Evolution or Intelligent Design: How Does My Teaching Grow?

Stories of Inspiration Celebrating Thirty Years at UWSP

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Evolution or Intelligent Design:
A View from My Classroom
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Yes – it's true – I've shamelessly exploited the old classroom debate in a cheap and obvious ploy to grab your attention. I know you're smart enough to turn away – but I hope you won't. Instead, I hope you'll read at least a few more sentences. You see, as I reflect on thirty-plus years of teaching, the evolution metaphor works pretty well. My basic genetic make-up – that is my fundamental love of teaching – is still pretty much intact. I'm thrilled to be nearby and witness students' meteoric growth; I'm in awe of our ability to figure out the molecular world and predict its changes; and I'm humbled by the good friends, colleagues, and family who shake up my world and inspire me to be better. You see, I believe professional mutations happen – meteors have rocked my teaching to the core, rendering my classroom dinosaurs extinct. And in spite of my hubris – the belief that *my* intelligence has led to my classroom design – it's these meteors that have dramatically changed and molded my teaching. In these essays, I share a few of those simple, yet earth-shattering events. I fear that this may be as boring as a look through my family photo album – but I hope that my stories will remind you of the things that have rocked your teaching world – and give you pause to reflect on their impact.

C'mon – you've stayed with me this long – turn the page – take a look at my first family portrait – maybe you'll enjoy the trip down memory lane, too.

Keeping Liberal Education Alive and Well in Central Wisconsin
Are we Training Workers or Cultivating Citizens?
February 2004

In my darker moments, I sometimes wonder how my students might respond to the following question: In your life beyond the University, how will you use the things you've learned in Chemistry 101? I fear that the answer to this question might be, for answers in a game of *Trivial Pursuit*.

This prompts me to wonder if society feels the same way – whether society values my course and the work we all do at the University. After all, the portion of society's resources (taxes) directed to the University is shrinking. We've all felt those cuts – and they hurt – not just in our programs, but also our morale. One way we can respond to shrinking budgets is to develop a "more relevant" curriculum - one that is, perhaps, more valued by society and more worthy of their support.

Some might argue that UWSP has already begun to do this. The Central Wisconsin Idea (CWI) focuses on partnerships with community businesses, UW-Colleges, and technical colleges to create course opportunities, job and technology training, degree completion programs, and collaborations between students and the workforce. As the CWI evolves, it will include more programs, like our new Web and Digital Media Development major, that reach out to Central Wisconsin communities (http://www.uwsp.edu.cwi/). The success of the CWI is evident in a quote about our WDMD major: "This major will provide a significant number of graduates prepared to fill such [technical] jobs. It is the kind of major businesses in Central Wisconsin have been asking for" (http://www.uwsp.edu/news/pr/scWDMDapproved.htm).

But it's the middle of winter – nighttime seems eternal, flu bugs have taken permanent residence in my chest, and my spirit is in a real funk. I can't possibly look at this cup as half full. I have to ask: Will *society* value this kind of curriculum or will it only benefit graduates (prestige and salary) and the business community (well-qualified, well-trained work force)? Will taxpayers open their checkbooks when they've concluded that a university degree benefits only graduates and businesses? To change *society's* view of the University, perhaps we need to return to a traditional liberal arts curriculum. But I know what you're thinking – a traditional, seemingly irrelevant liberal arts curriculum is what got us into this mess.

So let's change the descriptors. Liberal arts doesn't have to be traditional and it shouldn't be irrelevant. Let's consider a more 21st century version of liberal arts. Apparently, the Association of American Colleges and Universities (AACU) is doing just that. Their 2003 annual meeting was titled: *The Courage to Question: Liberal Education in the 21st Century*. At

that meeting, they wrestled with questions like: What does it mean to be liberally educated, and what is the future of the disciplines? At their 2004 annual meeting they considered broad visions liberal education – ones in which *students* gain practical skills and modes of thought that prepare them for a life of ethical and civic responsibilities in a complex and rapidly changing world.

I'm particularly fascinated by this because AACU is *not* defining liberal arts from a *content* perspective - they're defining it in terms of *students*. Liberal education is *not* described as a series of courses that must be covered – with the assumption that students completing the coursework are liberally educated. This 21st century definition focuses on the *students*, describing characteristics of a *liberally educated person*. A *student-centered* perspective seems perfect for this University! (See University mission statement, page 1, University Catalog.)

People on this campus have already grappled with this issue and written a wonderful document that describes the purposes, guidelines, and objectives of our general degree requirements. It describes the skills and modes of thought students should develop in the liberal arts component of our curriculum. (I found this document in the Public Folders at: University Offices, Services and Governance/Governance and Representation/Faculty Senate/GDR Subcommittee. The document is posted with the subject: Revised Report: General Degree Requirements, dated 11/26/01.) This document *and* the Central Wisconsin Idea together may be the answer to our lack of societal support. A way to "package, promote, and sell" (whatever horrible verb you'd like to insert) a University education so that students, businesses, society, and we all value it. We need to focus on *student* skills, *student* modes of thought, and *student* ethical and civic responsibilities *within the context* of contemporary content like, for example, web and digital media design. Our liberally educated graduate might think critically, have an aesthetic appreciation, solve problems, embrace diversity, and communicate clearly; *with 21st century ideas and concepts*. That graduate might apply her skill and knowledge by living well and doing good work, that is, leading a life of ethical and civic responsibility. Could we ask for any thing more?

Learning What??
April 2007

There it was again – that pesky catch-phrase of the accreditation steering committee – "Teaching? It's All About Learning". I call it pesky because it raises some rather thorny issues, like - what *should* students learn and how can we tell if they've learned it? I got a bit of inspiration about this a month or so ago when a former student came running down the hall –

"Hey, got a minute?" he asked.
"Sure", I replied – "I'm on my way to class – but let's walk and talk."
"I was just in the bathroom and I thought of you!"

This was definitely one of those moments – when a comment from a student has disaster written all over it. I had no idea what he was thinking, but I always fear the worst – so I started walking a little faster!

"Yeah - - I was pulling off my overalls and a piece of loose thread stood straight out."
"Really." I said, as I picked up my pace to a near-sprint.
"Yeah - - I knew it stood out because of static charge – and figured it had to involve electrons, but wondered – is the thread positively or negatively charged?"
I stopped in my tracks - "Good question" – of course I was thinking – Thank Goodness!!
The student continued - "I figured we could bring in a positively charged device near the thread to see whether it's attracted or repelled."
"Great thinking."
"Then", he said "the craziest thing happened – when I …… relieved myself …. the thread went limp. What a way to ground a charge!"

I danced into my classroom euphoric – we all know the feeling – when a student's really in perfect rhythm. This guy had done everything I could ask of a person in my class. He collected evidence by observing – not just what we talked about in the classroom, but beyond our discussion into his world – in this case – the world of a bathroom. He fit this observation within his understanding of chemistry concepts – he guessed, "this has got to have something to do with electrons!" And he proposed an appropriate experiment – bringing a positive charge near the thread. He thought critically with fundamental concepts of chemistry and he used the scientific method. I couldn't ask my students to do any more - - and I was pumped!

After class, as I thought more about it, I realized this student had really learned something special here at UWSP – not just in chemistry but in all his coursework. He learned to collect evidence – a loose thread in this case, but it could have been a picture of a mountain lion he saw on the internet that

claimed to be the elusive Wisconsin cougar, or perhaps a quote from the Attorney General about his role in firing Federal prosecutors. This student had learned to probe evidence using his conceptual understandings. Static charge?? He figured it must involve electrons – Internet pictures of Wisconsin cougars?? Urban legend. Truthful quotes from politicians?? … Hmmm.

