ARCHIVED BLOG POSTS:

Gerri St. Clair, Chemistry Teacher, Sullivan South High School, Kingsport, TN

Modeling Instruction has changed the way I teach chemistry

I have taught Chemistry at Sullivan South High School for 20+ years and nothing has changed my style of teaching more than attending the Modeling Chemistry workshops for 10 days each in June 2012 and June 2013 at East Tennessee State University. Modeling Instruction for teachers began in Physics in 1995 at Arizona State University and was expanded to Chemistry in 2005. A Modeling Biology course is currently under construction. Thousands of teachers across the nation have been trained in the modeling approach since its inception. Modeling instruction is a very student-centered approach to teaching and I firmly believe that it is the best way to teach chemistry. Also, it closely parallels the Common Core key points of reading, writing, speaking, listening, language, and media and technology by providing rigor with a greater depth of understanding chemistry. The activities and exams focus on students being able to explain their thinking and to illustrate their thought process with diagrams instead of traditional fill in the blank and multiple choice questions.

Modeling Instruction introduces chemistry by using particle models that increase in complexity as the students progress through the course. The course is divided into units that answer essential questions about how particles are arranged, how they transfer and store energy, how we count and measure them, and what internal structure they possess. Each unit begins with an investigative lab that is used as a springboard for discussion and expansion of the particle model of matter. Other lab activities occur within the unit as the particle model needs modification. This approach makes chemistry more concrete rather than abstract and there are three outstanding observations that convinced me that this approach is far better than the traditional way of teaching chemistry.

The first observation that I noticed when I implemented Modeling Instruction last year was that my students were actually having in-depth discussions about how the particles were behaving under the given conditions and how they should be represented on their whiteboards. The level of interest in what we are discussing in class has greatly increased and students seem to really enjoy working productively in groups. Each group must present their whiteboard to the class and be able to answer questions about their particle diagrams. The comments that I hear are “Do we get to whiteboard today?” and “I love whiteboarding.” Also, I have frequently heard,” Is class already over? Wow, time flew by.” I am also pleased to see that most groups take great pains to make their whiteboards colorful and well-illustrated. Groups are changed with every unit so that students don’t get accustomed to the same people and the same role within the group.

Secondly, I have noticed how much my second year students remember from last year. Usually, they can remember hearing the vocabulary, but their recall of concepts is sketchy. The Modeling approach relies on the particle diagrams so much that students can predict how matter should behave by drawing a diagram. My main prompt to help them figure out why matter behaves as it does is to remind them to either visualize or draw a particle diagram. Just recently, we were talking about gases and most remembered how to predict gas behavior and how to work out a gas law problem a year later from

when they were taught the gas laws. We do not memorize formulas. They learn how to use what they saw in lab and apply it to particle models.

Lastly, a comment made in my post-evaluation conference with one of my assistant principals fully convinced me that Modeling Instruction is superior to traditional instruction. After the assistant principal listened to class discourse and witnessed whiteboard discussions of particle diagrams, he commented that the class was surely full of honor students. On the contrary, only 4 of the 25 students were enrolled in honors classes. Depth of understanding was evident in their discussion.

Modeling Instruction has been a little bit of a bumpy road to travel and has its challenges. Students are accustomed to "regurgitating" information and they have to be taught how to explain why a scientific phenomenon occurs. Students are not used to dealing with the depth of understanding that is required by the course. I truly believe that after a few years of Common Core I will have students that are used to working problems, explaining their work, and diagramming their thought process. Are the challenges worth it? Absolutely. In the past, students could work problems, but they couldn't explain why the answer made sense. Now, I feel that students are more challenged and that they leave with a greater understanding of chemistry. I am a convert!

