Abstract: This paper argues that the question in the title is the wrong question. We must start with the students. What are their abilities, their goals and their attitudes? Data is provided to answer each of these questions. This data supports the claim that the "one-size-fits-all" introductory statistics course is inadequate. Statistical educators should define three versions of introductory statistics: Stat 100 Statistical Literacy for those in non-quantitative majors. Stat 101 the traditional algebra-based course for those in quantitative majors and Stat 102 Advanced Intro Statistics: a calculus and model based course for high-ability students and those in the sciences. All three courses must present the major contributions of statistics to human knowledge. These major contributions involve the influence of randomness and confounding on the relationship between association and causation.

Introduction

The USCOTS question was "What is wrong with Stat 101?" This leads to two related questions: What topics should we teach? How should we teach these topics?

If we want to teach statistics as being valuable, then these are the wrong questions! All statements involving value should entail two questions: "Of value to whom" and "Of value for what?" As teachers, we should start with our students:

Who are our students?

1. What are their aptitudes or abilities?
2. What are their goals or interests?
3. What are their attitudes?

Once we have answered these questions, then we can decide how to answer the USCOTS question.

#1: What the aptitudes or abilities of college students?

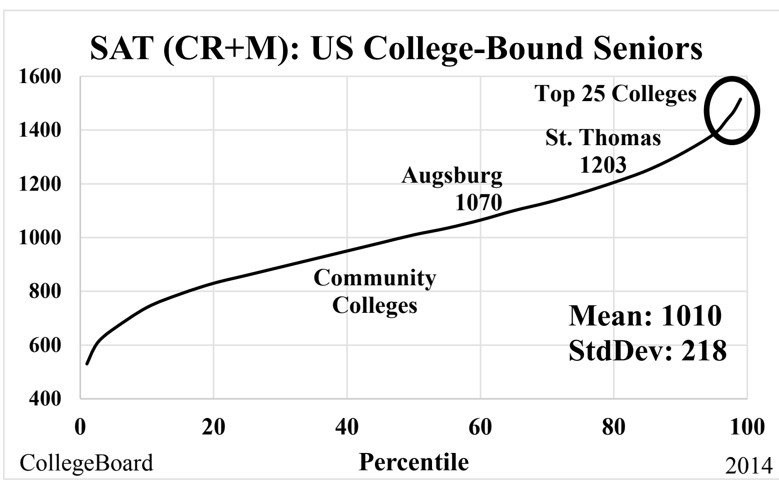

Figure 1: Scholastic Aptitude Scores (SAT)

Obviously college students vary greatly in their academic aptitude and ability. Many of the statistical educators attending USCOTS or other statistics education conferences come from highly-selective colleges: colleges where the students have SAT scores that average above the 95th percentile. What may work for these students may not work for those of us teaching at less-selective four-year colleges – much less for those teaching at community colleges and high schools.

#2: What are the goals or interests of those taking Stat 101?

Of those graduating in the US with BA or BS degree, 51% took Stat 101

Of the 812,000 students in Stat 101 at US 4-yr colleges, [1]

- 43% in Business or Economics,
- 21% in Sociology or Social Work,[2]
- 15% in Health,
- 11% in Psychology
- 10% in Biology, and
- less than 1% are in mathematics or statistics.

Most of those taking Stat 101 deal mainly with observational studies where confounding is the biggest problem. Tintle et al (2014) Business majors want to use statistics to make better decisions, whereas most of those in other departments want to use statistics to discover meaningful associations.

#3: What are the attitudes of those taking Stat 101?

Of those taking Stat I:

- less than 1% take *Stat II* (10-yrs @ Univ. St. Thomas)[3]
- less than 0.2% major in statistics (nationwide).[4]
- most see less value in statistics after the course than they did before. Schield and Schield (2008).
- more say "Worst course I ever took" [anecdotal]

This is important data. The attitudes of college students are fairly well formed. Trying to change their attitude toward mathematics or statistics – at this age – is not easy. Negative attitudes toward statistics were found when students at Pomona were asked to rank the various required courses in their general education. Philosophy ranked first while Data Analysis ranked last. Taylor (1999).

