STATISTICAL LITERACY: AN EVANGELICAL CALLING FOR STATISTICAL EDUCATORS

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Abstract: Students in majors that do not require a math or statistics course are often unbelievers in the value and power of statistics. If statistical educators are to serve the quantitative needs of these students, they must be evangelists to non-believers rather than being ministers to believers; they must focus on statistical literacy rather on statistical competence. They must be called to help students see the value of statistics in everyday situations; they must measure teaching effectiveness based more on improvements in students' attitudes toward statistics than in students' knowledge of statistics.

1. STATISTICS AND QUANTITATIVE LITERACY

Introductory statistics is unique in several ways. Introductory statistics may be the most widely required course at the college level. If all those majoring in business, economics, psychology and sociology take statistics, then over 50% of US college graduates take statistics. On this basis, at least 95% of those taking introductory statistics have majors outside mathematics or statistics and for most of these statistics is not a prerequisite for a subsequent course. A small study of business majors identified statistics as the least valued course in the business core curriculum. (Schield, 2004a) Statistical topics are seldom found in graduate entrance exams such as the GMAT, GRE or LSAT, or in the business cases used in the Harvard MBA program. Yet despite all these well known facts, support for requiring statistics remains high among educators in business, psychology, sociology and economics.

Despite all the aforementioned problems with introductory statistics, there is a near-universal agreement that college graduates must be quantitatively literate – if not statistically literate. The AACU (2004) reviewed desired outcomes of a liberal education. In each case statistics and mathematics was never mentioned, but quantitative literacy (QL) or quantitative reasoning (QR) was always mentioned.

Lynn Steen, a tireless leader in the quantitative literacy movement, has addressed this issue repeatedly. Steen (2004) issued a call: *"It is time for a change, time to recognize the unique quantitative requirements of universal education in the computer age."* Steen noted, *"QL is anchored in context; the objects of QL are data."* Scheaffer (2003) noted, *"Statistics is the branch of the mathematical sciences that deals with numbers in context – data – and makes systematic study of how to reason under uncertainty. Statistics must be a key part of QL!"*

Steen (2004) went further to say, *"In reality, data analysis -- what most statisticians actually practice – is typically more than the average person needs to be an informed citizen, intelligent consumer or skilled worker."* Scheaffer agreed somewhat in saying, "*In reality, full-bore data analysis is more than most people need to deal with the statistical issues of everyday life and work.*" Madison (2003)

Steen (2001) noted differences between QL and statistics. *"Despite its occasional use as a euphemism for statistics in school curricula, quantitative literacy is not the same as statistics. … Unlike statistics, which is primarily about uncertainty, numeracy is often about the logic of certainty."*

Scheaffer (2003) disagreed. *"Some of the QL leaders tend to see statistics as only the small part of QL that deals with chance. I see statistics as much broader than that; in fact, I see it as encompassing much of the QL litany of topics that deal with data and its practical use in everyday situations. Thus, there is an important role for statisticians to play in this expanding interest in QL…"* Scheaffer elaborated saying, "*many aspects of statistical thinking are not about numbers as much as about concepts and habits of mind. For example, the idea of a lurking variable upsetting an apparent bivariate relationship with observational data is a conceptual idea, part of statistical thinking, but not particularly about numbers.*" Madison and Steen (2003)

This claims made about statistics may be clarified by distinguishing statistical literacy and statistical competence. Moore (1998a, 2001) defined statistical literacy as "what every educated person should know" and statistical competence as "what someone who works with data at her job should know." Steen seemed to say that QL is not the same as statistical competence, while Scheaffer seemed to say that statistical literacy encompasses much of QL.

2. STATISTICAL LITERACY

Leaders in statistical education such as Moreno (1997, 2001), Holmes(2003), Utts (2003), Gal (2003), Sowey (2003), Scheaffer (2003), Ridgway et al (2004) and Hayden (2004) have noted that

statistical educators need to focus on the quantitative needs of the students – their needs as consumers of statistics in everyday life. This is statistical literacy as defined by Moore. Schield (2004a and 2004b) argued that statistical literacy should be viewed as the study of everyday arguments in which statistics are used as evidence. Best (2004) has made similar arguments. Steen (2004) noted, "*What everyone needs is typically called statistical thinking or statistical literacy, a crucial component of quantitative literacy*." Note that in every case, the focus is on reading and interpreting everyday statistics as found in the news and the media.