*Here at UWSP, he had learned to seek justification for his belief*s. It's these transferable skills like critical thinking, problem solving, and communicating clearly - that cut across all content areas - chemistry, literature, psychology, forestry - unifying those content areas into an education – an education worthy of anyone in the business world - - an education worthy of a global citizen. I get very excited when I see a student applying principles of chemistry this way - really demonstrating learning - critically thinking using conceptual understanding. After all – it's all about learning. Now if I could just figure out how to make going to the bathroom a part of my final exams.

Reflection on the CAESE
Active Learning Workshop
Summer 2007

Two clichés come to mind – "You don't know what you've got 'til its gone." And "Hindsight is 20/20." That's certainly true for the Summer 2007 version of the Active Learning Workshop. I miss the regularly scheduled banter between colleagues – our far-reaching discussion of learning issues and how they impact our classes. And I long for any excuse to gather with the group again.

Beyond that longing, a semester of perspective (hindsight) has given me deeper appreciation of lessons learned during the Workshop. I came to the workshop thinking that students in my Chemistry 106 class were pretty actively engaged. Unfortunately, I wasn't sure whether my active classroom resulted in enhanced learning. I felt like I was missing key pieces to the puzzle of student learning - missing a connection between what I expected students to know and convincing myself they had learned it. I hoped a clear definition of active learning and some new assessment strategies might help me find that connection – that's why I applied to participate in the Workshop – I wanted a way to determine whether students were actually meeting my over-arching course goals - developing a deep understanding of fundamental chemistry concepts while developing their habits of critical thinking.

I found our discussions of learning outcomes and measuring those outcomes particularly helpful. But, I didn't realize how helpful those discussions were until I attended an OPID meeting this past fall. At that meeting, Jane Henderson (one of our colleagues from UW-Stout) said, when it comes to student learning, we need to ask two questions. (I'm paraphrasing here – Jane said it much more eloquently.) First, what does successful learning look like, and second, does that learning plug into the enduring goals for the course. These questions brought me right back to the Workshop group's discussions and helped me understand the impact of the Workshop activities. I had been nudged to discover that my learning objectives weren't specific and clear enough to suggest appropriate assessment. In Jane's words, I wasn't describing what successful student learning looked like. During the Workshop, I re-wrote some learning objectives (with plenty of editing help from the Group), but it wasn't until that "ah-ha" moment – that 20/20 hindsight that I finally realized that *better learning outcomes led naturally to appropriate assessment.* The Workshop Group also helped me connect specific learning outcomes to the over-arching (enduring) goals for the course. But again, it wasn't until my OPID "ah-ha" that the importance of this sunk in – *every specific learning outcome must support enduring goals – the "must know" concepts - the very reason the course exists!*

I finally realized that students couldn't possibly benefit from a learning objective like: "understand the Bronsted-Lowery definition of acids and bases". With an objective like this, students would use a binge and purge learning strategy; memorizing and regurgitating a sentence of meaningless gibberish. This would, in no way, help students enhance their habits of critical analysis! "Ah-ha!" - re-tooling a single old objective into several specific new learning outcomes was just what was needed – and just what we did during the Active Learning Workshop. The old objective might be re-tooled into something like; "Using the Bronsted-Lowery definition of acids and bases, classify any given substance as acid, base, or neutral based on the substance's structure and/or chemical reactions". This learning outcome asks students to *use the definition and their ability to critically analyze* as they classify acids and bases. Are the old and new objectives similar? Maybe – but now I know what student success will look like and I'm able to connect it to the enduring goals of the course. Students are doing something with their concepts of chemistry - not simply memorizing definitions, but using those definitions to classify substances. As Bill Cerbin (one of our colleagues from UW-LaCrosse) might describe it, students have a *deeper understanding* of the content – as evidenced by thinking *with* the content, not just thinking *about* the content. As an added bonus, assessment now parallels the learning outcome – I'm really able to probe whether students are able *to do* what I expect.

Deeper understanding of chemistry concepts; enhanced habits of critical thinking; and assessment that probes what I hope students will learn. Sweet!

Julia's Ski Lesson
January 2008

"It's all about learning". That's the catchphrase used by the UWSP accreditation task force. It appeared on their newsletters and all their other mailings. And, it's a perfect phrase to sum up my thoughts about teaching – "It's all about learning". But that wasn't always my perspective. As I think back to my early years of teaching, I remember thinking only about covering content using well-organized methods of delivery – with no regard for the learner! I discovered how wrong my perspective was few years ago on a ski trip with my sister and her family. It was my tween-age niece, Julia's, first attempt at downhill skiing. After a morning of instruction, she was deemed ready for her first chairlift ride, and as fate would have it, I was charged with helping her. At the end of my five-minute "how-to" on chairlift procedures, I pointed out the warning signs and told Julia, "keep your ski tips up" when getting on the lift.

Since that day I've told this story many times – and had ample time to reflect on my teaching methods. I covered the important aspects of chairlifting in a well-organized, easy to understand method, and yet, *my teaching* was completely ineffective. Julia *didn't* keep her ski tips up, caught them on a small snowdrift, and was ski-less within the first three feet of our trip up the mountain!

My ineffective teaching, however, led to an incredible teachable moment; a learning experience that started with the comment: "Julia, we have a problem". *Together*, Julia and I used problem solving strategies; brainstorming ideas until we found a reasonable solution, which fortunately; we developed before reaching the top of the hill. I'd like to think that Julia learned some problem solving techniques that day - in addition to the important content lesson – keep your ski tips up! How do I know she learned this lesson? She hasn't lost her skis on a chairlift since.

This story provides (at least) four important lessons for my teaching. First, it's all about learning. Successful teaching isn't measured by what I've covered; it's measured by what students learn. I carefully lectured Julia on techniques of chairlift riding – and by some measures, my lecture would have been rated highly effective. A simple assessment of student learning (chairlift ride), however, informs me that my lesson was sorely lacking. It's now obvious to me that coverage does not always equal learning. In the words of my wise old grandpa: "just because you're talking, doesn't mean I'm listening".

Second, students in my chemistry class must be engaged with a situation, a story, or a unique problem that captures their imagination and motivates them to learn. Julia didn't learn until she was actively engaged. My words

were spoken, but until she was motivated (had no skis), learning didn't happen.

Third, process and content go hand-in-hand. When a student completes my course – moreover, when a student graduates from UWSP, she must be armed with *both* fundamental concepts crucial to further learning, *and* the skills necessary to think and reason with those concepts. I visualize a student walking across the stage to receive a diploma carrying two suitcases – one brimming with ideas about atomic and molecular structure, the other teeming with skills like critical analysis, problem solving, and communicating clearly. Julia learned problem-solving skills along with her content lesson – and, I believe she'll be able to apply both to new situations.

And finally, my students and I must all know whether their learning is on target. This implies that there is a target – a detailed learning outcome that students and instructor can measure – and that the outcome is being measured by frequent, on-going assessment. Julia had a specific learning outcome, which we determined she didn't achieve only because of appropriate (but unfortunate) assessment. If Julia never rode the chairlift, neither of us would know whether she had learned the art of chairlift riding.