Tim Smith, Eighth Grade Math and Algebra 1 Teacher, Bristol City Schools

As the math standards keep changing, the lessons learned from the Eastman Scholars Mathletes program stay constant. (The Mathletes program is a partnership between the ETSU Center of Excellence in Mathematics and Science Education and the Eastman Chemical Company.) I just completed the Mathlete program for the second time. The first time I went through the program I was amazed to learn that it really is ok to slow down and go deeper with each standard. As I began to make changes to my teaching strategies I noticed a rise in my test scores. Is this by chance? I think not!

Most recently, as I went through a second round of the class, I paid attention to the task-based teaching. I learned more about how to be a facilitator, not just a giver of information. I have already implemented the five elements taught to us by Dr. Ryan Nivens. (Dr. Nivens is one of three instructors who teach in the program.) When doing a task my students are to write an equation, create a table, write the process in words, draw a graph, and draw a picture. My students are getting better at showing their knowledge using these elements which is improving the justification of their work.

Overall, I have learned to be a facilitator; a facilitator is more than just standing around. It is being able to connect with all my students and challenge each one at his/her respective level.

More information about the Eastman Scholars Mathletes program can be found on the Center's web site: (http://www.etsu.edu/cas/math/mathexcellence/).

ARCHIVED BLOG POSTS:

Amy Hammonds and Rebekah Asbury, STEM Lab Instructors, Newport Grammar School, Newport, TN

Newport Grammar announces the start of a new STEM lab program for all students in grades 1-8. Our program strives to be an innovative and student-centered approach to learning. While in our school's two STEM labs, students are working together on projects based on real-world issues. Examples of projects our students have worked on this year include: Engineering with the Three Little Pigs, Proving Photosynthesis with *Elodea*, Designing and Constructing a Mechanical Reacher.

Technology is integrated as a component of our STEM labs. Our older students use iPads in STEM lab, while our younger students use iPad minis. We are learning how to best use this technology along with our students. And we are currently building our library of useful apps.

Funding for our STEM lab program comes from a variety of sources, including the ETSU Northeast Tennessee STEM Innovation Hub and the Niswonger Foundation. We have also been fortunate to receive financial support from local businesses and community members. Local funding was obtained after our principal, Mrs. Sandra Burchette, sent letters to community leaders informing them of our plans and goals.

With our school year in full swing, our biggest lessons learned are as follows: pacing must be slow and thorough to allow students ample reflection time; we must cheer our learners on as they struggle with real-world mathematics, especially when done without a calculator; and we must explicitly explain that *failing* is a necessary step toward success.

Our students are very excited about the technologies they are using, and we are equally excited to be a part of this innovative approach to teaching and learning.

Thomas Rutherford, Chemistry and Astronomy Teacher, Sullivan South High School, Kingsport, TN

I am a science teacher at Sullivan South High School in Kingsport, Tenneessee, where I have taught Chemistry for the past 23 years and Astronomy for the past fifteen years. South is one of the very few schools in Tennessee to offer astronomy as a science course.

I first became interested in student research in 2003, when I participated in a National Science Foundation (NSF)-funded variable star workshop put on by East Tennessee State University (ETSU). I realized that it was the sort of project that I could do with my students, if only I had the necessary equipment (I already had the content knowledge that I needed). I set about acquiring the needed materials by writing two grant proposals—a Tennessee Space Week grant, offered by the Tennessee Education Association (TEA) and a Putting Children First grant, offered by Eastman Chemical Company. I was successful in both cases, receiving $1000 from the TEA and $500 from Eastman Chemical. These funds were used to purchase a laptop (a big deal in those days), a CCD camera, and a couple of other

items that were required for the project—the school already had a telescope that I was planning on using—a local college (now King University) provided a photometric "v" filter.

The title of the project was "Using Small Telescopes for Variable Star Photometry." Most of the students in my Astronomy class that year were involved with the project and it was successful—we did manage to acquire data on two variable stars and submit it to the American Association of Variable Star Observers (AAVSO) for archiving in their database. However, even though there was a great deal of student involvement, this was not a research-based project—it was merely a "hands-on" opportunity for students to gain some insight into photometry.