But still there is a tension in defining statistical literacy. Rumsey (2002) noted this tension and said, *"I will attempt to clarify the issues by omitting the phrase "statistical literacy" from my discussion, and instead I will use two distinct phrases to refer to the two distinct learning outcomes that we have discussed. "Statistical competence" refers to the basic knowledge that underlies statistical reasoning and thinking, and "statistical citizenship" refers to the ultimate goal of developing the ability to function as an educated person in today's age of information. Statistical citizenship may very well require high order statistical reasoning and thinking."*

This tension between the statistical competence needed by data producers or data users and the statistical citizenship (statistical literacy) needed by data consumers is argued to reflect an underlying tension within statistical education between those who are ministers and those who are evangelists.

3. EVANGELISTS VERSUS MINISTERS

Rowe (1946) noted that religion requires both evangelists and ministers: evangelists convert non-believers; ministers minister to believers. While statistics is certainly different from religion, both have believers and non-believers. Most students are unbelievers; they don't yet see the value of statistics in their lives. They are generally open to being persuaded, but they need to see the cash value of statistics in their everyday life. These students need statistical evangelists.

But all too many statistical educators are ministers, ministering to the needs of those who already believe – or who with a little information will believe – in the value of statistics. These ministers focus on preparing these believers for advanced study. These ministers may be good in getting some students to become statisticians, but they may be complete failures as evangelists in getting most students to appreciate the value of statistics in their everyday lives. Those statistical educators who teach majors or minors in mathematics or statistics, or who teach advanced courses in statistics should be good ministers. But those statistical educators who teach the introductory course to non-majors must be good evangelists. Their job is not to get students to take more statistics. As evangelists, their job is to help students have a more positive view on the value of statistics in their everyday life.

Statistical educators must focus on students needs based on their beliefs. Many students in majors that don't require a math course (e.g., the humanities) are statistical non-believers as are many in majors that require – but don't often use – math in the major (e.g., majors in management and marketing). Even majors that require and use math (e.g., majors in science, economics and finance) students may still be non-believers. In dealing with statistical non-believers, statistical educators should be evangelists that focus on statistical literacy; in dealing with statistical believers, statistical educators should be ministers who present both statistical literacy and statistical competence. Treating unbelievers as believers, focusing on statistical competence in place of statistical literacy, and being ministers rather than evangelists may be why all too many students say of statistics, "the worst course I ever had." It is unfortunate that statistics is a required course. Requiring students to take statistics means statistical educators are shielded from needing to sell students on the value of statistics.

4. SIGNS OF BIAS

Of ministers, it has been said that "*the greatest obstacle to rendering efficient service is self-centeredness, self-interest, or to use a plain, simple term, selfishness.*" Rowe (1946), p. 69. Similarly, statistical educators may be biased by their allegiance to – and focus on – statistical competence. The potential bias of statistical educators toward statistical competence may explain:

- their unwillingness to measure the change in student attitudes toward statistics. Macnaughton (2004) has argued that this must be a primary goal of the introductory statistics course. Schau (2002) found that students had a statistically-significant *decrease* in the value they saw in statistics after the course as compared to before.
- the omission of students' attitudes in assessment tools (e.g., ARTIST).
- the lack of data on what statistical knowledge is needed by educated data consumers.

- the lack of data concerning the effects of statistical education on their student's careers
- the failure of the ASA to count students unless they are taught in a math or statistics department.
- the focus on a negative (in observational studies association is not causation.) and the lack of focus on a positive (In observational studies, associations are contextual.) Schield (2004b) argued that this positive focus on context is what links statistical literacy to the liberal arts.
- the failure of statistical educators to teach students about confounding – a topic that is central to the disciplines of most students studying statistics, yet is conspicuously absent from most introductory textbooks and was not even listed as a candidate for the most important topics in statistics in a survey conducted at the 2005 Joint Statistical Meeting of the American Statistical Association.
- the failure of statistical educators to teach students that statistical significance (p-values) can change after taking into account other factors. Schield (2004a) argued this is malpractice.

Cobb and Gehlbach (2004) presented the results of using statistics as evidence in a court trial. Judge Posner agreed with George Cobb's argument that the results of statistical inference in observational studies was contentious and that in this particular case "*the statistical evidence should not be allowed at trial*." Should the same conclusion be reached whenever statistical inference is taught to students in majors that rely on observational studies—such as business, economics and sociology?

If statistical educators are to minister to the quantitative needs of students, they must be willing to self-reflect on any tension between the quantitative needs of the students and their desires as teachers. If statistical educators are to serve, they must focus first on the statistical needs of their students – as these appear in their everyday life of work and personal decision making as citizens and consumers.