With these four lessons, my classroom model falls naturally into place. It must be student-centered and cooperative. Students should be actively engaged in the inquiry of chemistry, seeking theories for relevant data and solutions to authentic problems. Laboratory should also be inquiry-based, framed as a discovery of ideas, rather than a verification of scientific laws. Assessment should provide a clear and accurate measure of learning outcomes – probing whether students display a deep understanding of chemistry concepts by solving problems and applying their understanding to new (for them) situations. And, most important, this classroom model must follow the catchphrase: "it's all about learning".

Road Trip!
January 2008

Peggy and I had planned our family road trip to the last detail. We knew our destinations, schedule, and budget. So when we pulled out of Jackson, Wyoming, we felt good, we felt confident – the road trip was going well – and our three daughters, Aimee (age 11), Kelly (age 8), and Beth (age 4) were tolerating the long car ride - - and each other.

Unfortunately, the Jackson scenery was a bit too spectacular and the village a bit too quaint. We got a late start toward Yellowstone and we'd have to make up that time – breakfast would be served in the station wagon. Breakfast in the car isn't generally a big to-do, but on a tight budget with three finicky eaters, the challenge grows. Our menu included Cheerios and milk – right out of our portable cooler. Three bowls, three spoons, three disasters waiting to happen. I'll spare the unpleasant details, but suffice to say that long-term lessons centered on the glue-like quality of Cheerios on interior auto upholstery and the incredible stench of soured milk in a confined area. Short-term lessons focused on the level of chaos a driver can endure while driving through the mountains.

We found the nearest pull-off – which wasn't nearly near enough – and frantically shepherded the girls out of the car. Merry-Maids would have been proud of the speed and efficiency of our cereal spill clean-up – until – Peggy made a long reach for a plastic spoon – and clipped her forehead on the edge of the car door. The ice from the cooler kept the swelling down – and the beach towels from the laundry bag slowed the blood flow – but a visit to the emergency room was imminent. A grand-prix ride over a mountain pass brought us to the Teton National Park first-aid station – but Peggy didn't seem too thrilled about being the first patient to take stitches that year. More ice and some Tylenol, and we were on our way – if we hurried, we could still make it to Yellowstone that day.

Perhaps it was the frenetic start to our day; perhaps it was the suggestive aroma of spilt milk; perhaps it was seeing blood trickle between her mother's eyes – whatever the reason, Beth revolted – as we pulled through the magnificent gate at Yellowstone Park - she hurled her Cheerios in a projectile protest. I slammed the brakes and her sisters sprang from the car like sideways jacks-in-the-box. A quick assessment showed me the major damage was limited to the back of the front seat – and the front of the Beth. The seat would have to wait. I yanked Beth out of the car and held her skinny, limp, little body at arms length – my head pivoting back and forth as if I were at a fast-paced ping-pong match – looking for some divine intervention that would instantly un-do the day's events.

No such intervention occurred – and I was forced to face my fatherly responsibility. I set Beth down on the side of the road – near the back bumper of our car - and started to strip off her contaminated clothes. Her shoes, her socks, her "I ♥ Jackson-Hole" tee-shirt, her elastic waist-banded blue jeans. There she stood; this pale, frail, confused four-year old, stripped down to her princess panties, watching her dazed father stuff vomit-soaked sandals into a plastic bag.

"Daddy! Daddy!! Daddy!!! A bug's by my foot!" It was true – a misguided ant had infiltrated into Beth's space and was approaching her big toe. The shrill in her voice rivaled our city's tornado warning siren – I had to save her from the monster – so I picked her up and stood her on the station wagon's bumper. Her screeching soon quieted to whimpering, but not before we attracted some attention. Cars passed slowly, and occupants rubbernecked, trying to figure out why a nearly-naked, screaming four-year old was standing on the back bumper while a frazzled, middle-aged dad knelt before her – trying not to cry. The rubberneckers passed by when they realized a park ranger was approaching the scene to investigate. "Afternoon, sir. Having a little trouble here?" I gave a long look and my frustration spewed from my mouth as fast as Beth's Cheerios, "No ma'am – Beth's just practicing her balance beam routine." I tried to reel in my words, to smooth over my sarcasm, but it was too late – and I knew it. When I asked the ranger where to dispose of my plastic bag of hazardous waste, she told me – in no uncertain terms.

This day has become family legend, recounted every time we consider another road trip. But, I was especially reminded of it when I read a "My Turn" column in *Newsweek* a while ago. The column was entitled "The Lessons I Didn't Learn in College" – and it made me pause – what did Elmhurst College and Marquette University do to prepare me for that day? I couldn't remember ever discussing bloody beach towels in Philosophy 101 – or what to do with projectile spew in Art Appreciation. What lessons did I learn to prepare me for that day? Well - I assessed situations I'd never confronted before; I critically analyzed each new circumstance; I sought solutions to new problems and acted on those solutions; I communicated effectively with others about ideas – the solutions to our day's challenges. I just shouldn't have skipped that class on sarcasm and park rangers.

As I think of that day, I realize that Elmhurst and Marquette prepared me so well that I didn't even realize I was applying lessons learned. Critical thinking and problem solving have become so ingrained that I often use them instinctively – not giving Elmhurst and Marquette the credit they deserve! And that's what I'd like for my students; to help them develop their habits of critical thinking, problem solving, and communication so that they use those skills for each new challenge they face - to ingrain those skills so that they are, as they were for me that fateful day, instinctive.

Those broad learning goals have implications for my classroom strategies. If I expect these skills to become instinctive, students need to practice them. Each day I need to offer new data for students to analyze; I need to encourage them to construct new ideas based on those data; I need to provide authentic problems that encourage students to think deeply, applying the new ideas they've constructed; and I need to provide opportunity for them to communicate their ideas. In short, my classroom should be: student-centered, inquiry-based, cooperative, and data-driven; asking students to apply their knowledge of chemistry and communicate their ideas.

Natilie's Whirly-gig
October 2008

Our granddaughter, Natilie, was having a great time playing with the toy we brought her. It was just a cheap thing we picked up at Target the day before – I guess you'd call it a spring-loaded whirly-gig – a three-inch-diameter plastic circle with helicopter wings. The plastic circle gets mounted on a hand-sized plastic launcher, twisted a few times to load the spring, then push a button, and up goes the helicopter.

My wife, Peggy, was basking in the joy this simple toy evoked as she asked Nat some questions:

"So, Natilie, how does your toy work?"
"Well, Omi, you put the circle on here, twist it, and push the button."
"What happens then?"
"It goes up - - - and then it comes down."
"Why does it come down?"
Natilie thought for a few moments before answering - - "There aren't any magnets in the clouds".

I've thought about this precious exchange many times - - and on many levels. I find Natile's conclusion so appropriate - - appropriate for her four-year old observations and theoretical constructs. She's seen magnets attract objects and has no reason to think clouds wouldn't be filled with magnets. Her answer warms my heart. And yet, we adults know that without gravity, her answer is incomplete.

Assessment, and specifically, assessing critical thinking can be just like this – providing incomplete, and often, incorrect conclusions. My observations may indicate that my students are critically analyzing data, but are my students *really* thinking critically? I think my daughter Beth, a history teacher in the Chicago Public Schools, says it best: "Students can display behaviors of critical thinking without actually thinking critically".

