QUALITY, STATISTICIANS, AND UNIVERSITIES

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It is a pleasure to salute Don Owen by commenting on Bob Hogg's remarks. I will roughly follow the outline of Bob's paper, attempting to focus on the reactions and responsibilities of university statisticians, especially in applying quality management principles to our own activities and our own organizations. The claims of statisticians to contribute to the quality movement (perhaps even as general experts on scientific method, as Brian Joiner and others suggest) would be a good deal stronger if we offered convincing evidence that we could do more than talk about quality. My views have been shaped by studying, teaching, and trying to apply the usual technical material and some of the usual background (especially Deming), and also by a week at Motorola under the auspices of the University Challenge Program.

Background and Tools

Bob begins by listing "a few key points" essential to any quality operation. He wisely stresses the need for balance in our application of principles. He then surveys first data-analytic and then management tools for quality.

From the point of view of a statistics teacher, I would like to see *base decisions on data* elevated to a "key point," rather than hidden under "the scientific method." I would be even happier if *reduce unplanned variation* appeared explicitly when we are talking about efficiency and reducing waste. Both points are implicit in Bob's discussion, but I think he is too modest about the role of essentially statistical (though not necessarily technical) ideas in improving quality. If we statisticians have any claim to contribute to the "managerial" or even "strategic" levels of activity, rather than simply to the "operational" level (the language comes from Snee 1990), that claim rests on the omnipresence of variation and the central role of data.

A consistent emphasis on producing, displaying, and using data was one of the messages driven home at Motorola. Behind the counter at any Motorola service center are graphs of cycle times and measures of process quality, with trend lines and targets. Statisticians know that data beat anecdotal impressions for all serious purposes, even when the data are themselves imperfect. Let's say so. Once we are measuring interesting outcomes, we can strive to reduce unplanned variation. This leads at once to the distinction between common causes and special causes, a simple but powerful idea that every manager should understand.

What about tools? The version of the Magnificent Seven that Bob gives focuses on tools for dealing with data and variation (so we know that his heart is pure). He is quite right to insert flow charts. Flow charts and cause-and-effect diagrams stand a bit apart as process description and brainstorming tools, but they help guide the wise production of data, so let them stand as data-analytic tools. The list isn't high-tech. It adds weight to Bob's advice to us: KISS. He then says he prefers CUSUMS to Shewhart charts with runs criteria, however. That raises an issue that has no global resolution: how much weight should we give to comprehensibility relative to technical efficiency? CUSUMS are, in real settings, incomprehensible magic programmed into the local computer.

Having questioned CUSUMS, I do want to put in a word on behalf of design of experiments. Not 2^{7-4} designs of resolution III, you understand, but the ideas of experiment rather

than observation and of randomized comparative experiments rather than uncontrolled trials. These ideas are too important to be relegated to the "other 1 percent" that constitute our professional specialty rather than the common heritage of everyone concerned about quality.

I will also demur a bit about the Seven Management Tools. The (data-analytic) Magnificent Seven are magnificent because they help implement a consistent philosophy of understanding processes using data and reducing variation. What consistent management philosophy does the grab-bag of charts and diagrams called the Seven Management Tools implement?

A Role for Statisticians: What We Teach

Bob Hogg has hopes that statisticians will "become leaders" who "can help solve major problems." Some statisticians have certainly done so. For example, a list of the major problems which Fred Mosteller has addressed would be long indeed. I mention Fred Mosteller as a reminder that "quality scientist" at best describes one class of statisticians who address one class of problems. The reach of statistics, and the proper aims of statistical education, are much broader than impact on quality improvement. It would bother me if our educational programs did not give every student of statistics an opportunity to learn about control charts and to ponder the wisdom of Deming and Taguchi. It does not bother me that some students choose other directions within so rich a field. It would be a serious mistake to retool graduate programs to serve just one of our many customer groups.

That said, I agree that all statistics graduate students need experience in cross-disciplinary team collaboration and in written and oral communication in a cross-disciplinary setting. The nature of statistics in practice demands these skills, and I do not believe that even the most academic-minded of our students should be allowed to escape contact with practice. The clearest message that Motorola had for the academics assembled for the Motorola/Purdue University Challenge was: "All of our work is done cooperatively in teams. Why do you keep sending us students all of whose experience is competitive and individual?" Government bureaus and medical research centers would say the same. Collaboration and communication, unlike Taguchi and CUSUMs, are central to our broad discipline.

Because all strong graduate programs in statistics offer training and supervised experience in statistical consulting, we have at least made a start in the right direction. We should surely increase the emphasis on collaboration and communication throughout graduate course work. The research that underlies the current movement to reform teaching in the mathematical sciences (e.g., Garfield 1995) gives good reason to think that more teamwork and more emphasis on communicating findings would improve students' learning as well as respond to customer requests.

Bob Hogg suggests a one-semester course in QI. His outline includes much material already present in the technical courses offered by most graduate programs, so let me suggest an alternative: an *interdisciplinary* seminar on QM principles in which (I hope) statistics students will be outnumbered by students of both engineering and management. Reflection

on the messages of the quality gurus should certainly be on the agenda, for the gurus offer both much sense and some nonsense. When they move to industry, our students will meet disciples of the gurus who don't distinguish sense from nonsense. They will also meet sectarian controversies turning on minuscule points of vocabulary and doctrine. Let me give a few cautionary examples.

Bob Hogg quite rightly mentioned "zero defects" as a principle needing balance in its application. Here, in contrast, is Philip Crosby in a very public forum (Crosby 1995):

> TQM is a collection of undefined, unrelated activities conducted by committees and teams. It has good intentions, but no philosophy. By contrast, quality management has a clear philosophy and is practised by thousands of companies around the world, at virtually no expense, with dramatic results. The concept is straightforward: its aim is to achieve zero defects in all of a firm's activities.