In their zeal, some statistical educators try to be evangelists to nonbelievers and convert them to being statistically competent. These enthusiastic evangelists celebrate those few students they convert into taking another statistics course or even becoming statistics minors or majors. But they may be oblivious to the chance that their focus on statistical competence may have turned off a great number of unbelievers who needed more statistical literacy. In their zeal to promote statistical competence, they may be inadvertently creating statistical doubters or nay-sayers.

In religion it has been said, "*If a congregation goes to sleep during a preaching service, someone should go up and wake the preacher*." Rowe (1946, p. 62). The same might be said of statistical educators. If students become uninterested and bored – especially if they are good students – then someone should waken their teachers. The causes of failure in the ministry include "*Long, hard, dry sermons; Snobbishness; Preaching is tiring or paralyzing to hearers; Ignorance; Artificiality; Superficiality; Poor English; Inarticulateness; Trying to be smart; and Missed their calling.*" Rowe (1946, p. 58). How many of these might apply equally well to statistical educators? Waxing elegant for over half a semester (over 20 class hours) on the derivation, nature and consequences of the central limit theorem is more than most mathematics majors could take. Yet statisticians expect non-mathematical students to follow and even enjoy the full story from conditional probability and the binomial theorem to the normal sampling distribution and the chi-squared test.

Of a church it is said, "*Good publicity will help to build a church; bad publicity will injure it.*" Rowe (1946, p. 35). The same is true of statistical education. Yet statistical educators seem oblivious to the publicity their course generates. There is no plan to measure the problem, must less to fix it.

5. CONCLUSION AND RECOMMENDATIONS

Moore (1998b) noted that statistical educators have a tremendous opportunity to influence the vast majority of college students in their attitudes toward statistics. But as Ridgway et al (2004) noted, preparing students for citizenship imposes a duty on statistical educators. Statistical educators in introductory courses for non-majors must turn away from ministering to the needs of believers and become evangelists dedicated to converting non-believers. They must focus on statistical literacy rather than statistical competence. And in so doing, statistical educators may improve students' attitudes toward statistics. Instead of saying "worst course I ever took" they may say "I'd recommend that course to other students", if not, "I think that all students should take statistical literacy."

Effort is required to convert oneself from a minister teaching statistical competence into an evangelist teaching statistical literacy. (1) Study statistics in everyday life: See Schield (2004a) for the frequency with which various statistical concepts appear in various news sources. (2) Study arguments involving statistics in everyday life. In math and statistics, the answer is almost always a number – or is determined entirely by a number. But most everyday arguments do not have a number as

their conclusion – even if they use numbers as evidence. Numbers are more likely to serve as a premise than as a conclusion. Statistical evangelists must focus more on arguments using statistics as evidence. The birthday problem is not an everyday problem. (3) Study statistical studies. Statisticians study data for patterns and trends. Statistical evangelists study studies where the statistics are already summarized. This often means averages without ranges, standard deviations or effect sizes. Rather than curse the statistical darkness, evangelists must focus on what can be done with the material at hand. (4) Measure the effectiveness of your teaching in terms of the increased student appreciation for the value of statistics in everyday life. Focus on the Macnaughton (2004) goal: "*to develop in each student a lasting appreciation of the power and value of statistics*" in their everyday life.

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[1] A. T. Rowe is Milo Schield's maternal great grandfather.

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An Evangelical Calling

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ISI-55

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MINISTERS VS. EVANGELISTS

Ministers minister to believers;

Evangelists convert non-believers.

Believers may want (need) details:

