Conant Award Address

Triple Point: Chemist, Teacher, Student[1]

Three Phases of a Substance Exist in Equilibrium

by Sally B. Mitchell

Sitting on the deck at my friend's house on a lake, with the fog seeming to march across the water in columns, I thought about the beauty of this scene as well as the states of gas and liquid, wondering how my students would fare with the terminology of these physical changes. I knew my friend thinks like a poet and I like a chemist, so I was tempted to start explaining a phase diagram.

When we examine changes in our science or in the classroom, I offer this well-known paradox found in chemistry: the only constant is change. As scientists, we are acutely aware of this irony but perhaps less so as educators. In chemistry, the smallest interactions can make the largest impact. I think this axiom applies to teaching as well. When trying to make profound changes in the classroom, it makes sense to start with the individual, so I will begin with these anecdotes about a couple of my former students.

Impact on Students

A former student, Ashley Blincoe, attended Syracuse University and joined my chapter of Alpha Chi Sigma (AXΣ), a professional chemistry fraternity. It was very exciting to watch her grow as a chemist and to attend pharmacy school. Ashley has, on occasion, returned to our school (East Syracuse–Minoa Central High School) to help celebrate Mole Day on October 23, bringing with her 20 AXΣ brothers to help in the celebration.

I fondly recall Shannon Oliver, a student of mine at the North Carolina School of Science and Mathematics (NCSSM) the year I started my family. On the first day of school, she raised her hand to inform me that she hated chemistry. At first, I thought, why are you enrolled at a school for science and math? Then I decided she was going to be my challenge for the year, and I went about changing her mind regarding chemistry. I began my little experiment quietly enough: I started a Chemistry of Cooking Club. At NCSSM the students live on campus and only go home on selected weekends, so this offered a perfect opportunity to introduce the students to food chemistry. I purchased the book, *On Food and Cooking (1)* and the rest, as they say, is history. That year we cooked and baked every week until graduation. During the special projects week (a week of research and no classes for the students) I took a group of students and first introduced them to food science issues in the business of restaurants, then to the laboratories of North Carolina State University (NCSU) to learn about aseptic engineering and food science, and to food labs in the chemistry department. Two of my students from this week of research went on to study food science at NCSU. Shannon grew up not to become a chemist but as a woman who understands and appreciates chemistry each and every time she enters a kitchen.

Diverging from food chemistry, I recall an experiment in embossing. One of my students, Christine Doherty, was certain that chemistry would be of no value to her because she intended to go into art and fashion design. During the lesson in which I have the students silver the inside of a Coke soda bottle, decorate it, and take it home, I decided to add another component to the lesson plan that involves embossing and rubber stamping. I taught them about the low-melting-point polymer in the embossing powders and allowed them to make as many cards as they could in the class period while waiting to silver their bottles. Christine discovered something in chemistry that she not only was good at but also loved. A few years later, I ran into her as she was selling her designer purses. She was proud to show me that her label is a hand-made, embossed card, just like the ones she made while in high school chemistry class.

Bringing Practical Applications into the Classroom

These stories are excellent reminders of the use of practical applications of chemistry in the classroom. I have worked very hard on my laboratory lessons, blending lecture and lab.

Sally Mitchell works with students during a morning research class collaboration with Bristol-Myers Squibb.

photos by Marcia Kelly

Commentary/Award Address

Students enter the lab with an idea of what they will be doing because they actually help to develop the lab during the prelab discussion. When my students leave the laboratory, they know why they were there, and they continue to talk about the lessons. I use many examples of food science in the laboratory, and one of my very first food labs of the academic year deals with the separation of a mixture. Instead of putting together sand, salt, iron, and rocks and asking my students to separate them in the lab, we use this example as a prelab. Then when the students come to lab, they are reintroduced to milk, the good stuff they are about to ingest during lunch. They are pre-tested on their knowledge of milk with questions such as: is milk a pure substance or mixture, what is the main component of milk, why is milk "healthier" to drink than soda, and most importantly, what substance contained in milk is responsible for making cheese? The students' initial misconceptions would be humorous to most scientists, but after they are done separating skim milk components, using changes in pH, they have an appreciation for and understanding of the making of cheese as well as the chemical components of this food group. From this topic, I lead the students to a discussion of cheese pairings, yogurt cheeses, and then take them to the culinary room to sample different kinds of cheese. I end the lesson with an American Chemical Society *ChemMatters* reading on cheese, which includes a recipe for lemon cheese *(2)*. After this lab many students make this cheese at home and serve it to their parents. It really makes the lesson meaningful to their lives, and students tell me that they never forget this integrated lesson and the many others to follow.

