

## THE CRAFT OF TEACHING

DAVID S. MOORE\*

*Remarks on receiving the MAA's 1994 Award for Distinguished College or University Teaching of Mathematics, San Francisco, California, January 1995. MAA Focus 15 (1995) Number 2, 5-8*

In thinking about what I might offer on this occasion, I re-read the remarks of my illustrious predecessors Alan Tucker and J. J. Price (Price 1994, Tucker 1994). I can hardly surpass Alan Tucker's account of "The Joy of Teaching," enriched by his father's experiences as well as his own. My colleague J. J. Price also mentions his father, and I can hardly surpass his enthusiasm and his mix of good advice and instructive anecdotes.

So, at the risk of dishonoring my father—yes, he too was a teacher, and so was my mother—I will offer remarks on a different theme. The theme is announced by my title: *teaching is a craft*. I also note that I found nothing to disagree with in Alan and J. J.'s comments on teaching. Nothing tunes the neurons like a little disagreement, so I'm going to say some things you may disagree with. In fact, since there is no time for nuance, I'll be deliberately provocative and say some things that you *will* disagree with.

**Teaching as a craft.** Some teachers may have charisma. Not I. My image of a sound teacher is that of a skilled craftworker, a master machinist say, who knows exactly what she must do, brings the tools she needs, does the work with straightforward competence, and takes pleasure in a job well done. She does her work right every day, and every day's work fits the larger plan of her project. The craftworker's skill is quite separate from her enthusiasm on that particular day, which, as C. S. Lewis said in another context, depends more on the state of our digestion than on any more cosmic influence.

*A craft is a collection of learned skills accompanied by experienced judgment.* The great advantage of thinking of teaching as a craft is the recognition that anyone can learn it. Competent teaching requires no special gift, no actor's personality, no divine spark. And if anyone can learn to be a competent teacher, then all who are employed to teach have the obligation to learn. That seems a mild and obvious deduction. It has, however, been denied, in practice if not in words, by the faculty culture of research universities. That culture is now under intense pressure, and will surely change. Requiring that teachers reach at least the journeyman level in the craft of teaching is a change that is already in progress.

Here's a less controversial deduction from the fact that teaching is a craft: *good teaching is based on the teacher's learning*. We teach in large measure because we love learning.

"Learning" naturally means first of all learning our subject. Statistics, which is my subject, is connected with a large body of nonacademic professional practice. The continuing revolution in computing has transformed the practice of statistics in the generation since

---

\*David S. Moore is Professor of Statistics at Purdue University.

I left graduate school. A bit more slowly, our standards of what constitutes interesting research have also changed. More slowly yet, the content of introductory instruction has changed. It is fair to say that statistics as a field has drawn a bit away from mathematics back toward its roots in scientific inference and analysis of data. The content of up-to-date instruction, even for beginners, looks quite different now than it did a generation ago. The reports of the ASA/MAA joint focus group on statistics reflect these shifts in the field. If you teach statistics—particularly if you are a mathematician rather than a statistician—their reports (e.g., Cobb 1992) are a good place to continue learning the subject. My own views on the content of basic statistics instruction appear in (Moore 1992ab). I have considerable empathy for mathematicians who find themselves teaching statistics, because I too was trained as a mathematician. Jack Kiefer, the great mathematical statistician who was my Ph.D. advisor, sent me out into the world with these words, “There’s lots of statistics any sociologist knows that you don’t know.” I have tried to learn.

But learning our subject can be assumed. I want to talk primarily about *learning to teach*. Gerald Alexanderson’s letter asking me to make this presentation said that “Anecdotal accounts of novel approaches are especially encouraged.” I read his letter just after teaching the first class of a statistics course for liberal arts majors, in which I disparaged anecdotal evidence. I’m going to disparage anecdotal evidence about teaching. Remember the statistician’s motto: “In God we trust; all others bring data.” Our individual experience, both as students and later as teachers, is atypical. As students, we were the survivors, the fittest by some quite esoteric standards of fitness. As teachers, we tend to rely on “what works for me.” What we think works for us may in fact be relatively ineffective. There is an abundance of evidence from the study of innovations in all fields that loosely designed uncontrolled studies give innovations a much higher rate of success than more careful studies, especially controlled randomized experiments. A rule of thumb for assessing innovations in education is that all innovations succeed in the hands of the innovator, and that none succeed in other hands. That rule is fortunately not quite true, but it is true enough to be disconcerting.