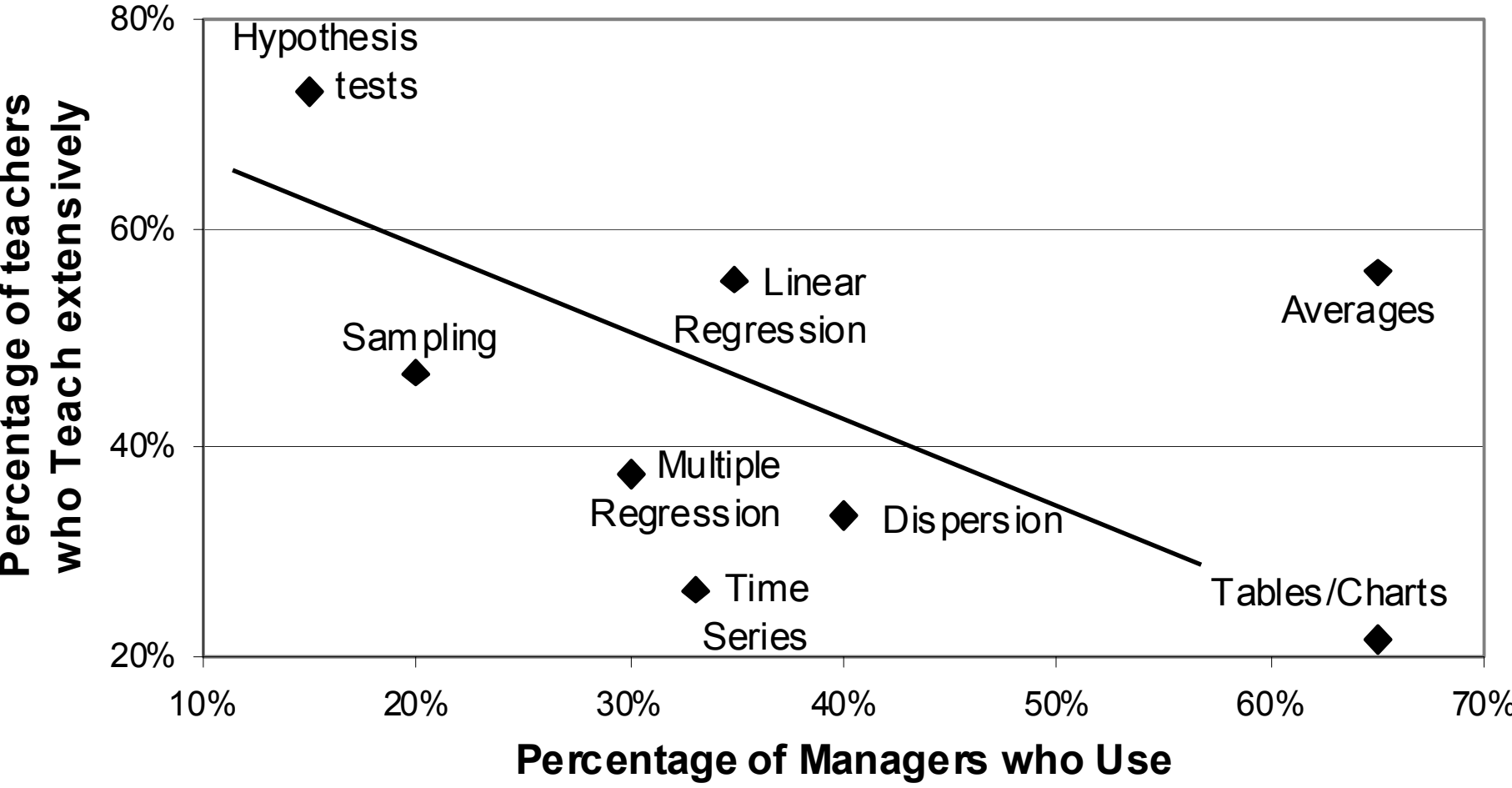
Conditional Probability, Binomial distribution, Normal approximation, Central Limit theorem, Sampling distributions, Statistical Inference.