> Two former presidents of the ASA have stated that "students frequently view statistics as the worst course taken in college" A third former president has stated that the field of statistics is in a "crisis" and the subject has become "irrelevant to much of scientific enquiry" (MacNaughton 1998)

MacNaughton (2004) argues that the primary goal of an introductory statistics course should be "to give students a lasting appreciation for the value of statistics."

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[1] This data assumes that all graduates in these majors took introductory statistics. Data on bachelor's degrees by field is in Table 302 of the 2012 US Statistical Abstract. In this 2009 data, there were 1.6 million graduates.

[2] While those majoring in Sociology or Psychology may take statistics inside those departments as part of a two-semester research methods course, others in these majors may be taking statistics in a common course taught in a math-stat department or a quantitative methods department.

[3] This data is available at www.StatLit.org/pdf/2015-Schield-UST-Enroll-in-Statistics.pdf

[4] This data on was compiled by the ASA and is available at www.amstat.org/misc/StatsBachelors2003-2013.pdf
It includes 1,135 stat majors in 2013 at 32 colleges. This ratio combines this data with that shown in footnote 1.

#4: So what can we conclude based on this data?

The students taking Stat 101 vary extensively in their aptitudes or abilities, in their goals and interests and in their attitudes. About half of all college graduates will take a statistics course. Aside from English composition, there is no other college course that has such a large "market share."

Teaching statistics to half of all college graduates is a tremendous opportunity for statistics as a discipline. Yet we seem to ignore this aspect entirely. The MAA tabulates how many students take introductory statistics inside math-stat departments. Neither the MAA nor the ASA makes any attempt to tabulate how many students are taking introductory statistics outside math-state departments.

The essence of the problem is in the phrase "THE introductory statistics course." This phrase presumes there is basically just one common course with minor variations: a "one-size fits-all" course.

This "one-size-fits-all" model has some definite advantages:

1. It facilitates transfer of credit between institutions.
2. It simplifies preparation for the many sections taught by adjuncts.
3. It gives textbook publishers a big incentive to publish a popular book in this big market.

But, the "one-size-fits-all" model has some definite disadvantages:

1. It ignores big differences in student aptitudes and abilities. Instead of allowing students at community colleges to focus more on critical thinking, it requires that textbooks reduce education to "plug-and-chug" procedures.
2. It ignores big differences in student goals and interests. Yes, there are differently-named introductory statistics textbooks for students in business, sociology and psychology. But these textbooks cover essentially the same statistical topics.
3. It ignores big differences in student attitudes. Students with math-phobia need a different set of topics than those who really enjoy math.

We have allowed statistics education to split based on the math pre-requisite: calculus versus algebra. We should be willing to take the next step and create and maintain standards for several different versions of introductory statistics. Based on this data, we should explicitly reject the current model: the "one-size fits all" model.

Proposal for three different versions of introductory statistics:

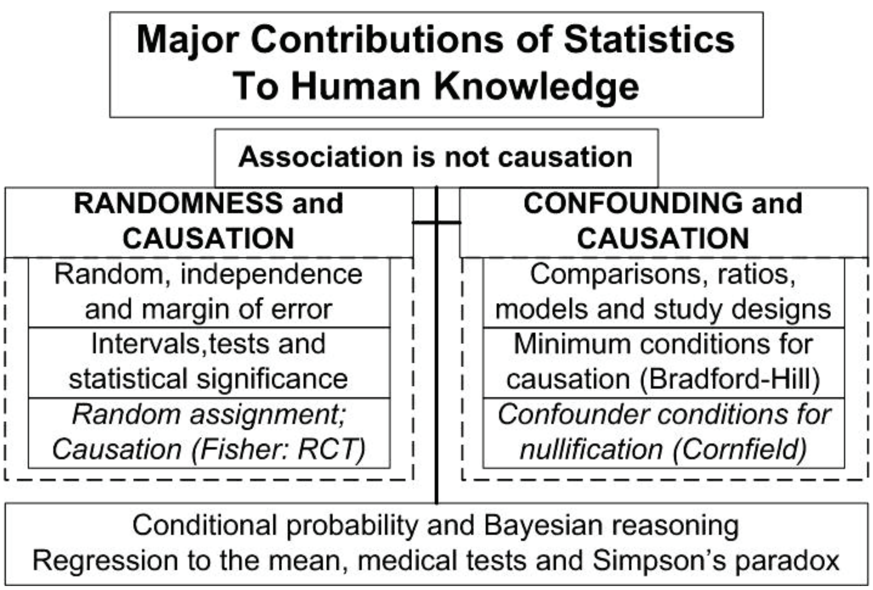
Since introductory statistics is taken by a wide range of students, statistical educators should set minimum standards for three different versions of introductory statistics. Here are my candidates and the associated standards. See Isaacson and Schield (2014) for background.