"Looking through the Beth lens": that's the catch phrase I use to remind myself that students are sometimes able to perform well on assessments without deep understanding or critical analysis. Have my students thought through the nuances of intermolecular forces to explain the unusual trend in boiling points of water and hydrogens - sulfide, selenide, and telluride? Or have they simply downloaded trivia into their memory bank – only to trash their memory after the exam? Please don't misconstrue my frustration as student bashing – it's *my* learning outcome, *my* lesson, and *my* assessment that encourages students to binge on concepts of chemistry, earn an 'A' on my exam, only to purge those concepts as they walk out the classroom door.

Occasionally, my assessment inadequacies smack me in the head – like yesterday. My students have worked a lot on the mole concept – it's a topic that gets repeatedly used in my course. And yet, when I asked students to determine the number of moles in 0.10 grams of naphthalene, the whole back row confessed to the rest of the class that they were unable to do the conversion. That was a dozen students – ten percent of my class. But if I stop long enough to look through the Beth lens, I can rationalize my students' brain cramp. Perhaps some of the back row left their calculator at home on the desk, perhaps they were busy with a text message – and didn't get the gist of the question, perhaps their minds were filled with anxiety over the upcoming zoology practicum. For these dozen students, it seems I can create a dozen reasons (excuses) why they were unable to determine moles – none of which relate to a true lack of understanding.

Actually, I'm pretty sure that my students can, indeed, to do this conversion. Today in lab, students were asked to compare the effectiveness of road deicers. After making comparisons, they were asked to determine which deicer was most cost effective – a calculation based on the mole concept. My students seemed to handle that calculation, and further calculations quite well – contrary to yesterday's observation. But if I stop long enough to look through the Beth lens, I can come up with some pretty depressing explanations, like: perhaps my guiding questions did the thinking for my students, perhaps one student did the thinking and the others followed the leader, or perhaps my students found an old algorithm in their notes that paved the way to a successful calculation without much thought.

Good or bad, the Beth lens reminds me that assessment is really pesky – and my hat's off to those who do it well. For me, I need to be careful not to over (or under) interpret the results of my assessments. Perhaps students are achieving levels of critical analysis – working chemical data and observations to justifiable conclusions beyond my wildest dreams. Or perhaps students are memorizing trivia with no hope for lasting understanding. It's likely that reality is somewhere between these extremes – but, I may never know – not without peeking inside students' heads. And that's my ultimate goal – to design assessments that do just that.

Thirty-Seven Across
February 2011

I love doing crossword puzzles. There's something satisfying about filling in that last square – without peeking at the answers in the back of the book. So when I saw the clue for thirty-seven across, I was pumped. Finally, a clue that was right up my alley – a three-letter word for atom fragment - - "ion", I filled in with a nod and a self-satisfied smile.

And then it hit me – is this the purpose for my professional existence? Do I walk into Chemistry 105 every Monday, Wednesday, and Friday to provide answers to my students' future crossword puzzles? Just the thought of this sent me into an emotional abyss – I couldn't conceive of a more dismal reason for a career in education – expecting students to memorize trivia. Moreover, if this is my purpose for teaching, I'm probably failing miserably. Peggy, my wife and fellow crossword enthusiast, has a hard time remembering "ion". If she struggles remembering "ion", I know my students do too.

Just before we were married, Peggy and I realized our relationship was about to suffer an automobile crisis. The car that would soon become "ours" had a manual transmission – and Peg had never driven one before. I remember searching together – maybe I was stalling - ostensibly looking for an open place for her first lesson; finally settling on the parking lot of the local Catholic church. Perhaps that was a Freudian choice – where better to ask for divine intervention when teaching your betrothed to drive a stick.

Before Peggy got behind the wheel, I thought I should provide a little foundation on the theoretical aspects of manual transmissions. I told her that the transmission changes the gear ratio between the drive train and the engine to keep the engine working near its top performance rpm and that the gears allow one rpm on the input shaft (from the engine) to give a different rpm on the output shaft (to the drive train). We talked about the purpose of the clutch – to disconnect the engine from the input shaft, leaving the drive train independent from the engine. Finally (at long last), I told her that shifting gears involved clutching to disconnect the engine and release the torque on the collar, revving the engine a bit so that the next gear and engine were at about the same rpm, and gently releasing the clutch to engage the collar and the new gear without grinding the dog teeth. All-in-all, it was a tidy little lecture on an abstract and hidden aspect of auto mechanics. (Who knows, perhaps I was still stalling!) After this mini-course, it was time for her to get behind the wheel. Incredibly (considering my stellar lecture), the car hiccupped and lurched. I felt my left leg groping on a virtual clutch and my mouth letting loose with some pretty salty language. My lack of support and encouragement didn't faze Peggy at all. Soon, she got the feel for the car and was driving like Mario Andretti. Thirty-some years later she still drives

the four-speed smoother than I ever could – even though the theoretical aspects of manual transmission left her long ago. In spite of me, she remembers the enduring skill – driving the car – but she'd only remember details of our transmission discussion if she'd gone into auto mechanics.

In that same vein, I'm forced to ask, why should my wife, a third grade teacher, have the jargon of atomic theory on the tip of her tongue? Ion is a part of my vocabulary because I'm a chemistry geek. There's no reason it should be part of Peggy's. This makes me wonder if the detailed conceptual content of what I teach is meant to be forgotten by all those students not pursuing careers in chemistry. It turns the view of course content all higgledy-piggledy – the conceptual details of chemistry are simply illustrations to be used to teach enduring understandings – not the be-all and end-all of my learning outcomes. Chemistry concepts are the framework to teach the crucial skills and big ideas necessary for students to become global citizens. *In other words, it's ok for my students to forget the conceptual details of what I've taught*. Ouch – realizing that really hurts!

My high school chemistry-teaching colleagues have occasionally asked me, "What do you think students should know as they start their first college chemistry course?" I know this question well because I've asked the same thing of my colleagues that teach organic chemistry, the course that follows mine. I'm embarrassed when I think about the answer I used to give to this question. Typically, I'd focus on content areas that my students struggle with – stoichiometry - - nomenclature. I was stupid – seventeen year old high school students have as much business remembering the difference between nitrate and nitrite as a third grade teacher has remembering the difference between cation and anion. I should have realized how stupid my answer was, considering that my organic chemistry colleagues continually told me that my students didn't remember things I had taught in my class. Carry-over – remembering content from one course to the next – is a common topic of discussion among my colleagues. I'm beginning to wonder if students should remember *any* of the conceptual details of my course unless they are using those concepts on a regular basis. Instead of being depressed that my students don't remember the exceptions to the octet rule, I should feel elated that they remember important enduring understandings – just like I'm elated that Peggy is such a four-speed whiz rather than saddened that she doesn't remember what dog teeth are – it's the big ideas and skills that really matter. Carry-over is only a problem if we expect students to carry-over crossword trivia.

But, distinguishing between crossword puzzle trivia and building enduring understanding is hard. After all, some of my students will work in a world requiring them to know stoichiometry, nomenclature, and ions. For most of my students, however, these are *not* big ideas that must be mastered and remembered long after they take their Chem 105 final exam. Presenting chemical concepts so that both audiences – the future chemists and the

future third grade teachers take important enduring lessons from my class is challenging – but I think there's an answer.

I believe the answer is two fold – first identify the big ideas that *every* student must take from the course and use – for the rest of their lives. In my world, critical analysis, problem solving, and communicating with abstract ideas are bedrock – the stuff that every student must develop. In addition, every student must know that we live in a world filled with a plethora of substances and materials – materials whose characteristics can be explained from a molecular perspective. Future chemists must take more – concepts that could be labeled "nice to know for your next course". But how do we teach a course that emphasizes big ideas and skills without neglecting ideas worth being familiar with? That leads to the second fold – integration – use the concepts of chemistry – the nice things to know as a four-speed vehicle to help students develop their big ideas. Use chemistry concepts to teach students to critically analyze data, solve problems, and communicate with abstract ideas – teach using the data driven approach (DDA).

