Statistics Among the Liberal Arts

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The liberal arts are usually understood to be general and flexible modes of reasoning. By this definition, statistics qualifies as a liberal art, and it is important to the health of the discipline that it be recognized as such. The "philosophical" tradition of the liberal arts that is now dominant has alternated with an "oratorical" tradition that also gives insight, as do ideas of "evolutionary psychology." This paper considers how understanding statistics as a liberal art influences our appreciation of the discipline and especially our teaching of beginners.

INTRODUCTION

In pondering what I might say on this occasion, I sought wisdom from my friends, including Bob Hogg. Bob suggested that no one would notice if I simply repeated his address of a decade ago (Hogg 1989). In fact, I am going to return to one of the most common themes of past presidential addresses, though from a somewhat different perspective. ASA Presidents have repeatedly urged us to broaden our understanding of the field of statistics and the work of statisticians. Last year, Jon Kettenring (1997) called for "a more inclusive interpretation of statistics" and used the nice phrase "holistic statistics." Don Marquardt (1987) urged us to take "a wider view of ourselves." Barbara Bailar (1988) and Janet Norwood (1990), who have much to say about statistics as a guide to policy, stress the need to interact with those who use data to make decisions, and Vincent Barabba (1991) said much the same thing from an industrial perspective.

Most of these leaders naturally focused on the concerns of professional statisticians and the needs and prospects of the profession. I have in mind a less professional audience: the students who sit before us in the only statistics course they will ever endure. The numbers are large. The last CBMS survey (Loftsgaarden, Rung, and Watkins 1997) found that 115,000 students took an elementary statistics course during the fall semester in college mathematics and statistics departments. This number increased by 38% between 1990 and 1995. In 1998, only the second year in which the exam was offered, more than 16,000 students took the Advanced Placement statistics exam, doubling the count for the previous year. If we add the rest of the academic year and the large numbers who meet statistics outside mathematics and statistics departments, "hundreds of thousands" seems a safe characterization of the masses who each year pass through a first course in statistics.

For most of these students, their first course is their one and only formal exposure to statistics. We can hope that an intellectually stimulating introduction will attract bright people to our profession, but that is not my present concern. How we introduce statistics to beginners is both our best opportunity for public relations and one of our most serious public responsibilities. All the groups whose attention we seek—CEOs, Senators, news correspondents—sit before us in a still plastic state. What we offer them does or does not equip them to think about data, variation, and chance. It forms or deforms the image of statistics that they will carry with them permanently. The image I would like to form is that *statistics is one of the liberal arts*, that we offer broad and flexible modes of reasoning that make smart people smarter in every aspect of life and work.

This is no trivial matter for statisticians, whether or not they ever teach beginners. The failure of statistics to achieve wide recognition as an independent field is the most serious problem facing our discipline. Gerry Hahn and Roger Hoerl (1998) describe the current environment in industry as "statistics without statisticians," and much the same is true in academia. When "performing a statistical analysis is no longer a marketable task—anyone with a laptop can do that," what do statisticians have to offer the medical researcher or psychologist or engineer? That is the practical form of the question whether statistics is in fact a separate and fundamental discipline. Hahn and Hoerl give the answer in a slogan that should be a motto for introductory instruction: "shift from statistical methods to statistical thinking."

The theme of the 1998 Joint Statistical Meetings was "Statistics A Guide to Policy." That statistics *is* so often a guide to policy is testimony to the unusual prevalence of statistical issues in policy discussions. It is easy to think of policy questions to which (say) chemistry is relevant, and also easy to think of issues to which chemistry has nothing to contribute. I find it hard to think of policy questions, at least in domestic policy, that have no statistical component. The reason is of course that *reasoning about data, variation, and chance is a flexible and broadly applicable mode of thinking*. That is just what we most often mean by a liberal art.

Thinking of statistics as a liberal art has immediate implications for teaching, which even those who teach goal-oriented colleagues in industry might ponder. We too often

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ignore broad ideas in our rush to convey technical content. We spend too much time calculating and too little time discussing. In short, *we are too narrow.*

I am going to reflect a bit on the nature of the liberal arts and about what placing statistics among the liberal arts says about the nature of statistics. To do this, I will first look at what the liberal arts have traditionally meant, under the intriguing title "orators and philosophers." Then at what they might mean in a contemporary perspective based on speculation about "how the mind works." At each step I will make brief comments on how we look at our discipline, but I am not going to expand at length on these implications, for teaching or otherwise. I prefer to let you use your imagination to do your own expansion (and seek the elusive balance: we do have technical content to teach).

