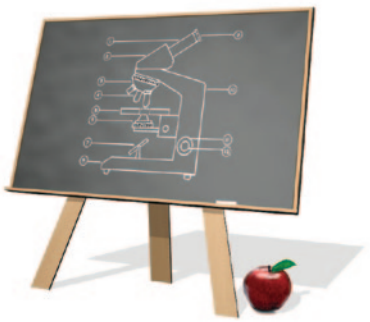
Promotion of Inquiry-Based Science Education: One Teacher's Story

The trials and tribulations of a hopelessly inquisitive mind.



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Every time I meet scientists, I like to ask what got them interested in their field. So far, of all the myriad reasons I have heard, not one has said "I always enjoyed doing problems and answering multiple choice questions."

A few years ago, I returned to teaching at a small private school in West Palm Beach, Florida, after several years of running my own business. I was extremely lucky, having been given a tremendous amount of latitude in my classroom. My first class, of both sixth and seventh graders, was an absolute delight to teach in every way. Although I was supposed to teach all subjects, I naturally gravitated towards the sciences. Lessons in social studies, English, and math were all based around scientific inquiry.

One day, we went out to a nearby canal and collected pond water. They first used some of the old, dirty microscopes that we had available. The students identified what they saw based on a printout I had provided. Their second task was to write a story using one of their "critters" as the main character for a creative writing exercise, fulfilling their daily English requirement. Finally, we discussed the role that bacteria played in spreading the plague in Europe in the 1400s and 1500s.

After my first year, I was promoted to the high school team, teaching science full-time. An empty 15- by 25-foot room was both my classroom and my lab. It would hold about 28 students at a time. Looking at the bare walls and the sole desk chair that surely could have launched a plague of its own, I asked my principal the fateful question, "What's my budget?" My principal snickered as he walked off, chuckling.

Teachers wear many hats over the course of their careers, and at this point mine was that of a purchasing agent/beggar for equipment. I purchased a lot of glassware using my own money and managed to secure donations for furniture and other major items. By the summer's end, I had amassed enough materials and equipment to teach a quality physical science class. Because there was no budget for books, I created a course, using state standards as a guide, that was inquiry-based.

The first lab was the classic "Does peanut-buttered toast land butter side up or down when dropped" lab. The students were apprehensive at first. I wrote the question on the board and asked the students what the answer was. The first five minutes were filled with conversation, but no real answers. Sensing that they were ready, I pointed to the loaves of bread and peanut butter in the back of the room and told the students to figure it out. For many of them, this was the first time in their lives that they had to figure something out on their own, without the security of the Internet or step-by-step instructions. Labs progressed in this manner—students devising experiments to develop the laws of physical science based on their own observations. All that was given to them was a demonstration or a question. The students were then encouraged to discuss and dissect the concepts to gain an in-depth understanding of not only *what* the concept was, but *why* it was.

At the year's end, my students showed a minimum of three grade levels of improvement in the science section of the SAT-10 standardized tests, used for progress tracking. I also had a well-equipped teaching lab filled with enough materials to do many simple labs. In addition, I also had $8,600 of personal expenses incurred for equipment out of my meager $24,000 salary.

I then attended the National Science Teacher's Association convention the next year in St. Louis, Missouri, at my own expense. This, plus my previous success, inspired me further. By then a for-profit educational company had purchased the school, so I was finally given a budget for textbooks, but not for materials. I chose a textbook emphasizing hands-on experimentation and continued to use my methods that I had developed previously. My goal was to give these students an experience similar to what I had growing up.

When I was in seventh grade in New Orleans, I was always bored with my classes. They weren't enticing enough for my inquisitive mind, so one day I decided to walk over and introduce myself to some of the professors at Tulane and Loyola Universities. One of them took me under his wing, allowing me to observe his research on bat tongues. He allowed me to bring in my own specimen to put in the SEM, and I was actually allowed to play with the controls! (Thank you, Dr. Hood!)

Naturally, given this experience, when I learned that a JEOL JSM-840 was available for donation, I took the opportunity to share this with my students. I hoped that they would no longer take a grain of sand for granted and realize that even the most common things can be immensely interesting. I spoke with my principal, and although wary, he was impressed by my methods and my proven success rate with hands-on teaching. The microscope was delivered a few days before spring break. I chose two student "interns" to help me move it into my second floor classroom.