The data-driven approach does just the right thing – turns the chemistry course all higgledy-piggledy. Rather than explaining the details of a concept followed by examples applying that concept, in the DDA students are first presented with data and then asked to format and scrutinize that data. Students then use the data to develop explanations of how nature behaves. Once students have developed consistent explanations of nature, they apply that knowledge. Ultimately, students are presented with more data that will nudge them toward the next level of understanding. In this way, students develop their skills of critical analysis and problem solving because they continually employ these processes *while* developing their fundamental understanding of chemistry. All students develop their enduring understandings – and those students going on in chemistry learn concepts that are "nice to know for your next course".

My classroom is now a mess – with desks all askew as student groups gather to discuss data and formulate their explanations. All the while, I float, prod, and guide them as they build their understanding of chemistry – together. I often feel the same way I felt when Peggy slipped in behind the wheel of "our" car – completely out of control. It's a little scary at times, but it's a classroom dynamic that I've grown to love.

Teaching Chemistry for the Twenty-Second Century
Spring 2011

My Great-Aunt Charlotte was the grandmother I never had. My dad's mother died when he was only nine years old, leaving Grandpa Wright to raise four small boys and their sister. My mom's mom died about a year before I was born, of ailments easily treated today. Fortunately for me, Grandpa Wright's sister filled my "grandmother void" wonderfully.

Aunt Charlotte had that perfect grandmotherly look. Her hair was snow white and in a perpetual bun parked just above the nape of her neck. The soft wrinkles on her face left no doubt of her experience, wisdom, and confidence. Her blue eyes sparkled like sapphires in a jewelry store display – piercing through me; exposing my soul. She did all the great things grandmothers do. She cooked, baked, and raised peonies. She did things that grandmothers don't do. She lived alone, in a small apartment over her garage, three blocks from a small lake in rural Wisconsin. She parked her sky blue 1955 Plymouth Belvedere in that garage and loved taking it out for a spin. She beamed as she eased out the clutch and took off to her to her quilting bee. At four feet ten, driving was a problem solved only by blocks on the pedals and a lift in the driver's seat. Aunt Charlotte never had kids of her own, but somehow instinctively knew the finer points of grandmothering. She always made me feel tall – both in stature and in spirit.

Aunt Charlotte lived an amazing life. Born in 1879, she died in 1973 at the age of ninety-three. She was twenty-four when the Orville and Wilbur flew at Kitty Hawk, read the headlines about Lindy crossing the Atlantic in 1927, and watched from her retirement home in Florida as Apollo missions took off for the moon. Unfamiliar terms like: proton, neutron, quantum levels, and molecular orbitals became familiar during Aunt Charlotte's life.

Thinking about the life and times of Aunt Charlotte sometimes makes me wonder: how will our understanding of the molecular world change during my students' lifetime? It reminds me of a pseudo-quote – that is, a quote that's been edited freely to fit many contexts. I first heard it referring to teaching and learning. Legend has it that a university president, giving an orientation speech to new students said, "As research advances, we'll find that fifty percent of everything we teach you here is wrong – unfortunately, at this time, we don't know which fifty percent that is." This thought stuns me: which fifty percent of the chemical theories I teach are wrong? More importantly, how can I prepare my students to adapt and learn to new ideas as nimbly as Aunt Charlotte?

Open-mindedness - - skepticism - - and a prolific sense of wonder - - these are *not* knowledge-based theories of chemistry - - these are *not* skills like problem solving or critical analysis - - these are dispositions, attitudes,

values that a person holds. And yet, these seem to be the characteristics that lifted Aunt Charlotte from a time when driver's licenses were unnecessary – because there were no cars – to a time when licenses were required - - to pilot super-sonic jets! Perhaps, my chemistry courses should include a healthy dose of character development – helping students develop those Aunt Charlotte attitudes that encourage life-long learning and intellectual adaptability. Specific learning outcomes should address dispositions, and if I'm true to those outcomes, I must assess them. For me, this is a pretty big paradigm shift. To begin, I'll add the following disposition outcome to my course syllabus: "Continue developing a sense of wonder about the natural world and the molecular theories that explain it – in this course and beyond." At the very least this will alert my students and me to the importance of attitude development and force me to consider teaching and learning strategies that will create positive feelings toward exploration, reflection, and theories of chemistry. It's a meager start, but it reminds me that feeling enthusiasm – especially enthusiasm toward learning – matters.

Feelings? In Chemistry Class?
April 2011

My parents weren't really harsh disciplinarians – I'd like to think they had an intuitive sense about teaching and learning – specifically cognitive strategies for long-term recall. In today's society some might call it borderline emotional abuse, but in the 1950's it was standard punishment – what loving parents did to raise good citizens. Mom and dad seemed to understand that connecting a lesson to a strong emotion would help retention. My informal, anecdotal assessment tells me they were right.

Mary was the summer romance every hormone-filled, pencil-necked junior-high-school boy longed for. She had a perfect, gently-freckled Irish complexion, auburn hair that fell softly over her shoulders, hazel eyes that sparkled with the mystery of an older woman of sixteen. She was easily the best water-skier at Birch Point Resort, performing tricks that would make Tommy Bartlett envious. When Mary took to the lake, the throng of junior-high admirers dropped their fishing poles and scurried over to gawk.

On this fateful day, however, the unthinkable happened. Mary skied past the beach in her standard formation – left foot on the slalom ski, right foot clinging to the tow rope, arms out for balance while waving to her fans – when an unexpected wave caught her off guard and sent her hard and twisted into the water. She came up with a strained smile, trying, unsuccessfully to hide the sharp pain of a wrenched back. She hurt badly and everyone knew it – everyone but me, an oblivious seven-year old kid.

That evening at the all resort barbeque, Mary mingled, assuring everyone that she was just fine – but her smile just didn't radiate in its usual way. The junior-high gang was up to their usual antics – looking and acting like gangly puppies, frolicking about trying to establish dominance. I should have suspected something when they came up to me – they had real mischief in their eyes – but as I said, I was seven and oblivious. The dime they offered me to give Mary a good hard shove from behind was nothing more than blood money – both Judas and I should have known better.

Mom let me have it that night. My deed made her ashamed and embarrassed, and she was determined to make me feel the same – and more. She carefully positioned the dime on the kitchen table – a place I'd have to pass several times a day – pointing to it until it was filled with ten dollars worth of guilt. Every time I passed that spot I got a good look at that guilt-filled coin and started crying again. I still feel a queasy pang whenever I see a profile of Franklin Roosevelt. My apology to Mary was indeed heart felt and emotional.

The lessons I learned those remorse-filled days were profound – and lasting. Over fifty years later I remember the pain – and the lesson. But mom didn't have a monopoly on effective teaching. Dad's effectiveness would make the best teachers envious, too.

