The dangers of classroom teaching

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Good afternoon. It is my pleasure to be here today, and to receive this award, which is named after one of the great engineering educators - Professor Frederick Emmons Terman of Stanford University. I was browsing recently through the list of past recipients, and feel truly humbled to be following in the footsteps of such illustrious giants, including, in particular, Professor Toby Berger, who received this award in 1982. I had the privilege to learn from him and have him on my Ph.D. dissertation committee at Cornell. He has always been a source of inspiration for me.

I would like to thank everyone involved in nominating me for this award, and HP for sponsoring it. I would also like to take this opportunity to thank publicly my family and friends, my teachers and mentors, and my students, in particular, the present and former members of the Autonomous Networks Research Group at USC, for supporting me through the years in many ways.

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I want to share with you today some of my experiences with learning, and some thoughts on education that have been percolating in my head recently.

It was in seventh grade, I think. My mother offered to pay me one Rupee each afternoon if I would tell her what I had learned at school in my science classes that day. Enticed by this opportunity to substantially increase my allowance, I eagerly agreed. I don't recall how long this arrangement lasted, but these sessions were to form the very foundations of an intense desire to share what I have learned with others, which has lasted to this day. I don't know if my mother knew all along this is what would happen. But, thanks again, Mom!

Another formative experience for me was during my undergraduate years at The Cooper Union in New York City. This school was founded due to the extraordinary generosity of Peter Cooper, a 19th century pioneer and entrepreneur, who wanted to found an institute where education would be, in his words, "as free as air and water". Late evenings before major exams, a large group of my classmates would gather in the EE department lounge, and we would take turns learning and explaining to each other portions of the material that we should have rightly learned the previous six weeks had we been paying more attention in class. The intense satisfaction I derived from these study sessions was what motivated me to seek a Ph.D. and then a career in academia. Interestingly, about a half of my classmates that year also went on to

do a Ph.D.

Through these experiences and others, the twin acts of learning, and sharing what I've learned, have become quite inseparable for me. I like to learn so I can share, and I like to teach so I can learn.

The book I wrote, Networking Wireless Sensors, was motivated by the same twin-fold desire. Networks of wireless sensors, each capable of a mix of computation, communication, and sensing, are increasingly finding use in a wide range of applications: environment monitoring, building automation, smart metering, surveillance, and asset tracking. As the research on this topic started to take off in the early 2000's with an exponentially growing list of articles, I found myself lagging in my understanding of the evolution of ideas in this field. I wrote the book because I wanted to better understand and organize the substantial literature on the topic for my own benefit, and because I also wanted very much to share what I understood with others.

Lately, I've been thinking about the conditions under which I learn best, and the best ways to share what I learn.

Four years ago, my son Shriram started at a school in Los Angeles, called Play Mountain Place. It is an unusual alternative school, that is based on a humanistic education philosophy. The core idea in this philosophy is that learning must be completely self-driven and autonomous. So, there are no regular classes whatsoever. From time to time, the teachers offer and facilitate various kinds of plans involving art, reading, math, or outdoor trips, but kids are not forced to participate in them if they don't want to. They can choose, if they like, to play outdoors in the yard under shady trees all day, and many of them often do. Kids of vastly different ages mix with each other freely. The school also emphasizes respectful, non-violent, non-authoritarian communication between all members of the community: the children, the parents, and the teachers and staff. In such a free environment, where they can learn at their own pace, and nothing is forced upon them, I have seen for myself, with marvel, that all children thrive, and grow up with great self-confidence.

My involvement with this school as a parent has lead me to reflect upon and grow my own understanding of learning and teaching in the context of college-level engineering education. I'd like to share with you my emerging views, which are also informed by conversations with colleagues and by reading the writings of a number of thinkers on humanistic education: Carl Rogers, Abraham Maslow, John Taylor Gatto, Alfie Kohn, and John Holt.

The following, I have come to believe, are essential aspects of true learning, at any age:
- Learning must always be self-driven and self-motivated.
- The learner must have freedom to fail repeatedly **without censure**, so he/she can learn from mistakes.
- The learning must be self-paced, and the learner should have the flexibility to go deeper on certain topics of interest and skip others
- The learner should be able to probe the very boundaries of what's already known, and push even further beyond, to create new knowledge.
- There must be a personal connection between the learner and the teacher.
- Learning must be perceived as a process having value in itself, not merely as a means to some end.
- Though it may be a diverse process, the learner must be able to find personally coherent

threads of meaning in whatever is learned.
- The learning process should leave the learner with an innate, ever-improving "filter" of quality, to be able to evaluate for oneself, when encountering some piece of information, whether it is reliable, new, significant, important, or useful.
- The learning process should continually aim to provide opportunities for what Maslow refers to as "peak experiences", creative accomplishments that inspire in the learner a sense of self-confidence.

My increasing belief, however, is that much of classroom teaching runs counter to these principles, and in doing so, not only inhibits learning, but actually **harms** students by diminishing their potential for future learning and growth. Consider these facts about institutional teaching, as experienced in many engineering classrooms across the world today:
- Teachers decide what is taught, at what pace, and how; there is a uniformity imposed on the entire classroom.
- The grading system puts a high cost on failure and creates emotional distance between teachers and students, who are often reduced to playing a game with each other that centers around what grade to give, or get.
- What is taught is often only what is already well understood, processed and neatly packaged. This makes it harder for students to think outside the box or understand the current limits of our knowledge, let alone how they can be extended.
- The loss of autonomy and the presentation of processed information deprives students of the confidence to develop their own filter to judge the quality, importance, and utility of information presented to them.
- The arguably desirable goal of "getting a good job" is confused as the main end of the learning process.
- The way knowledge is divided into disciplines, subdisciplines, and topics, makes it harder for students to see connections between concepts encountered in different classes, and to extract a coherent meaning from them.
- Classroom teaching often puts a greater emphasis on the transfer of information and mastery of facts, duly tested and graded, than on enabling creative experiences that leave the learner with a **can do** attitude.

I don't mean to paint too bleak a picture. There is, of course, a substantial body of educational pedagogy that addresses these very issues, that goes under various rubrics such as learner-centered education, active learning, and project-based learning; I am sure many of you here in this select audience today are very much involved with developing, implementing and testing such laudable approaches. But I know they have yet to reach every classroom, and I fear they may still not go far enough in granting greater autonomy to the students in a comprehensive way.

At the same time, we do have, within academia itself, a role model for a far more ideal learning process that is already in wide use. We call it the Ph.D. program. Here, we find learners who have much more autonomy to explore, probe and push beyond the boundaries of knowledge, who are allowed to pace themselves, who have a close personal connection to a mentor, who develop significantly their ability to think critically and independently, whose self-driven learning experiences form a coherent narrative, and for whom grades are not the be-all and end-all of the learning process. And though they do go on to a job when they are done with the Ph.D., their creative achievements leave them with a great confidence in their ability to tackle challenging problems and to continue learning.

So what I've been pondering lately is this - is it possible to transform the undergraduate engineering experience **substantially,** so that it more closely resembles our Ph.D. programs? Though such a transformation may mean that not everyone even within the same discipline is exposed to all the same knowledge, a far more self-directed and autonomous undergraduate program than what we have will no doubt yield more confident and capable engineers.

In the meantime, while we work within the structure of the system we have in place, and try to improve upon it as much as possible, let us at least keep reminding our students of that famous quote often attributed to Mark Twain: "don't let schooling get in the way of your education."

Thank you.