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TRYING SOMETHING NEW: UNLECTURING MATHEMATICS

At some point during my teaching journey, I boarded the "transmission-by-telling" ship in viewing mathematics as best learned by listening. For years, I delivered polished lectures of codified mathematics and paid excruciatingly close attention to detail. I rarely made mistakes at the board, I kept the topics lively and current, and I sprinkled in a good dose of humor to keep everything light and fun.

Yet year after year, I would lose about half of my students to withdrawal or failure. Despite feeling I was doing a good job and hearing my students' praise for my "Michael Jordan-like instruction," I found little satisfaction in the simple fact that *too many of my students were not succeeding*. I even noticed that those who thrived in my classes seemed to equate mathematics with ritualistic acts. These students knew *how* to do things, *when* to do them, but almost never *why* we did them. I found this extremely troubling and viewed it as a failure on my part. For years, I asked myself the same two questions as if someday I would find the answers:

- Is math just plain difficult?
- Are students simply lacking prerequisite skills?

Feeling I was doing all I could do, it was only natural to cast the blame on the subject matter or the students. The only piece of the puzzle I repeatedly ignored was the one I had never previously questioned—the method of instruction.

Lecturing is ubiquitous in education. It would be difficult to come across a person who has never listened to a lecture or benefitted from one, for that matter. I was curious if uprooting this practice would lead to a noticeable difference in my students' success, retention, or attitudes. For the fall 2008 semester, I was scheduled to teach a course I had taught several times by lecturing—Introduction to Differential Equations. This class is a staple for students aspiring to be engineers or scientists. At the time, I was vaguely familiar with the work of Chris Rasmussen from San Diego State University; he had developed course materials for what he called "Inquiry-Oriented Differential Equations" (IO-DE). However, when I read additional research in this area, I grew skeptical of its supposed effectiveness. Students build on informal understandings which set the stage for more formal understanding? Students argue about mathematics, negotiate its meaning, and reach a consensus? How does such a thing unfold in the classroom? And do the students learn anything worthwhile? How much time is this going to take to implement? How were students going to learn about challenging and theoretical content? I had such deep reservations about IO-DE that I almost went back to Teaching 1.0. But the inner voice told me I had to try it out.

The format of my Differential Equations class from past years was very traditional. First, I would answer students' questions from the homework exercises. Next, I would begin "covering" the new material, mostly by lecturing. Throughout the period, I assessed student understanding by asking questions, giving independent/group work, reflecting on the tasks, etc.—nothing too formulaic, but by the same token, nothing spectacular. I would repeat this daily until the semester ended. I feel if you look inside classrooms today, you will find this practice in wide use, irrespective of the discipline.

IO-DE is radically different. Here, I spent only the first five or ten minutes of class "debriefing" the task for the day. Students worked in their groups with no prior knowledge of the mathematics and sorted through the challenges inherent in the task, often inventing their own vocabulary terms and resolving contradictory situations along the way. Meanwhile, I moved from group to group, playing the role of sounding board and steering groups back on course if need be. Toward the end of the period, two groups presented their work to the entire class. As a class, we then decided the legitimacy of the results. Finally, my job in the last ten minutes was to tie a knot on the day's work to ensure everyone grasped the essence of what was done, as well as how this new piece of mathematics contributed to our existing knowledge.

As a teacher, the most rewarding part of this experience was witnessing students' reactions to

the work of other groups. With very few exceptions, different groups would arrive at similar conclusions, but the *trajectory* of each group's work was tremendously valuable for the whole class to witness. As we approached the mid-semester point, there were individual students who were eager to share group findings. In other words, I no longer had to ask groups to present their work; they volunteered! This was truly a *community* of mathematical learning. Hello, Teaching 2.0.

What I found most gratifying, as a teacher, was speaking to students near the completion of the course. These exchanges made it clear that students had a deeper understanding of the content than in previous years—a likely consequence of communicating one's thinking in an open forum, putting developments into written work, and answering challenging questions from classmates. In my previous lectures, I was always struck by the number of students who could carry out mathematical tasks effortlessly, only to miss the underlying substance. With IO-DE, I found my students had a more satisfying experience with differential equations simply because they could see what was happening behind the curtain. The *reasons* for the rituals were illuminated fully.

When the semester ended, I took some time to reflect on this experience. What shocked me was that the very elements I initially had viewed as components of "effective teaching" were precisely the elements driving students to failure or withdrawal. Let me explain. In my previous lectures, it was all about *me* delivering the goods, I reported exclusively on "finished" results, and I avoided making errors.

Of course, when attending a lecture, one would expect this from the person standing at the front of the room! However, I simply began to wonder if lecturing was the most effective way to teach (and *learn*) this material. Over several years, I have realized that polished lectures send a tacit message that math is a finished body of work with little room for growth. Moreover, students view math as a solitary activity as a byproduct of lecture-based instruction. Despite being *unintentional*, this happens, nonetheless. Additionally, listening to the details of lectures made some students focus on mathematics at such a fine-grain size that they missed the conceptual heart of the topic. Finally, my "error free" board work told students that math was not an emerging science—it was right or wrong.

The IO-DE format challenged these assumptions directly. To start, students had to develop a significant piece of mathematics as a group. Individual input was important, but it was the *collective* group effort—the sum of the parts—that was valued. Second, the group's work was anything but polished as their findings were presented, refuted, and negotiated over the course of their struggles. In stark contrast, we did the "polishing" in a communal fashion. Third, one could easily argue that making mistakes and disagreeing were the most critical elements to group success. In short, the IO-DE course took everything I had assumed about "good teaching" and slapped it broadside.

I believe my saying that "teachers are resistant to change" is unlikely to stir the waters. I think most students, administrators, and teachers would agree with this statement. But I would recommend trying something new, if only to see what happens. I was pleased that my students now valued classroom time and felt better prepared for ensuing coursework. One student said, "I feel I know this topic better than any other math I've ever taken." Another replied, "I can't believe you let us figure it out ourselves. I've never been asked to do this, and I actually get it now."

As for me, the benefits were abundantly clear. In the two semesters I have taught IO-DE, only two students dropped the course; of those who remained, only one failed—all of this with the added benefit of a deeper understanding on the part of the students. Today, more of my students are completing the Differential Equations course with greater success. They are learning more along the way and having more fun doing it—all because I took the initiative to get out of my comfort zone and try something new.

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