

Random Thoughts...

GOOD COP/BAD COP Embracing Contraries in Teaching

RICHARD M. FELDER

North Carolina State University
Raleigh, NC 27695

I've come to suspect that whenever any ability is difficult to learn and rarely performed well, it's probably because contraries are called for – patting the head and rubbing the belly. Thus, good writing is hard because it means trying to be creative and critical; good teaching is hard because it means trying to be ally and adversary of students; good evaluation is hard because it means trying to be subjective and objective; good intelligence is rare because it means trying to be intuitive and logical.

So says Peter Elbow in *Embracing Contraries* [1], perhaps the best book I've ever read on teaching. The theme of the book should resonate in the minds of all engineering professors. Most of us are often frustrated, feeling ourselves pulled in opposite directions. We want to be good teachers and good researchers, but don't see how we can do both given the finite number of hours in a day. We want to provide good educational experiences for our graduate students, which means letting them do some floundering and learning by experience, but we also need to produce results quickly for our funding agencies, which requires giving detailed directions. We want to be good department citizens, helping carry our share of the inevitable burden of committees, recruiting, etc., but we also need to maximize the time we spend on the things that get us tenure, promotions, and raises. It feels as though we have to be both particles and waves simultaneously, and we don't know how: we can either be excellent particles and lousy waves, or vice versa, or do a mediocre job of both.

Among the dilemmas inherent in our profession is that of trying to be supportive of our students while maintaining rigorous academic standards. I can't improve on what Elbow has to say on the subject, so I'll let him do most of the talking.

The two conflicting mentalities needed for good teaching stem from the two conflicting obligations inherent in the job: we have an obligation to students but we also have an obligation to knowledge and society. Our loyalty to students asks us to be their allies and hosts as we instruct and share: to invite all students to enter in and join us as members of a learning community—even if they have difficulty. Our commitment to students asks us to assume they are all smart and capable of learning, to see things through their eyes, to help bring out their best rather than their worst when

it comes to tests and grades. By taking this inviting stance we will help more of them learn.

But our commitment to knowledge and society asks us to be guardians or bouncers: we must discriminate, evaluate, test, grade, certify. We are invited to stay true to the inherent standards of what we teach, whether or not that stance fits the particular students before us. We have a responsibility to society—that is, to our discipline, our college or university, and to other learning communities of which we are members—to see that the students we certify really understand or can do what we teach, to see that the grades and credits and degrees we give really have the meaning or currency they are supposed to have.

Unfortunately, we can't play both roles simultaneously. Elbow's solution is to alternate between them. Start a course by spelling out requirements and grading criteria; think about handing out a representative final exam at the beginning of the course, with examples of strong and weak solutions. Then,

[Having done that] I can more easily go on to...turn around and schizophrenically start being a complete ally of students. I have been wholehearted and enthusiastic in making tough standards, but now I can say, "Those are the specific criteria I will use in grading; that's what you are up against, that's really me. But now we have most of the semester for me to help you attain those standards, do well on those tests and papers. They are high standards but I suspect all of you can attain them if you work hard. I will function as your ally. I'll be a kind of lawyer for the defense, helping you bring out your best in your battles with the other me, the prosecuting-attorney me when he emerges at the end. And if you really think you are too poorly prepared to do well in one semester, I can help you decide whether to trust that negative judgment and decide now whether to drop the course or stay and learn what you can."

Elbow suggests a number of ways to provide the recommended support. One would be effective in small classes or larger classes with student graders:

One of the best ways to function as ally or coach is to role-play the enemy in a supportive setting. For example, one can give practice tests where the grade doesn't count, or give feedback on papers which the student can revise before they count for credit. This gets us out of the typically counterproductive situation where much of our commentary on papers and exams is really justification for the grade—or is seen that way. Our attempt to help is experienced by students as a slap on the wrist by an adversary for what they have done wrong. No wonder students so often fail to heed or learn from our

about the Jordan canonical form of a matrix A . In every linear algebra textbook there is a section devoted to the explanation and calculation of the Jordan canonical form of a matrix A . Some emphasize it more than others. However, when dealing with large systems (as in many practical problems) where computers are employed for matrix manipulations, an approach employing the calculation of the Jordan decomposition, *i.e.*, $X^{-1}AX = \text{diag}(J_1, \dots, J_r)$, where each J is a Jordan block, is not numerically stable. This comes about because at several steps of calculating the decomposition, rank decisions must be made, and the final computed block structure depends heavily on these blocks, thus on these rank decisions. In practical applications, Golub and Van Loan suggest using the more stable Schur decomposition in eigenvector problems. Therefore, the Jordan canonical approach is not covered in detail in this course.

The course has now been taught twice at our university, and the students have received it with enthusiasm. Many of them have taken courses in linear algebra in the mathematics department prior to taking this course. They comment that the approach taken here is very different and that their intuitive understanding of the key theorems has increased. They further state that this course has helped them to better understand papers involving matrix manipulations.

CONCLUSION

A new applied linear algebra course, cross-listed in three engineering departments, has been created. The emphasis is on intuitive understanding and geometric visualization and interpretation of the key theorems of linear algebra. The students should learn the why's of doing certain matrix decompositions and manipulations and should be able to visualize the algorithms in 3-D space. Numerous physical examples from systems area are offered, tying together the mathematical manipulations and their physical significance. Computer projects are assigned from time to time to illustrate the utility of the various algorithms in solving practical problems. The course has also been made a co-requisite for the linear systems theory course offered by the electrical engineering department, so as to take the pain of teaching simultaneously both the applied linear algebra and linear systems theory out of that course. The students who have taken the course appreciate its approach, and I have found that every time I have taught it, I find more points that I am able to interpret intuitively that I was not able to before. The Chinese have an old proverb that says that new things are learned from review-

ing old things. It has proven to be the case with this course.

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commentary. But when we comment on practice tests or revisable papers we are not saying, "Here's why you got this grade." We are saying, "Here's how you can get a better grade."

Alternating between the roles of student advocate and guardian of standards—good cop and bad cop—enables teachers to serve comfortably in both capacities. It's easier to set high standards if you know you're going to be helping the students attain them, and it's easier to enforce the standards once you've made them quite clear and given the students every opportunity to meet them. In addition, the approach may also provide a significant fringe benefit:

In the end, I do not think I am just talking about how to serve students and serve knowledge or society. I am also talking about developing opposite and complementary sides of our character or personality: the supportive and nurturant side and the tough, demanding side. I submit that we all have instincts and needs of both sorts. The gentlest, softest, and most flexible among us really need a chance to stick up for our latent high standards, and the most hawk-eyed, critical-minded bouncers at the bar of civilization among us really need a chance to use our nurturant and supportive muscles instead of always being adversary.

There's much more. Get the book.

REFERENCES

1. Peter Elbow, *Embracing Contraries: Explorations in Learning and Teaching*, New York, Oxford University Press (1986)