My oldest son, Robert, now a food science major at Cornell University, tells me that he became interested in food science while helping me run the events at Science Olympiad as well as helping me prepare for my many workshops on food science. I had never realized how much he enjoyed working with me in the lab or cooking in the kitchen and discussing the science behind the preparation. He attributes his passion for research and his work ethic as a chemist to these early lessons. This past semester, he participated on a student exchange at the Swiss Institute of Technology in Lausanne, Switzerland, and this past summer he worked as an intern in the Food Safety and Microbiology Department at a major Swiss company. I hope that these experiences help to make him the best chemist he can be. What I want for Robert is what I wish for all of my students—to find their passion and become life-long learners.

Am I a Student or a Teacher?

In the process of learning about my students and reflecting on the pedagogy involved in teaching them, I continue to evolve as a student and teacher. Where is the delineation between student and teacher? The answer should never involve position or status in a classroom. As we know, all good scientists remain curious throughout their lives. What makes a transcendent teacher rather than a merely good one is not only the need to solve that puzzling question of the day (when waking in the middle of the night) but the ability to seamlessly transfer that intensely inquisitive mindset to our students. My life as a chemist really began as a research assistant in the lab of Richard Tidwell, Department of Pathology, at the University of North Carolina, Chapel Hill. Of course, he taught me separation techniques and how to characterize compounds (in an age before computers were widely used), but he also allowed me freedom to learn from trial and error as I worked on the synthesis of organic compounds. He would step back and allow me to learn even when learning involved error, all the while giving me confidence as a chemist and instilling a passion for precise measurements.

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Advancement of Chemistry

Advancing the sciences, in particular chemistry instruction, has been my passion, and it is the reason I can never say no when asked to do something in teaching the sciences. I always seem to find a connection to the advancement of chemistry, so I volunteer at science fairs, do demo shows for elementary schools, participate in National Chemistry Week and Earth Day celebrations sponsored by the American Chemical Society, and work on research projects with my students. The list goes on. One event that I love is the Science Olympiad, a national competition that has really changed the way I teach. With Science Olympiad, I have gone from being an event supervisor at the regional level to head coach, regional coordinator, state event supervisor, and a national event supervisor. My greatest thrill is to sit back and watch students who have a passion for chemistry just for the sake of learning as they enter the chemistry laboratory outside of the school day.

Every Science Olympiad experience has made me grow and develop as a teacher and life-long student. My students' as well as my own favorite event is Experimental Design. I first learned of this event when my daughter Eilish competed in eighth grade and won first place at the state competition. She explained to me how it helped her in her science class, and how it might help my students write and design their own labs. While I taught her chemistry and the art of education, she was teaching me how to improve as a teacher. I am very proud to say that she has decided to become a chemistry teacher herself, majoring in chemistry at Syracuse University and recently becoming my fraternity brother in ΑΧΣ. Eilish is my greatest success story and I am so proud of everything she has done. Together with her inspiration and the design of this event, I have become a better researcher and a better teacher in an inquiry-based laboratory.

Professional Influences

We do not often stop to consider the influences on our professional lives, but I would have to state that in addition to Richard Tidwell, Marvin Druger, my freshman biology professor at Syracuse University, taught me how to motivate students as well as continue as a life-long learner. His lectures were full of slide shows, but his stories were full of passion. We had many opportunities to practice test questions before the "real" test, and he gave us clear objectives for learning. When I was a senior, he asked me to become one of his teaching assistants. From that experience, I was hooked on teaching. It was not long after that he helped me secure an internship with the City of Syracuse School District. Twenty years later, Druger found out that I had returned to the Syracuse area to teach, and he contacted me and inspired me yet again—to go back to Syracuse University for my Ph.D. He is still my advisor and very good friend.