Pity the naive student who leaves Iowa thinking that TQM is a safe acronym and that zero defects ought to be subject to a cost-benefit analysis, and who then falls into a shop of disciples of Crosby.

"Eliminate work standards and numerical quotas." No doubt you recognize one of Deming's 14 points. Why then does Motorola chart cycle times and quality measures everywhere, and everywhere add specific targets to the charts? "Deming is wrong." That's a quote from Motorola, said openly during the University Challenge program. "Deming is wrong" is a bit abrupt. Deming was demanding change in an certain type of organizational culture. Motorola has successfully put in place a very different culture. As with zero defects, we need balance and a sense of context, both weak points of gurus.

In the next section I will list some principles of quality management chosen to fit a familiar and particularly low-quality environment: university teaching. One of these principles is "work in teams." When I listed these principles in a recent talk, an audience member responded that "Dr. Deming doesn't approve of teams." This isn't true (see his discussion of breaking down barriers), but it illustrates the power of gurus over the minds of disciples. The context of my list is a faculty culture whose weakest point is an anarchic individualism. Working in teams is a proven approach (Motorola; research on learning) that addresses that cultural weakness. It ought not to matter whether Deming approves. I will keep silent about the iniquitous consequences of Deming's emphasis on the distinction between analytic and enumerative studies, lest I really get into trouble with his disciples.

The point is not that Deming, Crosby, Taguchi, and others have nothing to offer. They do. I trust that we have all tried to absorb and apply the eminent good sense of the leading gurus, especially Deming. The point is that universities are places to reflect, discuss, and analyze as well as to absorb and apply. Let's keep that in mind in planning what we teach.

A Role for Statisticians: What We Do

University statisticians are professors (of statistics or of some lesser discipline, such as mathematics). As such, they rule their academic departments. Within very loose constraints set

by deans and the like, faculty have strategic *and* managerial *and* operational responsibility for, for example, the teaching of their discipline. Because a cohesive group of people well-informed about the principles and tools of quality management have near-total control, our teaching processes must be shining exemplars of reduction of unplanned variation, continuous improvement, ... OK, stop laughing. This is a serious question: Why don't we apply the principles of quality management to our own central activities?

The answer, alas, is that we are comfortable beneficiaries of an internal culture that discourages application of *any* management tools. As the author of a recent book on *How to Teach Mathematics*, published by the American Mathematical Society, puts it (Krantz 1993):

> The truth is that, as a college teacher, you *are* an autocrat and a monarch and can do pretty much as you please. But there is no need to flaunt this before your students.

The idea of *managing* the activities of faculty, who are autocrats and monarchs, is almost unthinkable. We may teach that unplanned variation is the enemy of quality, but we take few actions to ensure that students who sign up for the same course really receive the same course across instructors and across semesters. We enjoy being craftworkers, who insist on the superiority of individual products little constrained by requirements of uniformity. Individual creative expression, whether in a piece of furniture or in a classroom, does have its merits. It is hard not to agree, however, that the individualism of faculty culture is on the whole harmful to teaching. My section fits into a course with many sections, and that course fits into programs of study with specific goals. My creative ideas for content and presentation must be shaped by the larger whole. That is, I am part of a system which must be managed, even when the traditional style is "management by neglect."

I have participated in several discussions of the application of quality management ideas to teaching, and have found faculty to be almost unanimously, and often virulently, hostile. The hostility is directed not so much at specific notions (e.g., students as customers) as at the idea of being managed at all. Specific notions from quality management certainly do require analysis and modification when applied to higher education, as they do in any new setting. This process is well underway. See, for example, the helpful discussion of "customer" in Wild (1995). We shall soon have to put aside our hostility and participate in the discussion, because the external pressures on higher education are growing too strong to resist. We will be required to show both improved results and greater efficiency in our teaching. Because quality management aims to improve both quality and productivity, its use in higher education is inevitable. As Bob and Mary Hogg document (Hogg and Hogg 1995), quality tools are being widely adopted in the nonacademic areas of universities and pressure is building to apply them to teaching.

Let me simply suggest that some of the core principles of quality management are very helpful to teachers. The paired papers by Hogg and Hogg (1995) and Wild (1995) offer a starting point for further discussion. Here is a selection of quality management principles selected for applicability to improving university teaching:

- Customer focus: Ask what groups our teaching serves, and actively consult them. Stop insisting that we, the content experts, always know best.
- System orientation: My teaching doesn't occur in isolation; examine and optimize the larger systems of courses, programs of study, training and evaluation of instructors, management of laboratories, ...
- Continuous improvement: Institutionalize improvements, so that your very successful revision of a course isn't undone as soon as you change assignments.
- Work in teams: Admit that cooperative effort toward improving teaching will often surpass the work of even a brilliant individual; begin to reform the anarchic individualism of faculty.
- Base decisions on data: Here's a simple example. What percent of students drop each of our courses? *Why* do they drop? Don't know? After the first weeks, a student must obtain a signature to drop a course: hand them a short list of reasons for dropping and ask them to check all that apply. I find it shocking that statisticians make so little effort to gather and use data about their teaching.

As Bob Hogg says "there are great opportunities for quality improvement in organizations, and that includes universities too (or should I say *especially universities*)." When faculty realize that blanket rejection is no longer possible, they will begin serious consideration of these opportunities. Will we statisticians, on our own turf, show ourselves to be quality scientists who can effectively lead our colleagues in a reconsideration of our own work?

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