Teaching Comfort with Ambiguity

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My teaching career at Ohio State began by accident: in 1994 I was working toward my doctorate in industrial and systems engineering when I was asked by my department chair to fill in temporarily for another professor who had unexpectedly left OSU to accept a faculty position at another university. The course he was teaching was cross-listed in Industrial and Mechanical Engineering; since I had two degrees in mechanical engineering, and was working on a third degree in industrial engineering, it appeared that I might be a good fit.

When I began teaching in 1994, I was already forty-four years old. My career to that point had taken a rather convoluted path. I earned my first degree, in English literature, at Ohio State in 1971. I don't remember having any definite career goals at that time, other than a vague idea that I would somehow write the Great American Novel, sell the movie rights, and live comfortably ever after. A few years of working at a dead-end job in Boulder, Colorado, finally convinced me that the Great American Novel was probably a few years in the future, and it might be a good idea to find something more lucrative in the meantime. In 1977, I returned to Columbus, and in short order found myself working at the General Motors plant on West Broad Street. After a year of welding door frames on the production floor, I moved into the tool room, and began an apprenticeship as a tool and die maker. My apprenticeship required me to go to school, which led me back to Ohio State. While completing the math and mechanical drawing courses my job required, I came to notice that I had an affinity for engineering: I decided to stay on and earn a degree in mechanical engineering. For the next nineteen consecutive quarters, I worked evenings at General Motors while taking two or three classes per quarter at OSU. I earned my B.S. in mechanical engineering in 1983, and my M.S. in mechanical in 1986.

I mention this because my experience in the tool room was crucial to me when I found myself trying to learn how to be an effective teacher a decade later. Until I began my tool and die making apprenticeship at GM, I had had little experience working with my hands. I had no idea what precision meant until I learned to use lathes, milling machines, and surface grinders as a necessary part of my training; I had no idea how to solve ambiguous, open-ended problems until I learned the rudiments of building and repairing the complex dies that form the thousands of components that go into an automobile. Along the way, I was very lucky to work with skilled journeymen who were among the best teachers I've ever come into contact with. I'll always regard my apprenticeship in the tool room at General Motors as being equal in importance to my formal engineering training at Ohio State. I was incredibly fortunate to have that dual educational experience, and I know that it has helped me to become a better teacher.

In the years since then, I've come to understand that the most important lesson I learned through my apprenticeship was one I didn't even recognize at the time. Quite often the kinds of problems I was confronted with in the tool room required answers that could not be put into words. The journeyman I happened to be working with at the time would either lead me through the process one step at a time, or more likely, would tell me to try something and see what happened. When my solution invariably failed, my mentor would point out where I had gone wrong, and tell me to do it over. Although this might sound like the old 'trial and error' method, in fact a deeper kind of learning was occurring here. What I was encountering was what my colleagues in cognitive engineering refer to as "tacit knowledge": the sorts of things that we know without being able to explicitly verbalize them. By working with and learning from skilled craftsmen, I came to appreciate the fact that as humans we don't learn exclusively through language or symbol manipulation: we also learn through our hands, through repetition, and by encountering unfamiliar experiences.

My temporary teaching job eventually turned into a permanent faculty position at Ohio State in Industrial & Systems Engineering and Mechanical Engineering. The course I was originally hired to teach evolved from a course in 'computer aided design' to a course in "design for manufacturing" to its current configuration, "fundamentals of product design." It took me the better part of ten years to realize what it was that I was actually trying to teach, and to give the course an appropriate name. Today it's become one of the most popular in the College of Engineering; I think its popularity is due to the fact that it challenges the students to think in different ways about what they've learned.

I teach senior undergraduates and first-year graduate students almost exclusively. In the College of Engineering, the overwhelming majority of these students are preparing to embark on their careers as practicing engineers in industry: very few of them will continue on to the Ph.D. With that in mind, I try to pass on to the students the sorts of information that I assume they'll need to know. More than that, I've designed the product design course to be an experience in dealing with ambiguous problems. In contrast to almost every other course the students have taken up to that point, in this class they're confronted with the task of "solving" problems that have no "right answer." Because we talk about real products, and confront real design problems, the students are forced to deal with issues that they have probably not run into before.

My approach to teaching design requires the students to confront issues larger than the specific product they're designing. They first must look carefully at the context surrounding their proposed product. Who will use it? How will it be used, or possibly misused? Who is the customer? Is the customer the user? What will happen to the product at the end of its useful life? As a first step to designing a product, the students first design a persona: the imaginary user of their product. Once they've fleshed out a believable persona, they can begin to think about the product in use by their persona within specific scenarios.

Getting the students to think about context leads inevitably to them thinking about the constraints their products will be designed around. Some constraints are easy to identify, some less so. The students typically have spent four or five years learning how to identify and analyze physical constraints; for the most part, they have never given a thought to the other constraints that determine a product's success or failure in the market, including such things as cultural acceptance, ergonomics, and cost. These constraints are typically hard to quantify, which leads to quite a bit of frustration on the part of the engineering students - the curriculum they have come through is based very much on the idea that everything can be quantified.

This inevitably leads to the discussion that's been going on in the engineering education community for the past one hundred years or so, concerning the difficulty of teaching design in the classroom. It seems that many professors of engineering believe that it's not really possible to teach design at the university; rather, they believe that we should teach our students the skills they need to analyze any design, and leave the teaching of design to their employers. In fact, some of my colleagues believe that design cannot be taught, that designers are either born knowing how, or somehow acquire their skill through some mysterious process.

While I agree that teaching design is quite difficult, I do think that it's possible to teach students to be comfortable when confronting ambiguous problems that have no single clear answer. In fact, I would argue that this is the essence of engineering itself, because the world we live and work in is rarely obliging enough to present us with clear-cut choices and easy solutions. My own education, both my formal engineering education at Ohio State and my informal engineering education at General Motors, taught me the value of being forced to confront murky situations, where no one answer is ever clearly superior to all the others. I learned to be tolerant of ambiguity, to try a solution, evaluate it, and to revise it and try again when it failed. This is exactly what Professor Nigel Cross, one of the leaders in the European design community, means when he talks of "designerly ways of knowing." Successful designers and engineers learn that failure is indeed often the quickest route to success, and that much of what they know can never be put into language. This is perhaps the most valuable lesson I can teach my students.