**Learning about teaching.** I am convinced that we mathematical scientists have much to learn from psychologists and education researchers, who can provide data rather than anecdote. So radical a conviction must start with a conversion experience. Here it is.

Near the beginning of my career, I was walking to a meeting with a senior educational psychologist. Out of politeness, I asked what he was doing. He had graduate students sitting in the back of college classrooms with stopwatches. I felt that glow of superiority that comes from knowing that I, unlike my colleague, did *real* research. What had they found? “Wait 30 seconds,” he said. “Very few teachers wait long enough when they ask a question of the class. Wait 30 seconds.” I tried it. Thirty seconds of silence seems interminable; then the students began to respond to the question. The psychologist was right. That put an end to my mathematician’s contempt for people who sit in the back of classrooms with stopwatches.

Shortly thereafter, during one of the recurring debates about student evaluation of teaching, I read several surveys on the subject by educational psychologists. What do students respond to when they evaluate our teaching? Here, based on lots of data (Kulik and McKeachie 1975), are the big three in order:

1. Instructional skill (talk to the class rather than to the board, give clear explanations, foster student participation, give relevant applications, etc.).
2. Respect and rapport (especially not demeaning students).
3. Organization (clear structure, communicate expectations, efficient use of class time).

Our students, with midwifery by educational psychologists, offer us this three-point outline of the craft of teaching.

Enthusiasm is no substitute for craftsmanship. As an undergraduate at Princeton, I once had a teacher, a justly reknowned mathematician, whose enthusiasm for mathematics was unsurpassed. As a difficult proof of a subtle result moved towards its climax, he became more animated. His voice rose, he wrote faster, the chalk dust flew. When the board was full, and we students were writing desperately, hoping to record this wisdom for later digestion, he swept a diagonal swath across the board with the eraser and wrote the triumphal conclusion along the swath.

Notice also that these aspects of the craft of teaching *can be evaluated easily*. Shall we rehearse the usual faculty conversation on evaluation of teaching?

“Of course we want to evaluate learning, not teaching in itself.” “Of course.”

“And of course we want to evaluate the value added, not just what the students know, because otherwise we favor teachers of well-prepared students.” “Of course.”

“And of course we want to evaluate what students retain after 10 years, not at the end of the semester.” “Of course.”

“Evaluating value added after 10 years isn’t feasible. So we can’t evaluate teaching.” “Wonderful! I knew that all along.”

I suggest that this is simply an attempt to avoid being held accountable for our work. Learning is the students’ responsibility. Our job is to provide a framework for learning. One reason why evaluating learning is a poor way to evaluate teaching is that students compensate. If the teacher is poor, they spend more time with the text, or even meet to learn from each other. This last strategy is so effective that a really bad teacher might in principle actually improve learning. In practice, the students drop the course, but imagining what might happen in principle allows us to say that a bad teacher may be better than a good teacher, a statement that catches the Alice-In-Wonderland quality of much faculty talk about teaching. The craftsmanship of a teacher, on the other hand, can be evaluated. Data show that students do evaluate it, that they do so consistently, and that student evaluations correlate well with peer evaluations. (They do *not*, by the way, correlate well with self evaluations.) Teachers interested in data rather than anecdote might look at the references given in Chapter 48 of Davis (1993).

I learned from education researchers what makes up the craft of teaching. Many experienced teachers have of course learned on their own. If you read Steven Krantz’s recent AMS book *How to Teach Mathematics* (Krantz 1993), you will find similar emphases. The points Krantz makes most often seem to be: “Prepare!” and “Respect your students!” Preparation is the key to points 1 and 3 in my outline, and respect is exactly point 2. Because I will criticize Krantz a bit, let me first note that he gets the biggest points right. As Krantz

remarks, the casual talk of teachers often reveals a quite different attitude. How often do you hear it suggested that this elementary and trivial mathematics can be taught without careful preparation? How often do you hear laments about the sorry state of the students? You are listening to slovenly workers who take no pride in their work, indeed, who appear to think their work beneath them.

**What should we be learning now?** Learning continues through a teacher's life. For example, when I was embarking on a large video project, I consulted a colleague in Purdue's Department of Communication (a discipline even more *déclassé* than educational psychology). He pointed me to literature on the cognitive effects of video. I learned some interesting and helpful principles—see Moore (1993). At the present, teachers who keep learning about teaching ought to be thinking about

- Active learning (alternatives to lectures)
- Technology, especially multimedia
- Total Quality Management

All of these phrases trigger an emotional reaction in many faculty. All are surrounded by hype, but all have genuine promise under the hype. We ought to study before we react.