Oddly enough, one of my greatest inspirations as an educator came not from the sciences but from my high school volleyball coach, Joan Sitterly. I met Joan when as a 13-year-old I was manager for the varsity volleyball team and she was the coach. Watching her coach from the sidelines, I learned both the game of volleyball and the psychology of coaching. For those of you who have played a sport or been involved in sports, you already know the parallels between coaching and teaching. If we are not able to motivate our students, they will quickly fall behind just as a player on a team will seem to disappear if not motivated. Joan was a great teacher, and I was inspired first by her example and then by the observations I had made while working with her. Years later, I found myself coaching a high school volleyball team. At my team's first game, I looked over at the referee—there was Joan Sitterly in uniform. She was still teaching, and I was still learning even as I taught my young charges volleyball. It is funny how when you coach a sport, practice makes perfect. If you make 9 out of 10 serves, you practice, so that you can make 10 out of 10 the next time. Yet in teaching, it seems too many people settle for what amounts to mediocrity for the sake of moving on. Chemistry builds and builds and builds. One piece out of place, and the reactions are all wrong. As a student, it took me forever to figure out organic chemistry, but once I did, I soared. There was such a gap between learning freshman chemistry and jumping into organic the next year. If someone had just told me to draw the Lewis dot structures and follow the electrons during the reactions, I would have arrived at understanding so much sooner. So, I like the coaching analogy with teaching and learning in that we have to work at it all the time to find the joy, the success that comes with discovery.

Changes in Teaching the Sciences

I started my career teaching biology and physics at Westhill High School in Syracuse, NY. Not long after gaining permanent certification, I ventured off to North Carolina for the experience of working in the field as a chemist in a pathology lab. It was in North Carolina where I met my husband, Joseph, married, and started my family of Robert, Eilish, and Stephen. When I returned to teaching eight years later, moving back to central New York to teach at Cicero–North Syracuse High School, I found much had changed in teaching the sciences. At first I couldn't put my finger on the cause of the change, and then it became clear: students seemed to have lost the ability to do the mathematics needed in chemistry and physics. They didn't understand the metric system and struggled with manipulation of units. As mathematics skills worsened, more students dropped out of chemistry and physics classes. It was during this time that I began to advocate for the universal adoption of the metric system in the U.S.

Advocating the Metric System

My passion for the metric system comes from the heart as much as from my scientific need for precision. I grew up in the U.S. during a time of change and a race to the moon. During that period, American schools were teaching dual systems, introducing the metric system. I grew up using and understanding the simplicity of this elegant, efficient system of measurement. I bought a Viking sewing machine and have always measured my seams by marking off 15 millimeters. When I look back on the time when we were using a dual system of measurement, I remember the confusion this created. In kindergarten, we learned to measure temperature in Celsius. The two points of references were the freezing point and boiling point of water. When I became very ill with the mumps at the age of five, my fever was so high I became delirious and even became permanently deaf in one ear; I remember my mother taking my temperature and becoming very anxious when my fever was 105°! I waited for her to return with the moistened washcloth to place on my forehead, and I anticipated the sizzle of the water boiling on my head. The sizzle never came, and I was confused. Many years later, as I began teaching, my 11th graders struggled with this same confusion. When I pretested my students on the first day of class, I asked them several questions about measurement. One question concerned the normal freezing point of water and another was the normal boiling point of water. Most students responded 32° and 100° respectively. When I pointed out the fact that they were using two different systems of measurement, they were baffled because they were not making the distinction. I then asked them the normal boiling point of water in degrees of Fahrenheit, and not one student knew that it is 212°. We don't need to confuse our students when it comes to measurement, a skill so necessary to science. We need to use the international system of measurement both in school and in the home. We, as chemists, need to pave the way and demand the full changeover to the metric system.