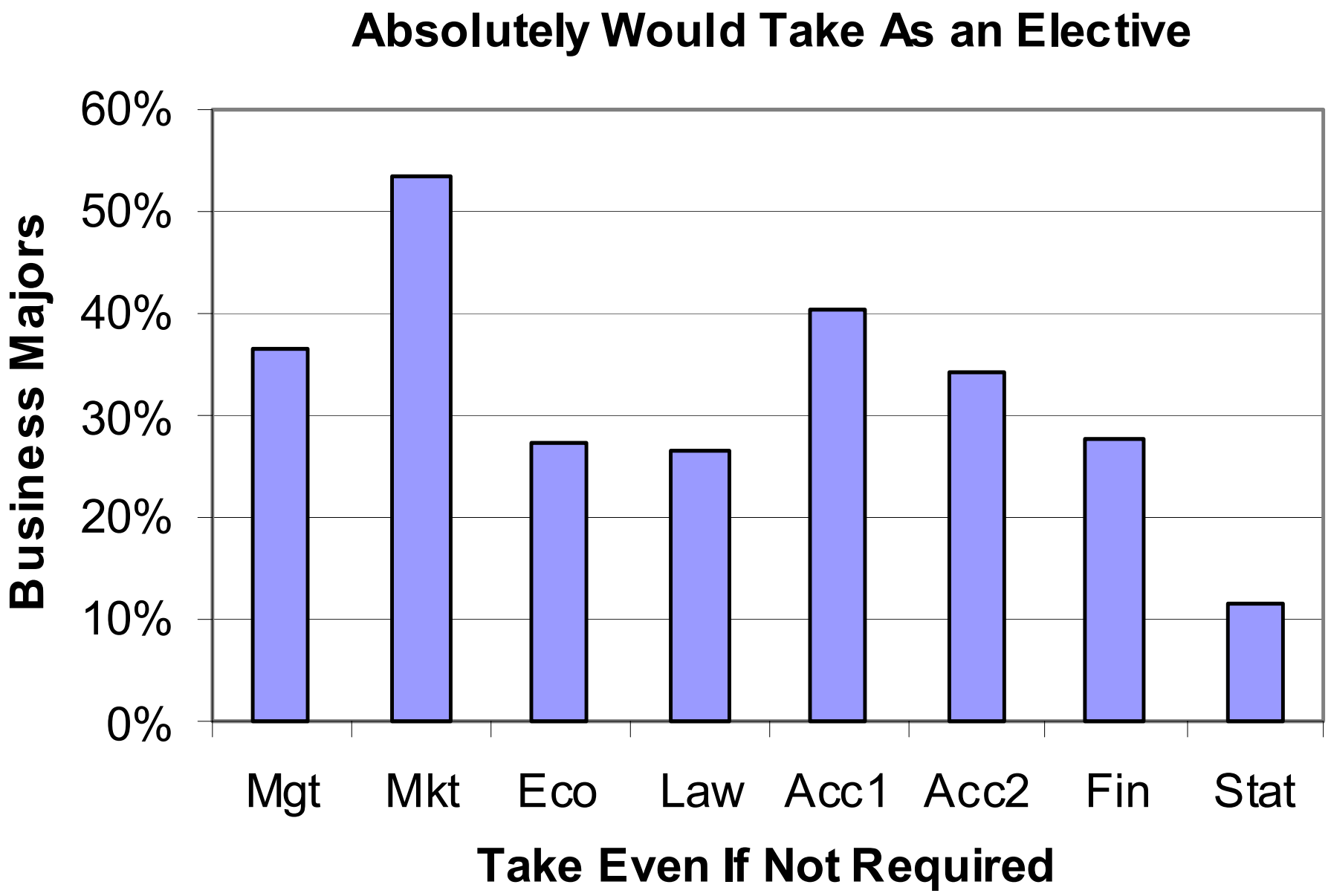
Non-believers need to see benefits:

If one can buy statistical significance, who cares?
How does confidence affect my decisions?

Statistics Topics in Business

Percentage who use vs. Emphasis if taught




Absolutely Would Take As an Elective
Business Majors
60%
50%
40%
30%
20%
10%
0%
Mgt
Mkt
Eco
Law
Acc1
Acc2
Fin
Stat
Take Even If Not Required

If the Congregation is Asleep

Business Majors	Attitude Toward Math		
MAJOR	ALL	Like	Dislike
ALL	**22%**	29%	16%
Acc, Fin, Econ	28%	**38%**	21%
Mgmt, Marktng	7%	12%	**0%**

Percentage who would Absolutely or Very Likely take Statistics as an Elective

If the Congregation has Very Good Reason to be Asleep

Study of education data, one confounder ,

- 117 instances of Simpson's Paradox.
- 50% of 117 had stat. sig. differences
- 10% of stat. sig. differences were reversed

Simpson's Paradox is not a rare anomaly.
Most students deal with observational data.
Yet few texts and fewer teachers teach students about Simpson's Paradox.

WAKE THE MINISTER!!!

Statistical educators:

- biased toward pedagogy: active stats, real data
- biased toward assessment
- biased away from examining content

No substantive change in content in 50 years.

No focus on modern topics (observational data):

- Epidemiology, public health, confounding
- Data Modeling and Data Mining.

Statistical Education
NEGATIVE FUTURE

Golden age for statistics – not for statisticians

Golden age for education involving statistics, but not for traditional statistics education.

Business majors say “Stats is least valuable class”

End of ‘Making Statistics Effective in Business’?

MBA schools not replacing statisticians with same

MAA has new modeling-based math program

PREDICTION: SYDNEY CONJECTURES

If statistical education does not change,

- Business will stop requiring it.