Active learning is the Big Idea of the current wave of reform in the teaching of the mathematical sciences. Both proponents and opponents have been shouting a bit. The difference between the camps is that the proponents point to a body of systematic study that we ought not to simply ignore. See, for the case of statistics, the surveys by Garfield and Ahlgren (1988) and Garfield (1995). Krantz, on the other hand, prefers anecdote to data.

Lectures have been used to good effect for more than 3000 years. . . . Turn on your television and watch a self-help promoter, or a television evangelist, or a get-rich-quick real estate huckster. These people are not using overhead projectors, or computer simulations, or MATHEMATICA. In their own way, they are lecturing, and *very effectively*. (Krantz 1993, p. 13)

This is not a nuanced discussion of the advantages and disadvantages of lecturing. His attitude toward technology is similarly simplistic.

We do not want to teach our students to push buttons. We want them to think analytically.

. . .

Being able to push some buttons and render a beautiful picture or transparency of a graph in  $\mathcal{R}^3$  is *not* the same as understanding the information contained in the graph. (Krantz 1993, p. 50)

Of course we “do not want to teach our students to push buttons.” We nonetheless don't give them tables of the trigonometric functions. We ought to ask, as Krantz never does, what aspects of student work can be fruitfully automated. We ought to ask, as multimedia progress encourages us to do, what aspects of the teacher's work can be fruitfully automated. We ought also to ask, as some multimedia enthusiasts do not, what roles are better reserved for human instructors. And we ought to seek answers from data and systematic study rather than from anecdote.

I hope my message is clear: we can learn from those whose professional subject is the study of teaching and learning. Not of course without critical thinking of our own. Yes, the current wave of reform does undervalue lectures. Yes, technology is often oversold. Nonetheless, we ought not to confuse our personal experience as teachers and our professional expertise as mathematical scientists with professional expertise in the field of teaching and learning. We can learn from those who do serious work in other fields. If we are serious about teaching, we will try to learn from them. Contempt for other tribes is as endemic in academia as it is in human history. It is also narrow-minded and smug.

**TQM and all that: managing instruction.** Recently another interloper has joined educational research in the contempt of those faculty who know about it: Total Quality Management, or TQM. Your administrators almost certainly know about it, as TQM is making a strong movement into the nonacademic parts of colleges and universities. Your local statisticians may also know about it. For example, I spent a week at Motorola two years ago learning how TQM is practiced by an organization that does it very well.

Not long ago our Dean was musing about TQM at a meeting of the School of Science faculty council. He was pleased and impressed by the effects of a TQM program in the nonacademic areas at Purdue. How nice it is, he said, and how remarkable a change from past experience, to be treated as a valued customer. The assembled faculty nodded: how nice that those bureaucrats treat us well. Perhaps, the Dean went on, our students would also like to be treated as valued customers. The faculty rose howling from their seats. “Students aren’t our customers. TQM is an industrial model that doesn’t apply to us.” There followed half an hour of denunciation almost completely uninformed by understanding of how TQM works in industry or of how its principles have been modified for use in higher education. Those interested in learning before denouncing might read the papers by Hogg and Hogg (1995) and Wild (1995).

The point of even mentioning TQM is to remind ourselves that teaching is a system that we should manage. Some system problems are obvious:

- Of what use are the brilliant innovations you made this semester if they are not institutionalized, and so vanish as soon as you leave the course?
- Should not students who sign up for the same course actually experience the same course in all sections every semester, unless change is planned?

Overlooking for the moment the fact that almost all faculty respond “No” to the second question, we see that we face management issues. Denunciation of TQM isn’t specific: it is triggered by any mention of the word “management.” Management of instruction opposes the attitude that Krantz puts so concisely:

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. (Krantz 1993, p. 3)

This is touchy, isn’t it? Many of us define academic freedom as the right to be “an autocrat and a monarch.” I have encountered an enthusiastic young mathematician who was certain that the right way to introduce the derivative to freshmen was via semigroups of operators. I have a colleague who, believing against all evidence that most people learn

best when presented with the general case first, introduces integrals and expected values as linear functionals on quite general function spaces—to sophomore business students. Both approaches are mathematically impeccable. Both are pedagogically disastrous. Can these instructors do this? Of course. They are professors. They are “autocrats and monarchs.” They can do as they please. It is unthinkable that they should be managed. Have we any notion how irrational and self-centered this faculty culture seems to anyone not carefully socialized into it?