Characteristics of Good Teachers

When asked to define characteristics that I demonstrate as a teacher, my colleagues most often tell me, "Lots of energy and a passion for learning". East Syracuse–Minoa Schools superintendent Donna DeSiato kindly wrote, "Sally Mitchell is most deserving of this prestigious award and is a shining example of a distinguished educator. Her enthusiasm and passion for learning combined with her ability to ignite students' quest for under-

standing the world though chemistry is recognized and valued by colleagues, administrators, parents, community leaders, and most of all by the students who benefit directly from her work in the East Syracuse–Minoa Central School District." Because none of us works in a vacuum, however, I think many would also add that I like to collaborate with my colleagues in coming up with new and intriguing ways to present material to our students. When I was a student teacher, Jamie Cucinotta was my master teacher. To this day, we still collaborate, talk chemistry, and put our thoughts into action. We have done several demo shows all over the country, attended National Science Teachers Association and Chem Ed national meetings, and held teacher workshops every year to help new chemistry teachers feel more comfortable in the classroom. Collaboration is a way of approaching the teaching profession that I value. Thinking back to 1997, it was then that I developed a periodic table activity with Daniel Wright of Elon College. We presented it at Chem Ed in Minneapolis/St. Paul, and companies offered to publish it for chemistry teachers *(3)*. This was a very exciting time for me because I had put so much into writing the directions, teacher notes, and student worksheets.

Professional Development

I have never stopped learning. Professional development is very important in the life of a teacher. Since I became certified in chemistry, physics, and biology in 1982, I have attended national conferences, summer workshops, and taken many graduate classes to improve my content knowledge. I am now certified to teach mathematics, and I am nearing completion of my Ph.D. in Science Education, working on my research apprenticeship and dissertation. Working on my Ph.D. has really opened my eyes to action research. It has made me more acutely aware of different learning and teaching styles, special education needs, and mentoring new teachers. During my Ph.D. coursework, I took a course in writing for the professional. One of our assignments was to write a book review. I subsequently submitted the review to the *Journal of Chemical Education* where it was published several months later *(4)*.

As scientists, we are all in collaboration with those great minds that have come before us. We do not teach or learn in a vacuum. While in college, I joined the professional fraternity, AXΣ, and became an ACS member. Membership in these two organizations has helped me grow and meet other chemists, science educators, and friends. Several winners of the Conant Award are my fellow AXΣ members, and when we attend meetings, we recognize this bond. When I presented a workshop at Chem Ed in 1999 at Sacred Heart University, I presented a talk on the history of the periodic table from the very beginning to the works of Glenn T. Seaborg, also a member of AXΣ. The talk was standing room only, and many people came up to me after the talk to introduce themselves as members of our professional fraternity. For Christmas this past year, I gave my two oldest children, Robert and Eilish, a membership in the American Chemical Society.

Connecting with Students

As I look to the future, I hope that all educators will advocate for new and innovative ways to reach our students. It was during the Chem Ed convention in 1997 that I first watched a group of Creighton University students perform a demo to music. With the help of my daughter, I have developed many demos accompanied by music to match the theme. This technology helps me keep in touch with the students, and I use their interest in pop culture to connect with chemistry. Students tell me that every time they hear a particular song, they are reminded of the demo that I did to Billy Joel's song "We Didn't Start the

About Sally Mitchell

Sally Mitchell earned a dual Bachelor of Science Degree in Chemistry and Biology from Syracuse University in 1982. She continued her studies at Syracuse and completed her M.S. in Science Education: Chemistry Grades 7–12 in the following year (1983). She is currently working toward a Ph.D. in Science Education at Syracuse University, which is expected by May 2010. The 20 years between her M.S. and Ph.D. studies were richly filled with informal learning experiences gained in the classroom, school laboratories, university research laboratories, professional workshops and meetings, and extensive community service work. She currently teaches Advanced Placement and Syracuse University Project Advance chemistry, honors chemistry, and general chemistry at East Syracuse–Minoa High School, East Syracuse, NY. She is also the advisor to the Metric Club, a science club dedicated to using metric-only measurements in all that they do such as the Adopt-a-Metric-Highway, all 3 kilometers worth.

photo: Peter Cutts Photography

Sally Mitchell at the award podium during the 237th ACS National Meeting in Salt Lake City, Utah.