ORATORS AND PHILOSOPHERS

I characterized the liberal arts as "flexible and broadly applicable modes of thinking." Scientists, at least, tend to accept this characterization without much reflection. To quote a cognitive psychologist (Pinker 1997, p. 333), the liberal arts "are intellectual tools that can be applied in any realm." In fact, two quite different basic conceptions have alternated and combined in complex ways. The nature of these conceptions is nicely caught in the title of Bruce Kimball's book, *Orators and Philosophers* (Kimball 1995).

Both traditions originate in classical antiquity: think of Socrates and Cicero as their embodiments. The *philosophers*, like Socrates, are seekers after truth. In the philosophical tradition, the liberal arts encourage skeptical, analytical thinking, unconstrained by *a priori* standards. Any conclusions are subject to continuing challenge. Methods, not conclusions, are the core of liberal knowledge. Adherents of this tradition "search for a precise, rational method of pursuing knowledge, and tend to regard mathematics, logic, and natural science" as the heart of the liberal arts (Kimball 1995, p. xi). David Hume (quoted by Kimball, p. 125) put it bluntly:

> When we run over libraries, persuaded of these principles, what havoc must we make? If we take in our hand any volume, of divinity or school metaphysics, for instance; let us ask, *Does it contain any abstract reasoning concerning quantity or number*? No. *Does it contain any experimental reasoning concerning matter of fact and existence*? No. Commit it then to the flames; for it can contain nothing but sophistry and illusion.

The *orators* have quite different emphases. They think that the liberal arts equip free citizens to lead society. They are not, like the philosophers, essentially individualistic: the public good is never far from their thoughts. They believe that there are known truths and fixed standards of personal and civic virtue described in a body of canonical texts. Therefore, "the task of liberal education is to inform the student about the virtues rather than, as the Socratic tradition held, to teach the student how to search for them" (Kimball 1995, p. 38). The educational emphases of the oratorical tradition are nicely caught by the title of E. D. Hirsch's bestselling *Cultural Literacy: What Every American Needs to Know* (Hirsch 1988).

As the Hirsch reference suggests, the oratorical tradition now has a distinct "culturally conservative" ring. The philosophers have, for now, captured most educated opinion. Yet it would be a mistake to dismiss the orators. The two traditions have alternated in being generally accepted. In roughest form, the history goes like this. The pragmatic Romans adhered to the oratorical tradition, as did the early Middle Ages. Scholasticism and the rediscovery of Aristotle brought the philosophers to the front in the High Middle Ages. Renaissance and Reformation sought truth in classical models and in study of the Bible and the Fathers, restoring the orators to dominance. The Enlightenment was emphatically on the philosophical side, as Hume's blast suggests; but in the 19th century, education continued to stress the preparation of gentlemen by classical studies. It was only with the rise of research universities and the acceptance of scientific research as an intellectual paradigm that the the philosophical interpretation of the liberal arts as generally applicable intellectual methods came to be seen as obviously true.

Philosophers and statisticians

I take it for granted that statisticians (though often not others) can see at once how statistics fits into the philosophical tradition of the liberal arts. Statistics is a *general* intellectual method that applies wherever data, variation, and chance appear. It is a *fundamental* method because data, variation, and chance are omnipresent in modern life. It is an *independent* discipline with its own core ideas rather than, for example, a branch of mathematics. I have argued this last point at length in Moore (1988). For comments emphasizing teaching and aimed at mathematicians, see Cobb and Moore (1997).

Although I leave to your imagination the full argument that statistics offers general, fundamental, and independent ways of thinking, I must at least hint that the argument has an empirical component. Both statisticians (show me data) and liberally educated people (courtesy of Freud and Marx) are wary of arguments from principle. Here is some empirical evidence that statistical reasoning is a distinct intellectual skill. Nisbett et al. (1987) gave a a test of everyday, plain-language, reasoning about data and chance to a group of graduate students from several disciplines at the beginning of their studies and again after two years. Initial differences among the disciplines were small. Two years of psychology, with statistics required, increased scores by almost 70%, while studying chemistry helped not at all. Law students showed an improvement of around 10%, and medical students slightly more than 20%. The study of chemistry or law may train the mind, but does not strengthen its statistical component.

Both the past and the present are of course messier than Kimball's dichotomy suggests. In the Renaissance and the nineteenth century, for example, distinct philosophical elements mixed with the prevailing oratorical tradition.