My big brother, Tim, spent most of the afternoon engineering a baseball backstop out of old netting and two-by-fours. Tim's mechanical creativity was a real source of pride for my dad – and he (Tim) expected to get some pretty good use out of that backstop. After all, it meant the two of us could play some pitch and hit without our little sister playing catcher. When I threw a high hard one that missed the netting, Tim was upset – it'd be hard to find that dirty old ball in the thick bushes that lined our back yard – the grass-stains on the ball were a very effective camouflage. Tim and I looked long and hard for that ball – but to no avail. Dad joined us in the back yard when he got home from work. When dad asked, "What happened here?", Tim filled in with gory detail. "Hmpf", dad grunted – a pretty typical response from him – and then he joined us on hands and knees to find that ball. While it seemed like an eternity, in retrospect I bet it took just a few minutes to find that ball – dad had a knack. As we walked away from the bushes, dad gave that ball a little flick in the air, caught it, looked back at the backstop and grumbled, "How did you miss that thing?" His words hit me harder than a 500-foot home run. At that moment I knew I'd never be a pitcher – and a moment later, extrapolated that to I'd never be an athlete. It was, perhaps, the shame of that day that led me to search for a geekier way to spend my life – athletics was out of the question.

When I think of cognitive psychology, it's not surprising that these events are so well remembered. My emotional response was deep – and replayed over and over – a perfect way to send a lesson into long-term memory. I've heard many people relate similarly emotional stories about their chemistry experiences. When a new friend finds out I teach chemistry, they enthusiastically regale me with stories about their sadistic chemistry teacher and how much they still hate chemistry. I've often wondered why I went into such a horrible profession. It's then that I remember that emotional lessons don't always have to be negative – and positive lessons can have some unexpected and marvelous consequences.

Mrs. Six was my fourth grade teacher. She loved science and passed that love on to her students with daily encouragement about our abilities and an infectious sense of wonder. It seemed like every day (although it was probably more like once a week) she brought something new to explore. Critters, machines, chemicals – we did it all in Mrs. Six's room. I specifically remember dropping a pea-sized piece of mossy zinc into a test-tube half filled with hydrochloric acid – affixing a rubber hose to that test tube with a stopper, and aiming the rubber hose into another up-side-down test tube filled with water. The hydrogen gas resulting from the zinc-acid reaction displaced the water and filled the second test tube. Under Mrs.

Six's watchful eye, I brought a flaming wooden splint to the mouth of the hydrogen-filled test tube. Whoop – the hydrogen in the test tube exploded! In my excitement I almost dropped the test tube and the flaming splint. It's easy to remember such a fun-filled day because I re-played it all week – and beyond. To this day, whenever my students make that whoop, I'm brought back to my fourth grade classroom and the warm feelings of Mrs. Six.

Mr. Pitts was as icy as Mrs. Six was warm. He was tall and lanky; he wore dark horn-rimmed glasses that accentuated his bug-eyed glare – a glare as frigid as dry ice. He was a tyrant, a dictator, an authoritarian who rolled a pencil between his palms and stiffly paced, with knees partially locked in a pseudo goose-step, as he lectured to a roomful of intimidated seventh graders. Mr. Pitts was the personification of every chemistry students' worst nightmare. And yet, this Mussolini in a lab coat did two things – two simple things that lifted my spirit – and made me love him and chemistry. First, he gave me a nickname – a nickname that only he used – but it became my special science-class handle. My nickname was Izzy – Izzy Wright. In the greater scheme of things, it's silly, but that nickname lifted my twelve-year old spirits, and motivated me in science class. The second thing Mr. Pitts did – wrote a two-word comment on one of my exams. I'd done pretty well on my test and he wrote "not bad". This was high praise from Mr. Pitts and it made me feel terrific – made me want to study chemistry.

Mom, dad, and my teachers offer incredible lessons for my classroom. They underscore the importance of evoking emotion – not only because emotion can help students remember content – but also because emotions mold attitudes – in my classroom, attitudes about chemistry. I remember the lessons of mom and dad – but I also remember how my friends have come to hate chemistry. This compels me to follow a positive, Mrs. Six-like example – offering support rather than guilt and shame. How does this play out in my classroom? I need to keep my eyes open for students doing things well – and comment favorably on their good work. Not false praise – but real, heart-felt praise for a job well done. And, at those times when students become frustrated (and those times *will* happen) I need to recognize their frustration and meet it with a human connection or a word of encouragement – just like Mr. Pitts did. This isn't easy for me – coming up with an optimistic word is challenging when a student stops by my office to discuss another failing score on a mid-term exam. That's when I must *remember the whoop* – that familiar sound that reminds me of the great feelings I have toward chemistry – in large part, because of my teachers. After all, if a student chooses *not* to major in chemistry – that's okay – if a student hates chemistry – that's not.

But a supportive classroom environment is only the first step. In a large lecture hall, positive feelings may promote a good attitude, but it does not necessarily evoke the emotion that helps students remember concepts. How do I capture a piece of the emotion that helped me remember the lessons of mom and dad? For this, I believe stories, anecdotes, and (of course)

demonstrations are helpful. When former students return to my office, they delight in telling me about a spectacular demonstration they remember – and the chemistry concept that goes with it. This is wonderful (albeit anecdotal) evidence of the effectiveness of demonstrations. I believe brief stories interjected into a lecture can have the same effect. Some people may consider it a waste of precious lecture time to encourage students to imagine how it must have felt when Rutherford observed alpha particles coming back to the source. Or the anguish Lise Meitner must have gone through, forced to emigrate to Sweden after the Anschluss in 1938. I'm convinced my students will never forget the formula and properties of anhydrous hydrofluoric acid once I've shown them the scars on my forearm. I believe that just like a Franklin Roosevelt dime, these human stories help students recall important aspects of lessons well-learned.

Whether we do it with an over the top method like mom or Mrs. Six; or a subtle comment, like dad or Mr. Pitts – we cannot underestimate the power of the emotions and feelings we pass on to our students – for their learning, attitudes, and even their life's decisions. Considering feelings – yes, feelings in chemistry class – should become a part of our daily classroom strategy.

Ava's Giraffe House
Savoring Education
Summer 2012

For most folks, the words, Giraffe House, conger up images of a tall space at the city zoo – a place where humans can climb stairs to gaze dreamily into the soft eyes of what appears to be one of the world's gentlest creatures. Not so for our four-year old granddaughter, Ava – for her, the Giraffe House is her favorite lunch spot – a place where she can nibble on chicken tenders dipped in ketchup, while enjoying a side order of applesauce and a cold glass of chocolate milk. Ava's Giraffe House is not the same zoological display most of us think of – rather, it's filled with LCD TV's, video games, and tall stools suitable for four-year old climbing challenges. Ava's Giraffe House is actually the Draft House – a local sports pub.

Applying constructivist learning theory, it's pretty easy to understand Ava's mispronunciation – giraffes are cuddly critters she knows well and loves dearly. Given her four-year-old learning scaffold, it's easy to imagine that the Giraffe House would be a fun and comfortable place to hang out. But never having encountered a tall cold draft, the Draft House is not a term she could imagine. Ava's error reminds me of the seven-year old kid I read about years ago. He misheard the lyrics to Abba's classic song, *Dancin' Queen*. Instead of "… see that girl, watch that scene, diggin' the Dancin' Queen …" this little guy heard "… see that girl, watch her *scream, kickin'* the Dancin' Queen …". Kids mispronunciations like this are cute, and around our house, their gaffs become a part of the family vocabulary – for us, the Draft House will always be the Giraffe House.