In 2005, when I was selected to go to Kitt Peak as part of the RBSE (Research-Based Science Education) program (TLRBSE was what it was called that year). RBSE was a program that taught teachers how to do student research with their classes. Prior to the trip, we were allowed to pick from several possible projects to work on and we were assigned to those projects once we arrived in Arizona—my particular group worked on the nova rate in the Andromeda galaxy (M31).

I came back from Kitt Peak all fired up about having my students do research and promptly fell on my face with it-- I wasn't nearly as ready as I thought I was. One of my problems (there were several) was that I tried it with my entire Astronomy class, thinking that they would be just as thrilled with doing stuff like this as I was (they weren't)-- after a couple of weeks, I realized that it wasn't working and stopped.

The next year, I tried a different approach-- I went to the AP classes as well as my astronomy class and asked if anyone was interested in an astronomy research project. I was able to offer the carrot of a possible trip to Arizona since I was allowed to apply for telescope time through the RBSE program so that might have helped get some students (I ended up with three students who were interested). We didn't get to go to Kitt Peak that year, but were able to get some data through New Mexico Skies Observatory (another benefit of the RBSE program). In the subsequent years, I was again able to get students who were interested in a project—on two occasions, the student groups and I were successful in our bids for telescope time at Kitt Peak. We flew to Arizona and spent 2-3 nights using the 0.9 meter WIYN telescope. Unfortunately, funding for the program eventually expired and the RBSE program ended.

A benefit of the RBSE program was that they had a peer-reviewed publication, the *RBSE Journal*, to which students could submit their research papers for consideration for publication. My students were writing proper scientific papers at this point and so all of them eventually were able to get their papers published in the journal.

Once the RBSE program ceased, I looked around for another venue in which my students could publish their papers and found the *Proceedings of the Tennessee Junior Academy of Sciences*. This publication, published by the Tennessee Junior Academy of Science (TJAS) is also a publication that is set up to publish scientific papers for Tennessee students who are winners in the TJAS competition. The TJAS program is administered by the ETSU Northeast Tennessee STEM Innovation Hub.

ARCHIVED BLOG POSTS:

Over the intervening years, I have managed to get 15 students to do some sort of research project, usually in groups of two or three, but sometimes by themselves-- we do not have a research class here at school so they do all of this work in their spare time (and in mine).

In late 2012, I was selected to participate in the NASA/IPAC Teacher Archive Research Project (NITARP). This program is designed so that teachers can do actual astronomy research, not just direct their students—the students and their teacher(s) are part of a research team directed by a scientist from Caltech/ JPL. I traveled to the 2013 AAS conference in Long Beach, California in January to meet the other teachers in my research group. Once I returned from Long Beach, I began looking for students who would be interested in participating in the project—eight students came forward, although four of them dropped out after a few weeks.

In July, 2013, two of the students and I traveled to Pasadena, California to spend a week at Caltech working on our project. Our project involved attempting to come up with a color-magnitude diagram for active galactic nuclei (AGN). If successful, such a diagram would help to determine the scale of the universe. In January, 2014, I and the other two students (the one who did not get to go to California) will be travelling to the 2014 AAS conference, this year in Washington, DC., in order to help present the group's findings, along with the teachers and students from the other schools.

With an eye toward the future, I currently have one post-NITARP research student who is in the planning stages of her project. Her data will probably be supplied by SARA, the Southern Astronomical Research Association, of which ETSU is a member. It looks like for the foreseeable future, student research will continue here at South and I am glad to be a part of it.

