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The Teachers of Creativity

Any physicist or mathematician will tell you that their field, despite the otherwise "popular" opinion is one of the most imaginative and creative of all fields, science or otherwise. Sit through a couple of quantum mechanics lectures and the imagination part is not so hard to believe! As physicists, we talk about the world in a different language, just as great writers and poets talk about the world in English, Russian, or French. Works in both fields are sometimes subtle, elegant, simple, beautiful… and sometimes not, and isn't it interesting that great works of physics are described with much the same language as great works of literature? Consider a quote from the writer Andre Gide (or was it Einstein?) "Only those things are beautiful which are inspired by madness and written by reason," or rather the quote from Einstein (or was it Andre Gide?) "The most beautiful thing we can experience is the mysterious. It is the source of all true art and all science."

Allow me to draw another analogy: Victor Wooten, a famous musician, thinks of music as a language. For him, notes, rests, beats, and rhythms form the letters, words, prepositions of the musical "sentences" he speaks when he plays. He is an amazing soloist and improviser and when people ask him what he thinks when he solos he responds "when you asked [your] question were you thinking nouns, pronouns? Did you count the syllables? How many conjunctions did you use?" This causes the questioner to pause: it is not the answer he was expecting. Victor continues, "It's because your 'vocabulary' is big enough that you have a lot to choose from." Physics, in this sense, is no different from music.

Just as when Victor "plays what he feels," physicists write down what their intuition tells them. A musician's bad note is a physicist's sign error; resting too long is the same as

being off by a factor of two. Classical physics is like classical music while quantum, chaos, complexity, relativity, and particle physics make up our jazz, rock 'n' roll, and hip-hop. Gauss is our Mozart; Feynman is our Eddie Van Halen (I guess that would make "What the Bleep Do We Know" kind of like the time Paris Hilton tried to release an album). A physicist spends his or her entire life building a mathematical vocabulary large enough to describe the phenomena encountered in nature. When learning general relativity, one must learn to "speak" or "improvise" tensors without too much thought. When struggling through electricity and magnetism, it is most likely because a student is not "fluent" in vector calculus. So why, with all of these parallels to the "typical" creative fields does the wealth of beauty and imagination contained in physics so often give the impression of pure rote?

The answer lies in a language barrier. In a kindergarten classroom somewhere, a future physicist is learning 2+3=5. In first grade she will learn 2+3=3+2. Skip ahead ten years. If she's a fast learner, she is becoming comfortable with the unit circle, radians, maybe limits. As she graduates high school and begins college she is only beginning to be able to form the mathematical sentences to describe the most basic physical phenomena. By the time she graduates college she will be conversational in certain areas of the physical world, but hardly fluent. It has taken twelve years to build up the "language" to quantitatively discuss where a ball fired out of a cannon will land, and sixteen to truly discuss how that ball might behave if put into orbit around the earth. For comparison, *Rosetta Stone* software promises to have you conversing in French in six months. In that sense, teaching physics to high school students and undergraduates is roughly equivalent to teaching Shakespeare to a tourist who knows how to ask, "where is the restroom?"

It is however at this point that excellent teaching is most critical. Not only is one teaching that **F**=m**a**, the teacher is showing the students the depth and power that Newton's second law possesses as well as the excitement that lies ahead for them. Physics is not only a tool to solve problems, but a rich, powerful, and fundamental description of nature that no matter how hard one might try cannot be escaped. Without conveying these ideas in freshman physics, the subject is inevitably reduced to rote; it becomes an exercise in flipping to example problems of a similar nature or searching Wikipedia for another person's solution to the problem. At this level it is the responsibility of the teacher to show the student that only one percent of physics is walking away with a solution, the rest is the struggle to find the answer, approaching the problem in ways you have not yet, and the thrill of seeing a solution start to develop. It is at the most basic level that physics needs to be taught as an exciting exercise in creativity and imagination. An instructor need not only break the math barrier, but also the barrier between others and our way of thinking.

This is a field of invention and innovation. How often has physics needed new math to fully describe a phenomenon? How often did Shakespeare invent a new word to describe an emotion or object? Our subject is without a doubt among the most visionary, influential, imaginative, quickly developing, and abstract fields of science, art, music, or literature. What we as physicists might not always realize however is that it falls to us to break the language barrier and communicate this fact to others. By disseminating what we know as well as our thought and creative processes to people within and outside of physics, we open up new horizons for not only others but ourselves. Fields such as biophysics, medical physics, and statistical mechanics are exploding because of physicists who are able convey

their science to others… but a student might never get to see that if we do not inspire them to look beyond **F**=m**a**.

We have to realize that as the current and future instructors of physics, we are not just teaching how to solve or derive equations: we are language professors building and creating new vocabulary; we are literature professors teaching the art of description; we are mathematicians, writers, scientists, artists and as such it falls to us communicate all of this to the next generation. We are, above all, teachers of imagination, new ideas, and new thoughts.

Was it not Einstein, one of physics' celebrities, who felt that "imagination is more important than knowledge?" Our job goes beyond teaching: it stretches to instilling a sense of curiosity, new ideas, and new ways of approaching ones surroundings. We see nature and problem solving differently and it is our job to show the world what that vision is. As teachers of physics we have one of the hardest and yet one of the best and most rewarding jobs on the planet. It is easy to recognize that research is fundamental to our field, but we must never underestimate the excitement, influence, and inspiration that can come from teaching: you never know when you may be teaching language, music, math, science and art, in a word, physics, to the next generation of great thinkers.