The point is not that someone other than professors should manage our teaching. It is rather that we have a collective responsibility to plan and organize instruction. As industry (there he goes again) has learned, team efforts beat individual activity in both efficiency and quality. From this broader perspective, thinking about TQM returns us to our starting point, the outline of the craft of teaching as evaluated by students. You don’t like the word “manage”? Talk about “prepare” and “organize” instead. You don’t like thinking of students as (in part) customers? Think about “respect and rapport” instead. We can change the words, but we can no longer avoid the substance of the discussion.

**Two conclusions.** My first conclusion is harsh (but true): *To improve teaching in more than local and temporary ways, our culture has to change.*

- Accept that good teaching is a craft. Insist that all who want to practice this craft study it and demonstrate at least basic competence. Admit that students can evaluate competence and have a right to do so.
- Accept that instruction is a shared responsibility that needs collective management.
- Adjust incentives: why learn a craft that isn’t rewarded? (We have now heard this so often that I allow it to pass without comment.)

My second conclusion is more positive. Almost all teachers teach because they love learning. With only a little redirection, our love of learning can be applied to improve our teaching. When the poet A. E. Housman was named Professor of Latin in University College, London, in 1892, his Introductory Lecture concerned the goals of liberal learning. Housman considers the usual justifications, and dismisses them. The purpose of liberal study, he says, is to awaken the joy of learning.

The pleasure of learning and knowing, though not the keenest, is yet the least perishable of pleasures; the least subject to external things, and the play of chance, and the wear of time. And as a prudent man puts money by to serve as a provision for the material wants of his old age, so too he needs to lay up against the end of his days provision for the intellect. (Housman 1961)

We teachers strive to incite our students to lay up some provision for their intellect. Our own catholicity of interests and obvious pleasure in learning and knowing are our best allies in doing so.

## References.

- Cobb, George (1992), “Teaching statistics,” in L. A. Steen (ed.) *Heeding the Call for Change: Suggestions for Curricular Action*, MAA Notes 22. Washington, DC: Mathematical Association of America.
- Davis, Barbara G. (1993), *Tools for Teaching*. San Francisco: Jossey-Bass Publishers.

- Garfield, Joan (1995), "How students learn statistics," *International Statistical Review*, 63, pp. 25–34.
- Garfield, Joan and Ahlgren, Andrew (1988), "Difficulties in learning basic concepts in probability and statistics: Implications for research," *Journal for Research in Mathematics Education*, 19, pp. 44–63.
- Hogg, Robert V. and Hogg, Mary C., (1995), "Continuous quality improvement in higher education," *International Statistical Review*, 63, pp. 35–48.
- Housman, A. E., "Introductory lecture," in John Carter (ed.) (1961), *A. E. Housman: Selected Prose*. Cambridge, England: Cambridge University Press.
- Kulik, J. A. and McKeachie, W. J. (1975), "The evaluation of teachers in higher education," in F. N. Kerlinger (ed.), *Review of Research in Education*. Itasca, Ill.: Peacock.
- Krantz, Steven G. (1993), *How to Teach Mathematics: A Personal Perspective*. Providence, RI: American Mathematical Society.
- Moore, David S. (1992a), "What is statistics," in David C. Hoaglin and David S. Moore (eds.), *Perspectives on Contemporary Statistics*, MAA Notes 21. Washington, DC: Mathematical Association of America.
- Moore, David S. (1992b), "Teaching statistics as a respectable subject," in Florence Gordon and Sheldon Gordon (eds.), *Statistics for the Twenty-First Century*, MAA Notes 26. Washington, DC: Mathematical Association of America.
- Moore, David S. (1993), "The place of video in new styles of teaching and learning statistics," *The American Statistician*, 47, pp. 172–176.
- Price, Justin J. (1994), "Open secrets," *Focus*, 14, No. 4, pp. 6–7.
- Tucker, Alan (1994), "Reflections on the joy of teaching," *Focus*, 14, No. 3, pp. 1 and 8.
- Wild, Chris (1995), "Continuous improvement of teaching: A case study in a large statistics course," *International Statistical Review* (63), pp. 49–68.