Constructivist theory aside, it seems strange that our granddaughter is so attracted to a sports bar – an establishment that strives to create an ambiance more suited to her parents. Perhaps it's those perfect-tasting chicken tenders, or sensory overload from all the TV's, or a willingness by the proprietor to allow a young girl to explore the surroundings. Whatever Ava's reasoning, I'm quite content whenever she chooses the Giraffe House as our lunch spot because they serve the best cheeseburgers in the city. These burgers are a far cry from the typical Ronald MacDonald variety – where preparation time is measured in milliseconds and the condiments are the only clue to any sort of taste. The Giraffe House chefs take their time to grill their works of art – and the wait is well worth it. In a world filled with fast-order dreck, these slow-cooked delights are dripping with the sensory overload I relish.

At our last Giraffe House lunch together, I found myself daydreaming while watching Ava play with the steering wheel of a non-functioning NASCAR video game. I wondered, which burger joint is more successful: the one with the great tasting food and comfortable ambiance or one that serves it quick –

and “your way”? In our free-market culture, the metric for determining success seems pretty simple; the establishment that earns the most money is the most successful. Fast food giants like MacDonald’s and Burger King have earned billions of dollars serving billions of satisfied customers – while the Giraffe House struggles to find the balance between quality and earnings. Some might argue that good marketing strategies and giving customers an acceptable meal for the price paid are the reasons MacDonald’s and Burger King flourish. Does that mean there is no place for a high-quality burger in our society?

I’m deeply concerned that our future educational system will parallel the downfall of the high-quality cheeseburger. As I watch the proliferation of advertisements touting the attributes of some universities, I hear very little emphasis on certain educational ideals like creativity and critical analysis. I fear that we’re being swept up by advertising campaigns that convince us that an incomplete education – where the condiments of the college experience are the only satisfying sensation – is perfectly acceptable. I worry that we’ll soon value a MacEducation that is quick, inexpensive, easy, and without substance. If we want our students to think deeply and communicate clearly with abstract ideas, if we want our students to find their place in a complex and evolving world, if we want our students to value, appreciate, and disagree respectfully with fellow humans, then we cannot quick fry their education. It’s going to take time – and yes, some money – to “grill” a better citizen.

I hope that there will always be at least a niche market for a high quality education – an education not only steeped with relevant content, but also filled with the skills necessary to creatively expand our knowledge base, the values necessary to use that knowledge for the betterment of our world, the social interaction to help students disagree about ideas while respecting the individuals holding those opposing thoughts, and, of course, the motivation to continue seeking truth, justice, and beauty. An education that *cannot* be measured by the metrics of a free-market, but rather, an “old-fashioned” university that takes the time to slowly grill and savor the perfect graduate, with all the skills and values of a learned individual.

It seems we are at a crossroad with the way we think about education – one direction adopts the highest quality education – an education that embraces the skills and values necessary to become a thinking, caring, world citizen. This education will most likely cost a bit more, and ask us to wait patiently for a future reward. The second option offers an adequate college experience at a bargain-basement price. An education that focuses on content knowledge as it exists today and a credential that allows the student to participate in a vocation – an education that is attained quickly and at the convenience of the student and society. I know which path I prefer – the one that, I believe, will better equip our students for the unknown issues of the future. And, if I’m true to my beliefs, it means I cannot be a gentle giraffe

allowing our educational system to slip into mediocrity by continuing to adopt a free-market culture – rather, I must be like the dancin' queen – kickin' and screamin' for the highest quality education – for our students – for our future – for our world.

Our Daughters' Lessons
January 2013

Our two older daughters learned to ride their two-wheel bicycles the same summer. That statement doesn't mean much unless you know that our daughters' age difference is almost three years. That's right, Aimee took her first solo two-wheeler ride just before her seventh birthday, while Kelly took off on her maiden voyage just after turning four. Before you ask what's up with Aimee, let me fill in with a few details – Aimee was an accomplished swimmer and gymnast – able to turn tumbling tricks on a four-inch beam and swing herself around a bar like an X-game expert. She had (and has) balance, courage, and tenacity. And Kelly was Aimee's equal – showing her youthful skills on the soccer field. Around our house she was known as the Queen of the Pitch – never to be outdone by her older sister. And that's my point, neither of them would be *outdone* by the other – the reason for the three-year difference in learning to ride a bike was not an internal issue based on *their* skills and desire – the reason was, I believe, external. The reason was, I believe, their dad - - me!

I've had plenty of time to reflect back on those early days of parenting (both Aimee and Kelly are now thirty-something). I've come to realize that I wasn't the same dad for my two older daughters. I didn't see it at the time, but my parenting skills evolved – morphed from one daughter to the next. I essentially practiced – and screwed-up a lot with Aimee so that I'd screw-up less often for Kelly.

My evolution is illustrated in how I "taught" them to ride their two-wheelers. Every time I took Aimee out to ride her bike, I was scared – scared that I'd end up in an emergency room with a banged up kid. She'd get on her bike – ready to ride, and I'd hang on her and never let go. It took Aimee longer to master her bike because *I* was afraid she'd fail. After finally letting go and watching her ride off, I realized my fears were just plain stupid – if Aimee had enough confidence in herself, how could I be so overbearing – the epitome of a helicopter parent sapping all the self-confidence and self-reliance out of her? Fortunately, for Kelly I learned a bit and developed more confidence in my kids' ability to fail and come back. A month or two later, when it was Kelly's turn to ride the two-wheeler, I developed a different approach – teaching with my hands off. As she glided down the road I flapped my arms like an albatross trying to take flight. Hold for a bit, let go for a bit … hold for a bit, let go for a bit – my literal wings flapping as she spread her figurative wings – taking off on her bike as she took off in life.

That summer, I began to learn that teaching, as in parenting, often times, means letting go – and being there to pick up the pieces when the inevitable

failure happens. Lest you think that I somehow became Jim Anderson[1] overnight, one day our youngest daughter, Beth swerved her two-wheeler off the bike-path, flew over her handlebars, and lost the battle between her head and a nearby red pine. I'll be the first to agree that finding the balance between hands off and hands on is a tricky issue – failure is bound to happen. (Just in case you're wondering – yes, we did end up in the emergency room – and yes, Beth is doing just fine. She is known in the family as the "Beast of Triathlon".)

But teaching with hands off is not the only lesson my daughters taught me. When Aimee was a teenager, I felt it was my controlling, authoritative, limit-setting duty to invoke and enforce a curfew – after all, it gave our new teenager and her dad something to fight about! We could fight about it before she went out – "But dad, it's homecoming, can't I have an extra hour??" We could fight about it when she'd arrive home late – "But dad, do you want me to break the speed limit and drive recklessly just to get here on time??" We could fight about it at the dinner table – "But dad, what does grounding me have to do with teaching me responsibility??" After fumbling around for years trying to answer Aimee's good questions, I decided to develop a different approach for Kelly. It'd go something like this:

> "So, Kel, you're going out tonight?"
> "Yeah, dad."
> "So, who you going out with?"
> "Aw, you know, the usual group … "
> "Where will you be going?"
> "Humph" (imagine teenage eye-roll), "the usual places …"
> "And, when do you think you'll be home?"

By the time we got to that final question, Kelly was so exasperated that she'd answer without thinking – giving me a time two hours earlier than I was initially thinking! By the time Beth was a teenager I'd perfected this technique, occasionally getting real answers from her!! My daughters called it the third degree, but I refer to it as formative assessment – just trying to gather data to make an informed decision about the night's curfew. The downside to this parenting method is that it takes time – time to sit down and talk – each night, before my daughters headed out for the evening. What a great lesson it's been for my teaching though – the more I take the time to shut up and listen the more I learn about where my students are and the kinds of problems they're having. That way, I can actually address the problems they're facing and *engaged with.* Teaching with Your Mouth Shut is such a good idea that Donald Finkel wrote a book with that title. I wish I'd have been as smart and creative as Don.