Because there was no elevator, we dismantled the SEM in the first floor cafeteria, breaking it down into parts that could be carried up stairs. When we got the parts upstairs, before just putting it back together, we went over the functions of every part in

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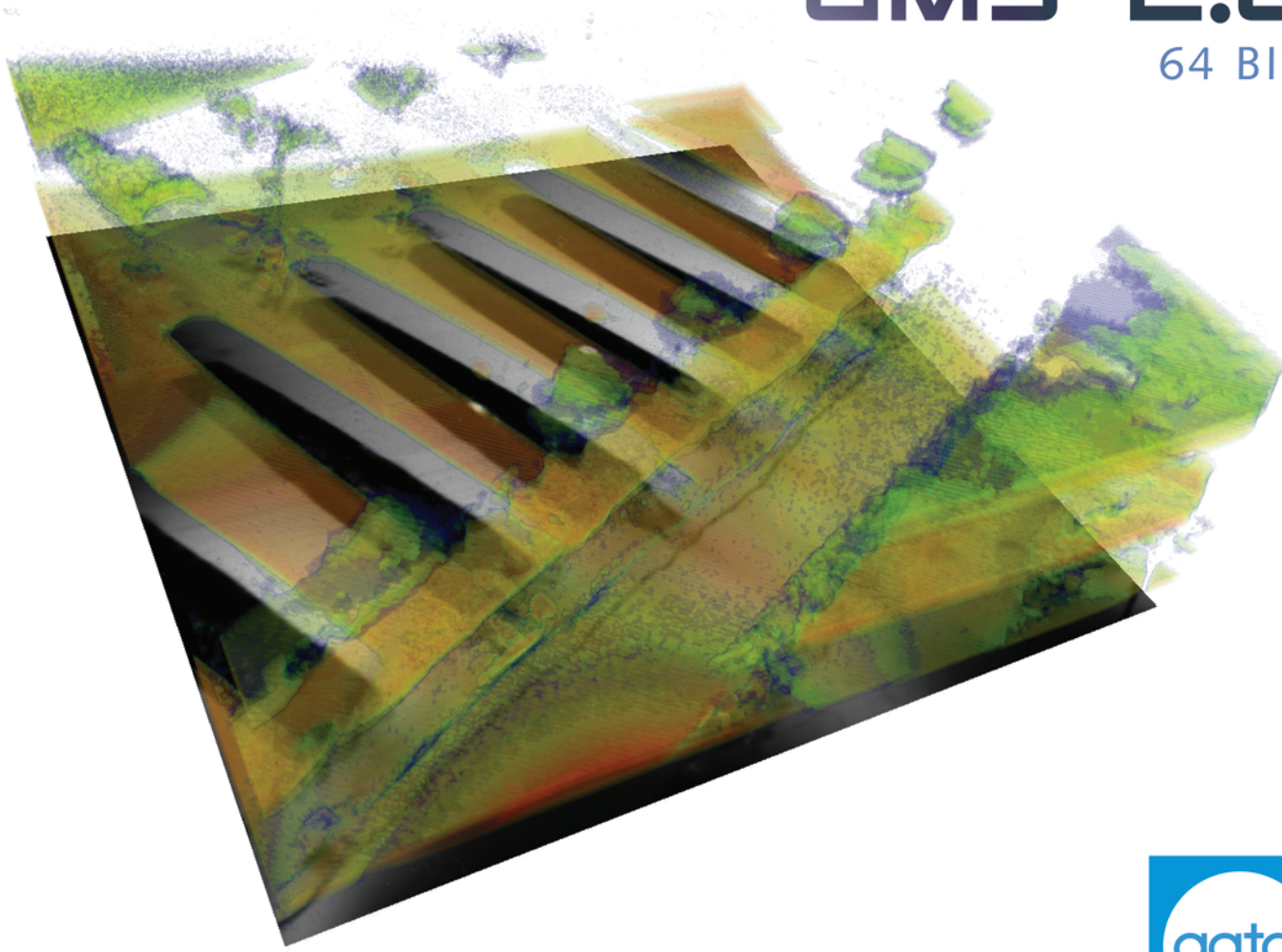

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An artistic rendering of an EFTEM spectrum image stack from a semiconductor sample. The data was acquired with a GIF Tridiem® energy filter using Gatan's EFTEM spectrum imaging software. The resulting data cube was rendered in GMS® 2.0. The extensive visualization tools and efficient large data set handling of GMS® 2.0 give you the freedom to explore data in new ways.

detail. We built a glass-lens analog of the SEM column and used a laser pointer to simulate the electron beam as it scanned back and forth on the "specimen" of our model. The students learned about signal generators, trigonometric functions, electronics, optics, and even a little quantum mechanics. We discussed electron mass and charge, and any other topics that came up. Much of this material was somewhat new to me as well, so I posted frequently to the Microscopy List server (a little too frequently, I admit...), getting wonderful feedback and technical information from the community. As I passed this on to my students, they realized how cooperative and supportive the scientific community could be.