Similarly, the contemporary victory of the philosophers is not complete. To give an example relevant to teaching statistics, the school mathematics curriculum in the United States has been steadfastly "oratorical." Students are asked to learn facts and techniques and to drill endlessly on their immediate application. Reformers would like a more philosophical tone that emphasizes flexible ability to formulate and attack open-ended problems, and the influential *Standards* of the National Council of Teachers of Mathematics (NCTM 1989) reflected the reform position. As states began to adopt reform-minded standards, a backlash set in that at least in California is aptly described as "the math wars." Traditionalists claim that the new curricula undermine students' ability to calculate automatically and shorten the list of mathematical facts that they know. Reformers claim that traditionalists want to train students merely to compete with calculators on the calculators' home turf. (Civil comments from both sides appear in Wu 1997 and Kilpatrick 1997.)

Statisticians have an interest in this conflict of traditions because teaching data analysis as a core strand in school math is part of the reform program. Working with data gives a context to mathematical exercises that would otherwise be abstract and is a rich setting for problem-solving and group work. The "philosophical" orientation of the movement to reform school mathematics fits the nature of contemporary statistics. It reflects at an appropriately lower level of sophistication our emphases on exploring data, scientific inference, and collaboration with other disciplines.

An aside: Francis Bacon, Thomas Bayes, and John Tukey

Speaking of philosophy: When I mentioned the title of this talk to Bill Cleveland, asking about perception, he made this comment: "Another connection with the liberal arts is philosophy. There is, of course, much philosophical thought about learning from experience, that is, inductive inference. It is relevant to the foundations of statistics." He cited some Bayesian literature.

I am not embarrassed to have ignored this aspect of my topic. Like most statisticians, I remain eclectic, respecting Bayesian approaches as sometimes useful but unconvinced by claims of universal hegemony based on first principles. Moore (1997a) and the other papers and discussion in that collection debate the place of Bayesian ideas in introducing beginners to statistical thinking. This discussion is directly relevant to planning the "one and only" statistics course, but I don't wish to revisit the controversy here.

I will note that both Bayesians and data analysts, in quite different ways, claim to have an operational approach to the thorny problem of inductive inference. Both consider background information, data analysts by an intuitive sensitivity to context and Bayesians by a mathematical model. Paul Velleman (1997) cleverly shows how closely John Tukey's guiding strategies for data analysis parallel Francis Bacon's seminal thinking about induction as scientific method. His extensive selection of aphorisms from Tukey summarizes, in my opinion, statisticians' best thinking on inductive reasoning. The recurring sections titled "Visualization and Probabilistic Inference" in Cleveland (1993) suggest that he prefers intuitive inductive reasoning of the Tukey variety to more precise but less comprehensive mathematical formulations of induction. Intuition and formalism have obvious relative strengths and weaknesses. (Once again, use your imagination.) For our present purpose, we can consider Bayesian ideas as firmly in the philosophical tradition of the liberal arts, and data analysis as having affinities with the orators in ways that I will now describe.

Orators and statisticians

Statistical thinking fits neatly into the philosophers' paradigm. Yet statistics considered as a liberal art also shares aspects of the oratorical tradition. Exactly because data, variation, and chance are so widely present in modern societies, statistical thinking has the same "preparation for citizenship" value that training in public speaking had in Cicero's Rome.

It is also true that statistics is best taught and learned in ways that mirror the older pattern. One of the most important principles for teaching statistics is *the value of good examples*. Working with data is an art as well as a science. We learn it not simply by mastering formal methods but by following examples set by our current teachers and by past masters. In this, learning statistics is like learning to perform music, another subject in which students develop practical wisdom and critical evaluation through context and example. Musicians play Bach, and statisticians reexamine classic data sets posed by masters. We return, for example, to Fisher's iris data, and sometimes (as in Cleveland 1993, pp. 298–301) improve on the master's work. Most of us have met the "stack loss" data, apparently first discussed by Brownlee (1965) and rendered canonical by the lengthy analysis in Daniel and Wood (1971). The "motorcycle crash test" data (e.g., Hardle 1990) are attaining the same canonical status in nonparametric regression.

We learn in this way because technique alone does not make an outstanding statistician any more than an outstanding musician. *Interpretation* in the specific context is always important. So is what Colin Mallows in his Fisher Lecture (Mallows 1998) called *the zeroth problem*: "Considering the relevance of the observed data, and other data that might be observed, to the substantive problem."