[1] For those not as addicted to early TV as me, Jim Anderson was the character played by Robert Young on the old program "Father Knows Best", which aired from 1954-1963.

Teaching with my hands off and my mouth shut – two great lessons I learned from my daughters. But how do we begin to develop these skills? I think the first step is simply recognizing what these methods might look like. I've gotten into the habit of taking a walk around the Science building to peek inside offices and watch my colleagues and their students interact. I like to take note – who is holding the pencil? Who is looking through the book? Who is doing the talking? While on my walks, I like to look inside classrooms too – looking deep into the eyes of the students in those rooms. Are they actively engaged? Are they only hearing the "Wha-wha-wha" of Charlie Brown's teacher? How might teaching with my hands off and my mouth shut impact students' engagement and learning in my own classroom and office?

So, here is my bit of advice – let your teaching evolve. If you screw-up with a class or a course, learn from that failure and morph into a better teacher. Poor Aimee had to endure a novice dad. Hopefully Kelly and Beth benefited from my rookie-mistakes. Second, consider giving up some of the control that you have in your classroom – consider taking the time to listen carefully as you informally assess your students and their understanding – reflect carefully on what it looks like to have engaged and interested students. Teaching with hands off and mouths shuts is worthy of the failures that will inevitably happen. Embrace those failures, and evolve into a better teacher and scholar. Then reflect with pride knowing you're better today than you were yesterday.

Have Things Evolved?
Statement of Teaching Philosophy
June 1999

I state four foundations upon which my teaching philosophies are based. First, teaching effectiveness can only be measured by *student* development. Teaching effectiveness should be determined by: 1. The fundamental knowledge students take with them beyond the course; 2. The desire and skill a person has for continued learning; and 3. The student's advancement in critical thinking skills. For these purposes, I define critical thinking as analyzing data and drawing reasonable conclusions from that data, while being tolerant of different, yet reasonable perspectives. Based on these criteria, it is very difficult to measure whether an instructor is effective. One thing is certain, however, an assessment that focuses on the number of topics appearing on a course syllabus is *not* a good measure of teaching effectiveness. At the very least, *student* assessment must be an integral part of measuring teaching effectiveness.

Second, student learning is based on constructivism[2], a model of learning which states that knowledge and understanding are constructed in the mind of the learner, with the learner trying to make sense of new observations in light of past experience. Students bring preexisting concepts to their courses and those concepts may be inadequate, incomplete, or misconceptions. Learning takes place when an individual becomes dissatisfied with their understanding, develops a new concept, finds that concept to be compatible with their other knowledge, and determines that concept to be useful. Students should be challenged with data and observations that force them to re-think their current understanding, and develop a more complete understanding. This means that the standard lecture with passive students as blank slates and authoritative lecturers filling those blank slates must be abandoned. At the very least, lectures must become interactive and student centered.

Third, students clarify and retain their understanding by communicating (or teaching) concepts to others. Synthesizing the words to explain a concept helps to organize knowledge. Cooperative learning, discussion, and writing are important components of organizing and retaining concepts.

Fourth, people must be motivated to learn. Leonard Nash, 1996 Chemical Manufacturers Association award winner states, "To put one's students in a learning situation, one must somehow get them *engaged in inquiry*."[3] I believe that this motivation is not effective if it is extrinsic, that is, students

[2] Bodner, G. M. *J. Chem. Educ.* **1986,** *63,* 873.
[3] Moore, J. W. *J. Chem. Educ.* **1999,** *76,* 725.

are not *well* motivated by grades or other outside threats. Students must be internally motivated to learn, and thus must feel a strong interest in the material presented and a desire to learn that material and more. Choosing topics of interest to students that will help them learn fundamental concepts of chemistry is a great challenge for chemical educators.

With these foundations in place, a classroom model falls naturally into place. The classroom must be student-centered and data driven. Students must be actively engaged in the inquiry of chemistry. Laboratory should be framed as a discovery of concepts, rather than a verification of concepts. Topics must be chosen to be of interest to the students. Student understanding and thinking skills must be assessed often. In one sentence, the classroom must be inquiry-based, student-centered, data-driven, covering topically stimulating areas and assessing student understanding often.

About the Author
Professional Bio
2002

I grew up living the life of Beaver Cleaver – from the old time television show, *Leave it to Beaver*. I lived in an ordinary home on Main Street, Suburbia. I played baseball with my buddies, challenged my mother's laundry skills, and stayed out of trouble – mostly. My mother wore a dress while vacuuming the house and gave me milk and cookies after school. She made me wash my face, eat my vegetables, and feed the dog. My father wore a suit to his mysterious job - I knew nothing about his job and I'm really not sure whether he worked at all – only that he seemed to be at work all the time. He made sure that I swept the garage, mowed the lawn, and cleaned up after the dog. My brother is older than me. He wore the coolest clothes – like all the big kids. He short-sheeted my bed, taught me new vocabulary, and generally picked on me unmercifully – until his friends picked on me – then he protected me fiercely.

It was a great childhood and a simple existence until one event changed it all – the birth of my sister. My sister is a caboose – born many years after me – a fact she continues to harp on. My sister's birth changed me – from the little brother to the forgotten one, from our pride and joy to "who's that kid?", from the top of the heap to the bottom of the barrel. I realized that the only way to make it back into the family photo album was to do something to show up my siblings. So I attended and graduated from a small liberal arts college and attended and graduated from a mid-sized Jesuit university. I figured that my parents might be impressed with my chemistry major, but alas, my brother majored in physics – out-done again.

Desperate to re-gain my position in the family, I decided to pursue a university career and in 1982 was lucky enough to join the faculty of UW-Stevens Point. My early days at Point were focused on K-12 science teaching methods and on environmental health and safety. I spent a lot of time performing chemical demonstration programs and leading hands-on science activities for elementary and middle school students. After these "field tests", I decided to run a few workshops – some dealing with hands-on-discovery science in the elementary and middle school, a few on infusing polymer chemistry into the science curriculum, and one on visualizing chemical concepts.

I met many great teachers and learned a lot about educating students from them. I realized that learning theories about young students seem to apply to my university students. I learned (and continue to learn) about constructivist learning theory, collaborative learning, and the importance of clearly stated learning goals. I've come to believe that skills like critical thinking and problem solving are a crucial part of any education. So lately,

I've been trying to write curricular materials for the general chemistry course that employ a data-driven approach – an approach in which data are presented to students so they may collaboratively analyze that data while constructing their understanding of chemistry (explain the data). I'm attempting to provide students with clear learning objectives that employ this data-driven approach. My goal is for general chemistry students to develop habits of critical thinking while fully understanding the unifying concepts of chemistry. Writing these curricular materials has been one of my challenges, assessing whether students are maturing in their critical thinking and chemistry understanding has been another.

Along the way, I married my high school sweetheart – my best decision ever. Together, we've raised three terrific daughters. They're scattered throughout the world now – pursuing their dreams and leaving my wife and I to an empty nest. We enjoy playing volleyball and golf, water and snow skiing, baking bread and listening to the Manhattan Transfer. We're living an ordinary existence in an ordinary house on Main Street, Wisconsin. Hey Wally, did the Beaver had three girls too??!