

TEACHING STATEMENT

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I often reassure graduate students about to teach for the first time, and apprehensive about doing so, that teaching is an incredibly fulfilling experience and a perfect counterpoint to research. For it is the nature of research, I claim, that it generates a lot of self-doubt; and for me teaching is *the* antidote to these feelings. The reason is simple: every time you stand up in front of the class for an hour, your students leave understanding something which they did not understand before. You can *see* that you have made a positive difference. Every time you answer a question in office hours and hear a student smile and say ‘thank-you, that was really helpful’, you know that you did something worthwhile that day. But it gets even better: I believe that the ingredients which make this happen are rewarding in and of themselves. Let me say why.

To begin, I will exhibit a lecture at my university’s semi-annual teaching conference taught by someone who you might never expect to see at such a conference in the first place. While the conference has many excellent lectures, this one is special: it has the participants crammed into the classroom, standing and sitting cross-legged on every available surface, packed like sardines. The speaker is the director of speech and language at the American Repertory Theater, and her theme is the role of the theatrical in teaching. The talk is phenomenally popular for a reason: she not only conveys a key ingredient of excellence in teaching, but does so in a way which reminds people that delivering it should be as fun for the teacher as for the class.

The theme certainly has immense importance for me, and I would say that a big part of what makes teaching so exciting for me is the fact that there is so much opportunity for the dramatic, for showmanship. In fact, they are almost indispensable. The front of a classroom is a stage, and those of us who perform in lecture theaters, as in the other kind, can only earn our keep by holding people’s attention for the span of time we’re in front of them. I feel the same nervousness before I teach as before I would take the stage at the Amateur Dramatic Club as an undergraduate. Eye contact, voice projection, infectious enthusiasm—these all matter, because the more you can enthrall, the more the students will remember what you say. Even silly things help: I’m almost as happy that students mention my jokes on evaluations as that they compliment my presentation of material, because it means they are listening and enjoying.

Indeed, teaching is the most exhilarating kind of theater of all—improv— because you can never afford to have a script. I want an interactive classroom, and I tend to have a lot of back-and-forth in my classes, asking questions of the class, bringing out ‘volunteers from the audience’, and of course, responding to their questions. Sometimes a question will be unexpected and I’ll have to think on my feet; sometimes a student will ask a question that I’ve been secretly hoping for because my response will move me on seamlessly to the next topic. All this should and does *add* to the showmanship and to the momentum of the lecture; and it certainly adds to my enjoyment because the frisson of an unexpected turn is always possible.

Delivery, of course, only takes you so far; it is the end of the process rather than the beginning. A play needs a plot, and teaching needs to convey an *idea*. That means I, as teacher, need to think the idea through, from all angles, trying to find the best way of conveying that idea that I possibly can: the right metaphor, the right examples, or perhaps an approach which methodically builds the concept up step by step. *This* is a joy because the new perspectives I find for my students in turn enrich my own understanding of the material.

I have been lucky at Harvard to have had an opportunity to teach at many different levels, and each of these opportunities has given me new opportunities to think about how ideas can be conveyed. I have taught courses from elementary single variable calculus,

through multivariable calculus, up to advanced topics like category theory. In calculus classes, the large scale arrangement was out of my hands but the details still gave great scope for fruitful thought: and for the more advanced topics, I had complete freedom to set my own course. Moreover, I have had the opportunity to be a resident advisor in one of the undergraduate dorms, which lets me provide academic advising, mentoring and informal ‘math help’ for many undergraduates; and I also have taught for three years for the Math Circle, a local non-profit which provides math outreach for area schoolchildren aged 8–12, providing another interesting teaching experience.

In our department’s most elementary class (integrated calculus and precalculus), I thought it was important to explain what the *point* of calculus was. This was because, for many entering the class, ‘calculus’ was not thought of as a tool to help them understand the world around them but rather had a reputation as enforced confusion, mandated from on high and otherwise irrelevant. I framed the whole course by showing, in my first lecture, high speed photography images which captured moments frozen in time. The images themselves were captivating, and students immediately grasped that time was missing and that a world without time was scarcely recognizable as *our* world. When I pointed out that every math formula they already knew, from areas of circles to trigonometry, only even dealt with frozen pictures, they *saw* how much of life was missed by the math they already had, how much could potentially be achieved with a mathematics of change and time. Thus the stage was set. And when a student said, unbidden, that one needed movies to see change, I had a perfect segue into the need to formalize the notion of functions.

In an introductory multivariable course, I knew that the divergence and curl were thought to be particularly tricky. I constructed visualizations, in 2d and 3d, showing particles flowing according to a vector field. The particle density was held constant in space and time by adding and removing particles. It was immediately visible that particles ‘should be’ piling up in certain places, and other areas should be emptying—and so the students could immediately visualize divergence. Similarly, I could ask them what would happen if a small circle of material were frozen. They could *see* that it would start rotating, and hence grasp the basic idea of curl.

I also had the opportunity to teach ‘summer tutorials’, an entire 6-week upper level class on a topic of my choice. I have taught tutorials on category theory and Ramsey theory, and the greater freedom offered by these courses gave even more opportunity for reflection on what I thought the best way of conveying the ideas might be. For instance, in teaching category theory, I tried to avoid the rather abstract nature of many presentations, which I had found to be confusing as a beginner. I focussed instead on the concrete problem of trying to define as many familiar mathematical objects as possible using commutative diagrams. The students appreciated this as a rather fun puzzle—until we took these definitions and translated them from one category to another. A definition we’d worked out for the product of sets suddenly defined the product of groups and of topological spaces: a miracle, right out of left field. They were hooked.

I strongly believe that with the simple ingredients of enthusiasm, connection and clarity, it will never be long before you can tell that your students get something tangibly good from your time with them. To attain the enthusiasm and connection you need to perform with drama and showmanship which is exhilarating in its own right; to attain the clarity, you need a reflection on the topic to be taught that rewards you as much as it rewards the class. But while the exhilaration and the rewards of reflection would be alone reason enough to teach, for me the biggest reason of all is the simple fact that one cannot teach a class well without knowing for sure that one has done something worthwhile.