Fire". The demo involved hydrogen peroxide and yeast, and baking soda and vinegar. As chemists know, the carbon dioxide puts the flame out, but when Joel sings, "we didn't start the fire", I put the glowing embers into the oxygen tube, and the flame bursts back in full force.

Teachers know that what defines an effective teacher is not content knowledge or understanding of pedagogy alone. Compassion for children, an ability to work with others in the field, a willingness to share this knowledge with colleagues are also critical, but there is the other face of a teacher. The one that is shown to students outside the classroom in being aware of their needs, their busy, complicated lives... planning around big events like the school play, band competitions, sporting events, the dances, SAT testing, and so on. Great teachers help students plan and coordinate their study times, balance their social events, and, most of all, find connections. When the students are reading Arthur Miller's play *The Crucible,* I ask them to explain the plot, and I discuss both the symbolism and the chemical reference to the crucible in a chemistry laboratory.

The Conant Award and the Future

After all of these lexemes, it is possible to sum up what winning the James Bryant Conant Award means to me: opportunity for change. As an award-winning teacher, my voice may receive a wider hearing, and I hope to help my fellow chemists make a change in the way we teach measurement. I have long been a proponent of the value of teaching and using the metric system, as does the rest of the scientific world. The opportunities that may present themselves because of this award are welcome and may come in the form of meeting new colleagues, exchanging ideas, and discussing pedagogy; or they may occur in the classroom, directly benefiting our students as administrators give additional weight to requests for more investment in lab materials; or they may come in the dialectic with my students and my own children who have an interest in education and science; or they may come in the form of making a lasting impact on science education as I take part in promoting the great changeover to the metric system in American schools and culture. I will remain a chemist, a teacher, and a student for the rest of my life, evolving as I go, and now I have an opportunity to make my voice heard in the political battle to change our system of measurement and enter the 21st century of science and culture. You already know the date we are aiming for: 10/10/10.

photo by Marcia Kelly

Jamie Cucinotta and Sally Mitchell present a demonstration during a new teacher workshop.

Note

1. The recipient of the Conant Award usually responds to a set of questions by the *JCE* staff; the edited responses then appear in the *Journal*. In this instance, however, Sally Mitchell preferred to adapt her award address to the print medium, which appears here.

About the Conant Award

James Bryant Conant Award in High School Chemistry Teaching

This award of the American Chemical Society is intended to recognize, encourage, and stimulate outstanding teachers of high school chemistry in the United States, its possessions or territories, at the national level. Thermo Fisher Scientific, Inc. sponsors the award, which consists of $5000 and a certificate; reasonable travel expenses to the national ACS meeting at which the award is presented will be reimbursed; a certificate will also be provided to the recipient's institution for display.

Any individual, except a currently enrolled student of the nominee or a member of the award selection committee, may submit one nomination or support form in any given year. Local Sections of the ACS are especially encouraged to submit nominations for the award. The nominee must be actively engaged in the teaching of chemistry in a high school (grades 9–12). Information about candidate's attributes as well as nomination procedures is available from the American Chemical Society: go to *http://www.acs.org,* choose Funding & Awards; Awards; National Awards; then find the James Bryant Conant Award in the alphabetical List of National Awards.

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2. Baxter, Roberta. *ChemMatters* **1995**, *13* (1), 4–7.
3. Simulator, Development of the Mendeleev Periodic Table. *http://www.carolina.com/product/mendeleev+periodic+table+simulator.do?keyword=simulator&sortby=bestMatches* (accessed May 2009).
4. Mitchell, Sally. Review of *Encyclopedia of Forensic Science* by Suzanne Bell. *J. Chem. Educ.* **2004,** *81,* 1122.

Supporting *JCE Online* Material

http://www.jce.divched.org/Journal/Issues/2009/Sep/abs1013.html

Abstract and keywords

Full text (PDF) with links to cited URL and *JCE* article

Supplement

Word document with individual activity sheets for:

Milk Is a Mixture: prelab, information sheet, yogurt cheese recipe

Molarity of a Solution KoolAid Lab: student handout and teacher notes

Candy and the Chemist: prelab

Making Perfect Fudge: prelab, recipe sheets

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