the grammatical signs of comparisons, ratios and comparisons of ratios. The idea of "controlling for" can be extended to include sophisticated models.

Statistical educators can teach the influence of *assembly* (how groups and measures are defined) on statistics without requiring a deep understanding of the ideas involved by focusing on how simple grammatical differences extend or restrict the range for counts or totals.

RECOMMENDATIONS:

1. A larger group of statistical educators should be surveyed with a more in-depth survey.
2. Statistical educators should go beyond chance and bias and analyze all kinds of influences on a statistic.
3. Statistical educators should focus more on *Context*: what is – and is not – taken into account.
4. Statistical educators should focus more on *Assembly:* the choices made in defining groups and measures, and the sensitivity of statistics to these choices.
5. Statistical educators should start each course with the Isaacson (2011) question: "Where do statistics come from?"
6. Any course titled "statistical literacy" should have the social construction of statistics as the central focus. Once students realize that all statistics are constructs, socially-constructed tools, then statistics can be taught as a liberal art (an inductive activity) rather than as just a mathematical skill (a deductive activity).

REFERENCES

AACU (2009). Quantitative Literacy VALUE Rubric. Copy available at www.aacu.org/value/rubrics/pdf/QuantitativeLiteracy.pdf

Best, Joel. (2001). *Damned Lies and Statistics*. University of California Press.

Best, Joel (2008). Birds – Dead and Dying: Why Numeracy Needs to Address Social Construction, *Numeracy*, Vol. 1, Issue 1, Article 6.

Isaacson, Marc (2011). "Where Do Statistics Come From? - Setting the Table for Introductory Statistics." Poster USCOTS. See www.statlit.org/pdf/2011IsaacsonPosterUSCOTS.pdf

John Jay Report (2004) by the John Jay College of Criminal Justice. See http://en.wikipedia.org/wiki/John_Jay_Report

Schield, Milo (2007). Teaching the Social Construction of Statistics, 2007 Midwest Sociological Society, Chicago. See www.StatLit.org/pdf/2007SchieldMSS.pdf

Schield, Milo (2010). Assessing Statistical Literacy: TAKE CARE in *Assessment Methods in Statistical Education: An International Perspective*. Edited by P. Bidgood, N. Hunt and F. Joliffe. Wiley Publishers, Ch. 11, p. 133-152. Excerpts at www.statlit.org/pdf/2010SchieldExcerptsAssessingStatisticalLiteracy.pdf

APPENDIX: SURVEY RESULTS

Five answers were shown for each question: (0) strongly disagree, (1) disagree, (2) neutral, (3) agree and (4) strongly agree. A failure to answer was left blank.

Table 2: Detailed Survey Results (%)

Answer	Q1	Q2	Q3	Q4	Q5	Q6	Q7
0	18%	0%	18%	10%	33%	9%	18%
1	36%	18%	27%	30%	22%	27%	18%
2	18%	27%	27%	20%	33%	27%	27%
3	27%	55%	27%	40%	11%	36%	36%
4	0%	0%	0%	0%	0%	0%	0%

Table 3: Summary Survey Results (%)

Answer	Q1	Q2	Q3	Q4	Q5	Q6	Q7
0-1	**55%**	18%	**45%**	40%	**56%**	36%	36%
2	18%	27%	27%	20%	33%	27%	27%
3-4	27%	**55%**	27%	40%	11%	36%	36%