Susan Quave, Middle School Science Teacher, Johnson County Middle School, Mountain City, TN

As a veteran teacher, I realize how important it is to engage students in real world experiences. However, I truly witnessed this concept at the beginning of this school year when I received a grant from the ETSU Northeast Tennessee STEM Innovation Hub to purchase an Apple TV and an HDMI Flat screen TV. It makes perfect sense to present information to students via the technology that most students are using on a daily basis. With the influx of Iphone's, Ipad's, ITunes, IMovies, Twitter, Texts, Facebook, YouTube, and the like; what better way is there for teachers to stay connected to students? Most importantly, what better way is there to develop and enhance the students' interest in STEM, thus preparing them to enter college and the STEM workforce?

The first day following the installation of the Apple TV system in my room was as exciting to my students as it was to me. They were mesmerized by the images, the technology, the Apple TV screen saver, the YouTube videos, digital whiteboard apps, sounds, and the ability to quickly change from Science 360, to TED Talks, to PBS, to Northeast State, to Walters State, to NASA, to Mars, or any other app quickly and efficiently. They were engaged and interested in seeing

the National Geographic Parks or the ability to go on Virtual Field Trips anywhere in the world quickly and digitally.

Students can't wait to get to my classroom and watch a forty second video on the evacuated tube transportation system, or the newest hybrid technology, or the most improved robot of the future, all of which become great classroom starters and brain accelerators. I can honestly see their interest peaking in the STEM areas of engineering, medical breakthroughs, clean energy, electronics, digital media, and many other areas of interest. These experiences are creating an environment in which many great ideas are generated for project-based learning activities.

And speaking of apps, I have discovered there are many that offer experiences that are not possible through other printed materials such as textbooks or web sites. I am also experimenting with preparing innovative and engaging lesson plans from selective apps as well as "spicing up" existing lessons plans. I have been truly impressed with how Apple TV can serve to level the playing field for students and engage them in learning skills so necessary for college and career.

Technology like the Apple TV can keep teachers connected with students or even facilitate the connection. Technology is their world. STEM is their future. I can feel the creativity and the inventions brewing in my classroom, and I can't wait for it to unfold. It's all about the connections!

Vanessa Greenlee is the 7th grade Language Arts Teachers at Innovation Academy of Northeast Tennessee

"These kids have learned so much," I think to myself as I watch my 7th graders present their last STEM projects of the year to an audience of external evaluators. Board of Education members, reporters, engineers, scientists—all keep approaching me with wonder on their faces to report how thoughtful and provoking the students' designs were after they reengineer some fourteen commonly-used household items.

Ritz crackers housed in an Oreo-style tray for ease of access, nail clippers enhanced with an adhesive sandpaper strip to improve the grip, deodorant applicators with a small loop applied to the inner-most plastic seal to make the container easier to open—all have been designed by our 7th grade engineering teams with a researched target user in mind. These student-improved product prototypes were created with materials bought through purchase orders that the students requisitioned themselves, and then the prototypes were tested, modified, and retested using testing procedures that the students designed. It's all pretty impressive work for twelve and thirteen-year-olds.

I grin with pride as I see one of my students walk several steps forward to extend a hand and confidently draw the next evaluator into the fold of his team's ready presentation pitch. It was not that long ago—August, to be exact—when many of these same students were shaking with anxiety at the prospect of presenting their itineraries for an Olympic recruiting trip to a group of adult coaches. In class I tell my students, "In business and in

industry, it doesn't matter how impressive your idea is if you can't communicate it intelligently to the right audience." Everyone in this exhibition hall today is noticing how much more confident our Innovation Academy students are with their communication skills compared to where they were last fall.

As I watch, I am so proud of the language arts skills my students have gained.

I'm not sure how common it is to think of a language arts teacher as being relevant to a premier middle school STEM academy. The truth is, I've learned this year that the role of the language arts teacher in a STEM program is nothing short of essential. My job is to help these STEM students gain the collaboration and communication skills they need to bring their science, technology, engineering, and math skills to fruition in the job marketplace of the 21st century.