As a **percentage of all college grads**, traditional inferential statistics will be reduced from a class required by 60% in 2005,

- to a class required by 40% by 2020
- to a class required by 20% by 2040.

Statistics for Life
Statistical Literacy

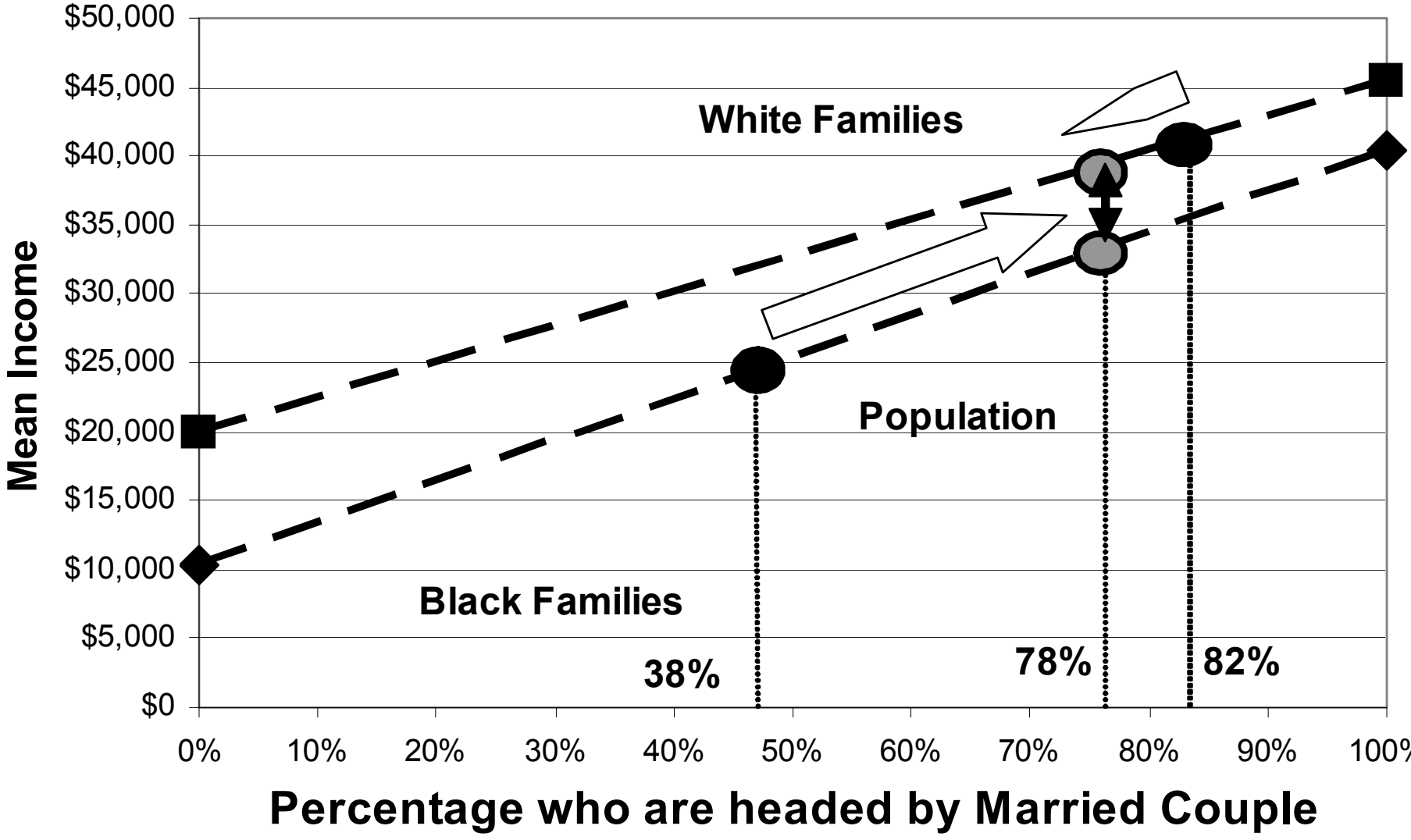
Conditional probability |Ordinary English

Widows are more likely than widowers

- among suicides
- to suicide

“100% Natural Cotton”

Income: US Families by Race & Structure



Recommendation: Statistical Literacy

Study statistics as used in **everyday** arguments

Students in introductory statistics need to see

- focus on observational studies & decisions
- statistics used in arguments about causation
- statistical prevarication & opportunism
- statistical significance and confounding

Opportunity to be of greater service.