Finding the Right Formula

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The decades-long debate about "research versus teaching" appears to have no end in sight. But, is this a bad thing? Not really! The relative merits of leaning one way or the other in the professoriate is a ceaseless but positive source for the self-examination of what professors do.

It has been known for a long time that good teachers with solid backgrounds in their area of research are the very people who will educate, train and produce the future leaders of society. Such leaders should have the scientific tools and knowledge to keep a good balance in the day-to-day activities of their lives and the lives of those around them, and to realize that leadership is a form of service to all humankind. It is indeed gratifying to know that university-level teachers are so vital to the shaping of our future leaders and the destiny of our world. Hence, it is our duty as college-level educators to constantly acquire the right tools and knowledge that help us inside the classroom.

Whether it is a visit to my physician or to the supermarket, it is hard not to hear people proclaim, "I've never been good in math." In fact this is the most frequent comment echoed by students throughout my entire teaching career. The required mathematics course is always left to the last minute (or quarter) to deal with in order to graduate. When you try to get to know why such an attitude prevails in our society, you get the common answer, "I had a really bad math teacher" somewhere during elementary, junior, or senior high school. Whether this is the real reason or not, I am always reminded of the great opportunity presented to me, a professor of mathematics, to change such an attitude and in some cases reverse it.

We have to recognize that we are in the information age and our students come to us with a universal remote control in their hands that can be used to instantly communicate, calculate, graph, view, and analyze any set of data they may encounter in their daily lives. Whether it is watching TV, listening to music, sending e-mails, multiplying or dividing, it is all at the tip of their fingers. Today's students are born into a world of high-tech tools and are immersed in a high tech culture up to the day they enroll in their first university course, throughout their college days, and for nearly all, the rest of their lives. This is where the generation gap between students and faculty resides today. I grew up in a different environment, and learned my love of mathematics without so many electronic helpers. I am left to wonder: when the most basic mathematical questions are answered using the calculator, how can I, a professor of mathematics, find the right formula for providing students with the arithmetical skills and logic they need to be effective leaders of the world of the future.

I may not have completely solved the complex equation of college-level teaching, but I have discovered some constants that work for me. On the first day of my class, I ask students to forget about any bad experience or encounter they may have had with mathematics in the

past. I promise them a class full of fun, and an experience they will never forget. No matter how advanced the course, I tell them we will do everything together and that I will be there to remind them of any mathematical formula or technique necessary so that they can emerge with a successful and positive learning experience. I am not against the use of the graphing calculator; in fact it is mandatory in some cases. However, we will do the calculation with our own hands and we will check our answers with the calculator. The calculator plays second fiddle to our brains. No memorization in my class, I declare, because we will derive all the formulas together.

The most important feature of my class is the question, and students are free to stop me at any time with a query. Let me repeat that again! No memorization and feel free to ask any question, anytime! Further, there are no limits on questions. I tell them: "Even if you ask me about my dinner, I will provide you with the detailed menu; in return, I will be asking you questions throughout the entire lecture."

It is very helpful to avoid starting the class or a lecture with a prepared definition, theorem, or proof. In fact, I normally do not write or quote the same definition, theorem, or proof as presented in the book. I always start with an example and slowly build up the lecture and get the students to volunteer the definition or what the theorem should be. With a guiding hand from me and lots of examples, I and my students arrive at the same conclusion that happens to agree with the stated one in the book. I make sure that the students are involved in every step of the way and that they retain rightful ownership of the final answer. When we derive the definition, theorem or proof together, the slogan "No Memorization" is at work with full force.

The art of entertaining their questions and of seeking answers to my own questions is extremely delicate. Professors must be mindful of actively involved students who are always willing to answer every question, and the spectators who are always waiting for the answers.

I start by asking simple questions that I know they can answer. I look around and say, "I know that you can provide me with an answer," and in a non-threatening tone and very carefully, I point to someone who is usually hesitant to answer and I ask him/her to follow his/her intuition to arrive at the correct answer. As I keep asking questions and seeking answers, I ask students to state their names before they answer, and in a couple of weeks we all get to know each other and literarily feel at home with each other. No matter, how wrong students' answers are, I never say to someone, "you are wrong" but rather try a 2^{nd} input, a 3^{rd} input, and so on. I let them clarify each other's input, and at the end we mutually arrive at the correct answer together. It is equally important to show why a particular technique does not lead to the correct answer. In fact by showing several incorrect approaches to a particular problem, the students more deeply appreciate the final and correct approach to the problem. I say to them: "You are answering one of the most important questions that keep popping up in mathematics: why this way and not another?" I also find it very helpful and the students find it rewarding to write their answers on the board next to their names. Going through each answer, one at a time, I gently state, "Let us see what Jill has said," and "Let us go through what John has suggested." All of these efforts are done in an entertaining, enjoyable and non-threatening way. I never say no to a question, no matter how trivial or how hard it is. In fact, I emphasize to students that any question is appreciated by me and the rest of the class, and indeed, when I provide the answer I do so for the entire class. On some occasions, I divide the class into small groups of 4 or 5 students and give them a few minutes to arrive at a group answer. While they are working I stroll about the classroom, insisting on collaborative work and providing assistance as needed. In my own words and by example, I seek to connect the learning of mathematics and the learning of leadership skills that will help students live good lives and serve others.

Throughout the entire class, my vocal pitch changes to make sure they are awake, and the speed of my questions and answers vary

from very fast to very slow. On several occasions I demand what I call lightening-quick answers. I say to them the moment I lift my hand from the board I need you to hit me with the bolt of an answer and, to my amazement, the answers come back to me at high speed, with lightening-like gleam in their eyes and self-confident thunder in their voices.

It does not hurt to insert lots of humor, fun and magic into a mathematics lecture. I take a few minutes to explain the Goldbach conjecture, Fermat Last Theorem, String Theory, the four-color problem, the Honeycomb problem, and many of the interesting and easily accessible well-known math problems that have proven entertainment qualities. I share my research ideas in a non-threatening way with students. I tell them how much time it takes to finish a research problem, and much one can enjoy exploring the different ways that do not lead to an answer.

One final part of my formula for effective teaching is to realize that contact with students outside the classroom is as important as anything that goes on inside those four walls. Students share their experiences with each other-whether that experience was in my office, by e-mail, or an encounter in the hallway. These points of contact, in turn, have an enormous impact on one's teaching effectiveness inside the classroom. An open door policy is definitely a great idea because it will make a huge difference in students' cooperation inside the classroom. It also decreases the distance between the instructor and the student. Some students will love to share their dreams and thoughts with you;— in fact you might be the only one to listen and provide direction because such an opportunity may not exist at home.

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