Stat 102: Advanced Introductory Statistics (Applied Math-Stats). This course is designed for students in majors that require – or encourage – calculus. This course must have a Calculus I pre-requisite. It must use higher-level mathematics throughout the text. It can include non-standard topics such as logistic regression, MCMC, Metropolis–Hastings algorithms or Gibbs sampling even if this means less emphasis on the derivation of the central limit theorem and the many forms of hypothesis tests. However, it must indicate the process of deriving the central limit theorem and it should feature at least one form of hypothesis test along with a mention of Type I and Type II error and power. At least a third of this course or the textbook must focus on statistical inference and related topics but this may be done using a frequentist approach or a combination of frequentist and Bayesian.

Stat 101: Traditional statistics. This course is designed for students in majors that require statistics. Calculus is not a requirement, but Algebra I or higher must be a pre-requisite. Algebra must be used where ever possible. Although most traditional intro textbooks devote almost the entire book to the derivation and application of statistical inference, this is not a requirement. That requirement is loosened In order to allow courses and textbooks with greater focus on descriptive statistics, conditional probability using ordinary English, multivariate models and confounding. The requirement is that at least a third of the textbook or course must focus on statistical inference and closely-related topics including conditional probability, the binomial and normal distributions, sampling distributions, standard error, margin of error, confidence intervals, hypothesis tests and statistical significance. While all of these topics are required, textbooks may vary considerably in terms of the depth involved in any particular topic. For example, statistical significance could be presented using resampling or the lack of overlap in confidence intervals.

Stat 100: Statistical Literacy. This course is designed for students in non-quantitative majors: majors that do not specifically require any mathematics or statistics. It is designed for students that will be consumers of statistics. Algebra is not a requirement and the use of algebra should be minimal. In order to allow courses with a greater focus on where statistics come from, and how statistics are defined, counted and measured, the only requirement is that at least a fifth of the book should focus on statistical inference and closely related topics such as conditional probability, etc.

All three courses must present the major contributions of statistics to human knowledge. Not mentioning Fisher's use of random assignment as evidence for causation is statistical negligence. Not mentioning Cornfield's brilliant rejoinder to Fisher as to whether smoking causes cancer is equally appalling. Statistical educators have not reached a consensus on this matter. Here is a starting point.



Most students taking statistics are in majors that analyze observational data and most data in the media is observational. Thus, every introductory textbook must include confounding, review various statistical techniques to control for confounders, and note that confounding can influence statistical significance.

Conclusion:

Explicitly recognizing that "one size does not fit all" is the first step in reforming THE introductory statistics course. Statistical educators should support the development of classes and textbooks that address the wide differences among those taking introductory statistics. They should adopt the MacNaughton goal of giving students "a lasting appreciation for the value of statistics." This paper recommends supporting three introductory classes: Stat 100, Stat 101 and Stat 102. Stat 100 has no math prerequisite; Stat 101 requires Algebra I and Stat 102 requires calculus. The course requirements differ in other ways, but all three courses must present the major contributions of statistics to human knowledge. These must include association, causation, randomness and confounding.

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