Each of the eleven STEM curricular units we've designed this year at IA have contained an integral English Language Arts component. For example, as part of our Agriculture Unit, students learned to write attention-getting hook sentences and use an inverted pyramid organizational structure to write newsletter articles about our 500 rainbow trout eggs. As part of the Fossil Fuels Unit, students designed drills and then used text features such as titles, subtitles, captions, and sidebars to write about their prototypes in a clear and organized way. After our Transportation Unit, students presented vehicle modifications to the Army Corp of Engineers and learned valuable presentation lessons about tone, transitions, and anticipating an audience's needs.
A growing body of educational research is beginning to confirm the relevance of writing and communication instruction in the 21st century STEM classroom. For example, Dr. Judy Willis of UC Santa Barbara has recently published a thought-provoking paper entitled "Writing Sprouts Conceptual Brain Networks from the STEM of Math and Science." Willis attests that "through writing, students can increase their comfort with and success in understanding complex material, especially when the subject has unfamiliar concepts and subject specific vocabulary." Our work at Innovation Academy this year incorporating the English Language Arts into STEM studies certainly supports Dr. Willis's findings.

The exhibition hall is beginning to clear now, and one of my 7th grade students approaches me, his face beaming. "Mrs. Greenlee, we followed up with the mayor and asked him for a business card. Our group wants to network with him some more about his ideas for communicating our Ritz packaging modification to Nabisco!" These are exactly the presentation and communication skills the marketplace is telling educators that we need to cultivate in students to build a stronger STEM workforce.

I'm thinking that for tomorrow's STEM lesson, students will study the appropriate tone and formatting one should use when writing a business email. It's true—at Innovation Academy our kids are learning about science, technology, engineering, math, and so much more. I am thrilled to be along for the ride.

ARCHIVED BLOG POSTS:

Charles Miller, Senior Chemist, Eastman Chemical Company

STEM education is important for three primary reasons. First, it is critical to our economy's future to prepare students for high demand jobs. Second, all citizens will need a STEM background to understand and participate in an increasingly technical society. Third, science and math are fundamental to understanding and appreciating the universe. STEM is important to me, my employer, and my community. I am an analytical chemist for a major manufacturer, Eastman Chemical Company. Analytical chemists develop techniques of detection and measurement, essential for any science and necessary for quality control and safety in a manufacturing environment. There are also many non-technical roles at Eastman (such as sales, law, HR, etc.) that must function within a STEM business. In addition, I am a Board member of the American Chemical Society (ACS) and support our mission to "educate the general public about the importance of chemistry in our lives". This mission is facilitated by initiatives to advance STEM education.

My initial interest in chemistry was philosophical. There are many paths to different understandings of how our world functions and our place in it. Many millennia have produced many philosophies that can be debated ad nauseam in the absence of data. In a few short centuries, amazing insights have been produced by the objective, verifiable process of science. It is a means of determining which explanations correspond to what is measured. Data can dispel ideas that seem reasonable to the existing cultures and paradigms. Therefore, STEM plays a role in moving humanity forward. Chemistry, with physics, is fundamental to all known processes in the universe. An appreciation of these fields allows one to share in the excitement of discovery and participate in solving the critical issues of our day. Society has shifted dramatically to a science and technology basis due to both the practical innovations that improve our lives and the discoveries that enhance our understanding. The Big Bang, fundamental particles, formation of the Earth, life, the brain, our mind, climate, health/disease, the future are all topics that are described and understood in scientific and mathematical language.

STEM education has become increasingly necessary for all people. It is necessary as an informed consumer to understand product efficacy as well as the ecological, health, safety, economic, and other impacts of our choices. It is necessary for an informed electorate as we wrestle with political issues of a technical nature, such as global warming, energy, genetic engineering, medical care, and other topics. It is necessary for making healthy decisions, including those about diet, exercise, lifestyle, diseases, and treatments. STEM has a permanent and growing presence in all our lives. This makes STEM education of the utmost importance to a thriving society and to you individually.