Even settling the substantive problem is not always the end of the matter. The impetus for the theme "Statistics A Guide to Policy" was a remark of Fred Mosteller in an interview in the first issue of the *Journal of Statistics Education* (Moore 1993):

> Usually people think (and many statisticians tend to think) that once good data are available, then the answer to the policy question is at hand. But that usually is not true, because policy implies politics, and politics implies controversy, and the same data that some people use to support a policy are used by others to oppose it. So it's very difficult to handle policy questions, but nevertheless data do help the debate.

The mention of politics recalls the oratorical tradition's emphasis on the public good. That tradition also stresses *generally accepted standards*. Statisticians involved in policy issues or under pressure from funders or employers need standards as guides and as protection. I invite you to study the "Ethical Guidelines for Statistical Practice" prepared by ASA's Committee on Professional Ethics.

These brief remarks make it clear that the philosophical tradition is incomplete. All real science has aspects of the oratorical tradition as well. But I suggest that statisticians stand out—we worry about context, interpretation, and policy implications more regularly and more intensely than do chemists and mathematicians. We are perhaps either "more liberal" or "more an art." We are certainly, in Kimball's sense, more oratorical.

HOW THE MIND WORKS

The oratorical tradition insists that the liberal arts are *civilized* ways of thinking that prepare citizens to participate in society. None of these arts are much help when you are lost and hungry or confronting an armed man intent on doing you harm. Perhaps the currently fashionable topic of evolutionary psychology can help us understand this.

The mind, say the evolutionary psychologists, is a collection of organs of computation, organs adapted for reproductive success in the African savannas in which we humans spent most of our evolutionary history. As Edward O. Wilson puts it (Wilson 1998, p. 96), "the brain is a machine assembled to survive." Wilson notes that cognitive neuroscience is in its "heroic" or "romantic" period, which I take to mean that its ideas are tentative and speculative. Nonetheless, they are intriguing. This view of mind suggests that *the liberal arts are those modes of reasoning needed in civilized society that are not innate because they had no survival value on the savanna.* I like this formulation. It is a more specific form of the prevailing philosophical definition that draws some insight from the orators. And it emphasizes that these ways of thinking must be learned. This will eventually lead us back to those hundreds of thousands of students.

An example: perceiving predators and perceiving graphs

Consider an example: perception. Cognitive scientists have considered perception at length, partly because they would like to program robots better. Attempts to program artificial perception have led to deep respect for the complexity and subtlety of the perceptual computations that we humans need never think about because we come equipped with them. Steven Pinker, from whom I borrowed the title "How the Mind Works," gives a summary (1997, Chapter 4). A camera, says Pinker, records the world as it is. So photographs taken in low light display a reddish tinge. The human mind compensates, so that we see "normal" colors. The camera finds it hard to distinguish a snowball in a dim room from a lump of coal in sunlight, but the human mind analyzes subtle hints to make the distinction at once. We need no formal training to "see" three dimensions when we process the two-dimensional images on our retinas.

We are good at perception because perceiving the predator in the brush helped our ancestors stay alive. How good are we at reading graphs? Because graphs are the most effective way to present data, statisticians are interested in our perception of data graphics. Cleveland (1985, Chapter 4) distinguishes our immediate perception of patterns, which is made "effortlessly and almost instantaneously" and varies little among individuals, from the complex cognitive task of interpreting these patterns, which is presumably a learned skill. Our innate perceptual algorithms are not designed to decode data graphics, for the obvious reason that there were none on the savanna. Judging the strength of a linear relationship from a scatterplot seems less subtle than Pinker's description of the coal-snowball problem, yet we are easily misled by so simple a change as increasing the white space around the scatterplot. See Figure 1 and, for a careful study, Cleveland et al. (1982).

We need no formal study to distinguish coal from snowballs in almost any light. We *do* need to learn to decode data graphics. Cleveland and others study how to make graphs that better fit our perceptual apparatus, and teachers of basic statistics know that students are no more born able to read graphs than to read words. That even quite basic statistical reasoning must be learned is part of the nature of the liberal arts as civilized arts.

Figure 1. Two scatterplots of the same data. The linear pattern appears stronger in the lower plot because of the surrounding white space.