After spring break, however, the corporation that ran the school began to rein in our principal's freedoms, and consequently my own teaching came under scrutiny. Various requests for small items were being denied from superiors in the corporation, and I was given less and less to work with. I poured even more of my personal resources into my class and managed to finish off the year achieving two to three grade levels of improvement with my students. I had proven to myself that hands-on education works at a higher level.

On the last day of school, I received distressing news that the corporation had eliminated my position. They decided that math and science were so similar, one person could teach both. The math teacher at the school had a master's degree, therefore she was obviously more qualified than I. This decision was to cut operating costs so that they could provide a greater return for their investors. I was told to have the SEM removed by the Saturday following graduation. I broke down the SEM, giving the parts to a local JEOL technician who turned out to be a good contact to have in setting up the next SEM. My personally purchased materials went with me.

My next teaching job was at a charter school. The principal knew about both my success rates and my methods. I was again given a tremendous amount of latitude in what I could teach and in the way I was allowed to teach it. I selected a high school forensics curriculum. It seemed the natural choice because student interest was high and it built on their previous knowledge of biology, adding a physical science component. Again, I secured a donation of an SEM, a JEOL JSM-35C. The students were eager learners and would come to class ready to devour whatever topics we were discussing for the day. Every day they were given a problem. To solve the problem, they had to incorporate lessons in biology, physics, chemistry, and many other disciplines—truly a wonderful integrated approach.

In Florida, public and charter schools are subject to the Florida Comprehensive Assessment Test (FCAT). Based on my previous experience, I naïvely assumed that if I taught by using hands-on instruction and challenging my students to answer their own questions, that they would pass the test without my teaching to it. My chance to prove this never came. In December, the board of directors met and decided the principal was making too many changes for their comfort level. She was summarily dismissed.

The new principal was fresh from the local school district administration office and had little creativity. She not only accepted, but also embraced, the standardized testing movement as a positive advance in education. She did not believe that anything should be taught using methods other than what had been done for years. Shortly after accepting her new position, she came to my classroom and told me to drop the forensics curriculum and handed me my new textbook, an FCAT preparation book. It was printed on cheap newsprint, and contained multiple-choice questions. For the next three months, my instructions were to drill, repeatedly. I was no longer allowed to teach; I became a constant proctor. This book did not teach critical thinking. It did not inspire inquiry. It did, however, catch fire really easily when I went camping and needed kindling. At least two questions in the FCAT prep book had incorrect answers. My challenge shifted away from finding ways to make material interesting. Should I teach them incorrect answers in anticipation of their seeing it on the actual test, thereby getting the question right by answering wrong, or should I teach them the correct answers and give them true knowledge? I was no longer allowed to inspire them to ask questions, I was required to teach them how to take a multiple-choice test.

After one week in this abyss from which no knowledge could emerge, I finally spoke to the new principal regarding my concerns. I showed evidence of my past successes and discussed the reasoning for my methods. Over winter break, the board of directors voted to eliminate my position stating that having two science teachers was redundant. Later, I discovered, they hired a replacement science teacher.

In 2006, *Wired* magazine published an article entitled "Don't Try This At Home." The article detailed, among other things, how schools were taking labs out of their curricula in favor of teacher demonstrations or video demonstrations. Science education has become more about facts and equations and less about discovery. To borrow a phrase from Richard Feynman, whatever happened to "the sheer enjoyment of finding things out?" Our complex world requires critical thinking skills that students do not get by memorizing facts and producing the correct answer on a test. I have seen the result of teaching actively, not passively. When granted access to equipment and problems that "working" scientists face every day, even jaded teenage students become excited and eagerly devour new information.

I have tried to get away from the sucking vortex of multiple-choice questions, but I have been shut down. Although I fully recognize that one person cannot save science education, I feel that I must try. As a community that loves science, we must bring back the wonder of science and show students our passion. For this reason, I am taking a break from the frustrations of teaching until I attain my PhD in physics. Perhaps that will give me the credentials to make a difference.

There have been discussions in the HS_SEM Google group, started by Margo Gill-Linscott, about what we can do to help teachers improve science education. Many in the community are willing to go to classrooms, host field trips, and talk to students. I want to encourage this, but with the caveat that it is not always easy for teachers to accept even free help. Despite my trials, I was very lucky for the freedoms that I was given in my teaching. I have been one of the lucky few. I have worked with teachers in south Florida who want to bring in people and equipment to enrich the education of their students, but their administrators have been against the idea. Unfortunately, it goes against the "conventional wisdom" of teaching. Hopefully, the educational world will soon realize what most scientists already know: science is not about regurgitation of facts. Science is about discovery. Perhaps one day, we can put that discovery back into the classroom.

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