Todd J. Barber, Senior Propulsion Engineer, Jet Propulsion Laboratory, Pasadena, California

I recently had the great honor and privilege of visiting the tri-cities area (Kingsport, Johnson City, and Jonesborough) in Northeast Tennessee for the National Storytelling Festival and a NASA Education Workshop for local K-12 STEM teachers. In fact, I have been blessed to enjoy this opportunity for the last few years, thanks to the generosity of my home institution, NASA's Jet Propulsion Laboratory (JPL) in Pasadena, California, ETSU Northeast Tennessee STE M Innovation Hub, and the Cassini Mission to

ARCHIVED BLOG POSTS:

Saturn Outreach Office and Alice Wessen in particular. I feel it is important to "give back" to the education community that gave me so much, helping me realize my dream job as a propulsion engineer on some of NASA's most storied robotic planetary missions. In my twenty-two years at JPL, I've been fortunate to work on the Galileo mission to Jupiter, the Cassini mission to Saturn, the Mars Exploration Rovers (Spirit and Opportunity), Deep Space One, Deep Impact, and Stardust (three comet missions), and most recently and visibly, on the Martian rover, Curiosity. Quite literally from childhood, I dreamed of working at JPL, building upon missions such as the Voyager mission to the outer planets and the Viking landers on Mars. In fact, these two missions inspired me directly to pursue B.S. and M.S. degrees in aerospace engineering from MIT and attain my childhood dream job. This is my first job, and I hope it is my last—but I wouldn't be here without the great support of my K-12 public school teachers, particularly those in STEM disciplines.

Even though our society is becoming more and more tech savvy, ironically we know less and less about the technology we are using, and increasingly it is designed and manufactured outside the U.S. Inexpensive third-world labor certainly contributes to this, but so does the lack of STEM emphasis and careers within this country. Study after study shows STEM skill preeminence slipping in the U.S. vs. other countries in the world, and to me this trend is heading in the wrong direction for the 21st century. I believe NASA and other organizations may be uniquely qualified to help inspire students into STEM careers, because of its broad public appeal and "coolness" factor. Thankfully, NASA and JPL devote 1-2% of their total project budget to outreach efforts, and within the very real time constraints of my "day job," I try to do as much outreach as possible. Watching teachers in the tri-cities area "light up" during our recent educator workshop makes all of our efforts to travel across the country worthwhile. When a teacher tells us they will use our curriculum materials directly in their classroom, that year, we know we have helped make a difference, and that is our fondest goal. In addition, visiting local TN schools directly and speaking with students, parents, and teachers about (for example) landing a 2000-pound "car" on the red planet helps me remember why I love my job in the first place.

I am very appreciative of my K-12 public school education in Kansas, particularly the tireless support of my own STEM discipline teachers. Many days after school, my middle school chemistry teacher would stay behind, helping me execute the most bold experiments I could find (likely at great personal risk!), never fretting about coming home from school late most evenings. My high school math, physics, and astronomy teachers were unbelievably gifted educators, too, nurturing every bit of natural interest I had in math and science. If I have helped give back to K-12 education through my outreach work, even a little bit, it is well worth any effort I have put forth in this arena. My favorite high school math teacher wrote something in my yearbook that I keep with me always. She said, "Whatever your successes in life, please take a little piece of me along with you." I've never forgotten that, as I hope the students, teachers, and parents with whom I've interacted in TN will fondly remember our time together, as I do. I hope I have inspired a few students in the tri-cities area to pursue STEM careers, for that is the true purpose for my annual visit in October every year. I also wish to thank everyone who enabled our NASA outreach odyssey in northeastern Tennessee, particularly Dr. Jack Rhoton, the Executive Director for the Center of Excellence in Mathematics and Science Education at ETSU. Jack, I believe we have really set up something very special in our affiliation, and I hope we are able to work together for many years—not only bringing hands-on, useful tools directly to K-12 STEM educators in northeastern TN, but also providing inspiration and awe to the students in your state. I do hope to see you next year! Thank you.