Statistical thinking is unnatural

What is true of perception is also true of conceptual thinking: our thought processes are shaped by an environment very different from those we now inhabit, so that we are subject to illusions that can be overcome only by targeted learning. Many statisticians can testify from experience that intellectually sophisticated people are not automatically adept at statistical thinking. Reading statistical graphs is elementary compared with thinking about probability and causality. Tversky and Kahneman (e.g., 1983) have made us all aware that intuitive probability often does not conform to the laws of mathematical probability. Gilovich (1991) is an excellent and charming survey. Velleman notes that Francis Bacon already remarked on the human tendency to construct an order that need not actually exist, so that science must constantly critique our natural thought processes.

That critique in turn invites critical study. Intuitive probability may often be inaccurate in our present environments, but it is intuitive for good reasons. Responding to Tversky and Kahneman, other psychologists noted that long series of independent trials rarely occur outside the casino, and that intuitive probability often makes sense in less artificial environments. Pinker gives an example that I will use to illustrate the fact that even the most basic aspects of "statistical literacy" require the regularity of a civilized environment.

High on my list of elements of statistical thinking is the claim that *data beat anecdotes*. This is surely a learned principle, and one much neglected by public opinion. Recently, a five-year, $5 million epidemiological study concluded that there is no association between low-level electromotive fields (i.e., living near power lines) and childhood leukemia (Taubes 1997). The editorial in the *New England Journal of Medicine* that accompanied the study report thundered that "It is time to stop wasting our research resources on this question." Compare the impact of this study with that of one television appearance by an articulate mother whose child has leukemia and who happens to live near a power line. The anecdote wins every time. We grit our teeth and try yet harder to convince our students of the virtues of data from well-designed studies.

"Data beat anecdotes" is a good principle. But here is Pinker's example, originally by Gerd Gigerenzer. You live in a village near a river where no crocodile attacks have occurred for years. You hear that a neighbor's child was eaten by a croc there this morning. Would you let your child play in the water? Pinker (p. 351) concludes that, "The person in the street who gives a recent anecdote greater weight than a ream of statistics is not necessarily being irrational."

My conclusion is a bit different. The anecdotes statisticians have in mind (the articulate mother on TV) have much less value as data than a body chewed by a crocodile, yet they easily sway our thinking. Our minds are configured to give undue weight to anecdotes because of the crocodiles in our evolutionary history.

Compare the crocodile and the epidemiological study. It seems clear that the usefulness of statistical reasoning depends on *regularities* in the problem studied and on artificial regularities that we commonly create in designing data production. This is a matter of some subtlety. Art Dempster remarked that repetition is at the heart of these regularities, but this is not the whole story. That we statisticians have become comfortable with statistical reasoning does not make it more natural or less dependent on an environment to which evolution has not adapted us. How much we pass over, to our students' confusion, as we race through a first course.

STATISTICAL THINKING, STATISTICAL TEACHING

Statistical thinking is a general, fundamental, and independent mode of reasoning about data, variation, and chance. Effective use of statistical reasoning requires considering the zeroth problem and interpretation of formal results in the context of a specific setting. Statistical thinking is an artifact of civilization, not part of our natural neural equipment. It is learned in part from well-chosen examples rather than entirely from general theorems. All this fits the description of statistics as a liberal art. All of it has implications for our teaching. None of it is new to thoughtful statisticians.

What may be news to many statisticians, especially nonacademics, is that we academics are doing better than in the past. Compared with a generation ago, beginning instruction is now more likely to emphasize working with data, the design of data production, and the reasoning and limitations of formal inference. That is, current thinking in statistical education is consistent with the view of statistics as a liberal art. This is not because teachers have been persuaded by rhetoric. The pressures that changed our first courses are more concrete: technology has forced us to focus on what isn't automated; introductory instruction has gradually followed trends in research away from mathematics alone back to data and interdisciplinary work; and insights from research in education (see Garfield 1995) have influenced our classroom behavior. Whatever the driving forces, the result is teaching and learning that gives more attention to big ideas and general strategies for dealing with data, variation, and chance.

Richard Scheaffer, whom I am willing to take as an authority, says (in his discussion of Moore 1997b), "With regard to the content of an introductory statistics course, statisticians are in closer agreement today than at any previous time in my career." At a time when we must defend the independence and importance of our discipline, we are fortunate to have reached general agreement. Compare the fractured state of historians—a recent forum on teaching American history (Cronon *et al.* 1998) shows very little agreement on the relative role of facts versus structures (orators versus philosophers again) or anything else.

You can see the elements of our agreement in a report (Cobb 1992) in which ASA's joint committee with the Mathematical Association of America lay down recommendations for any first course in statistics. A summary (Figure 2) has been adopted by the ASA Board of Directors. That summary repays careful reading. Note in particular its insistence that beginning instruction should present core statistical ideas (the importance of data, the

1. **Emphasize the elements of statistical thinking:**
   (a) the need for data,
   (b) the importance of data production,
   (c) the omnipresence of variability,
   (d) the measuring and modeling of variability.
2. **Incorporate more data and concepts, fewer recipes and derivations**. Wherever possible, automate computations and graphics. An introductory course should:
   (a) rely heavily on *real* (not merely realistic) data,
   (b) emphasize *statistical* concepts, e.g., causation vs. association, experimental vs. observational and longitudinal vs. cross-sectional studies,
   (c) rely on computers rather than computational recipes,
   (d) treat formal derivations as secondary in importance.
3. **Foster active learning**, through the following alternatives to lecturing:
   (a) group problem solving and discussion,
   (b) laboratory exercises,
   (c) demonstrations based on class-generated data
   (d) written and oral presentations,
   (e) projects, either group or individual.

Figure 2. *Recommendations of the ASA/MAA Joint Curriculum Committee for first courses in statistics.*

omnipresence of variation, observation versus experiment) that can rightly be described as broadly applicable intellectual tools.

Don't stop here

There is much to be said about how we can build statistical thinking in those hundreds of thousands of people who pass through a one and only statistics course or through the equivalent in corporate training. Trusting again in your imagination, I will say just one big thing: *We are still too narrow.*

Our teaching has moved in the right direction. Yet we still often take big ideas for granted in our rush to present technical material. We less often commit the mortal sin of omitting the distinction between observation and experiment. But venial sins remain: we give scant time to building by experience broader aspects of statistical reasoning such as these:

- Data beat anecdotes.
- Is this the right question?
- Does the answer make sense?
- Can you read a graph?
- Do you have filters for quantitative nonsense?

Any thoughtful statistician can recall examples that demonstrate that though these are not technical issues, they are also not trivial. Thinking of statistics as a liberal art helps us balance our essential technical expertise with the will to expand on it rather than be limited by it.

A corollary is that *the first course in statistics is not primarily intended to develop statisticians*. I am not sure that this corollary is part of the consensus Dick Scheafer identifies. Although we all agree on the move toward "real data and reasoning about real problems" in beginning instruction, it may be that "developing tomorrow's statisticians" remains the priority of some thoughtful people, even in a first course. Indeed, I borrow that phrase from a paper by Rex Bryce (1998), though I read him as primarily concerned with programs rather than with the one and only course. Bryce and those whom he cites (Box, Hunter, Marquardt, Snee, ...) urge the broadening of statistics programs to include preparation for employment in such areas as team, collaboration, and communications skills. Hahn and Hoerl (1998) repeat the same message in describing what business and industry require of statisticians. They are surely right, and some of this fits new pedagogical techniques that are appropriate even in a first course. I remain convinced, however, that the one and only statistics course is too broad an opportunity ("hundreds of thousands") to focus on primarily professional ends.

SO WHAT?

Why does all this matter to the working statistician? Because the future prosperity of our discipline depends on our willingness to take the broad view that "statistics among the liberal arts" suggests. The liberal arts image is deliberately non-professional. I have chosen it in part to emphasize the importance of what we present when we teach the hundreds of thousands of students who pass through that one and only statistics course, but it has a wider message.

We ask, for example, whether statistics will be overwhelmed by technology, so that we become a minor branch of information science. Quite possibly, if we restrict ourselves to addressing only technical issues. If we are simply nerds, we are the wrong kind. The point of considering statistics as a liberal art is to remind ourselves that we need not be simply nerds. One of the clearest lessons from attempts to apply technology to teaching and learning (Ehrmann 1995), and one that applies more generally, is this: If you use technology to simply carry the same old thing, you get the same old results. To get different results, you must add new thinking to new technology. The reason: *Technology empowers. But thinking enables.*

The liberal arts image emphasizes that statistics involves thinking. It is because statistics involves distinctive and powerful ways of thinking that we will not be swallowed up by information technology. The computing/communication revolution presents everyone with very large masses of very disordered information. Statistical thinking offers simple but non-intuitive mental tools for trimming the mass, ordering the disorder, separating sense from nonsense, selecting the relevant few from the irrelevant many. What is more, any revolution implies that we face *new* problems. New problems require general and flexible modes of reasoning. As Bob Hogg put it in the address I did not replay, statistics is a guide to the unknown. Statistics as a liberal art is in the longer run the most useful and most practical form our discipline takes.

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