There and Back Again

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Introduction

Recently a friend told me that I was a *doer*, as in a person who takes action and does things. I know this friend meant this as a compliment, and I took it as such when she said it, as she was referring to my busy schedule of working and travel and more working. Like most positive things, there is rarely a downside to being a so-called doer.

Diving head first into an activity is something I have a habit of doing, which has led to some of my biggest blunders and to some of my most memorable moments. If it sounded like a good idea at the time, chances are I barreled straight ahead, whatever the consequences. While there have certainly been times when being a *doer* instead of a *thinker* led to some painful outcomes, a majority of the time taking action has led to something good. This behavior has gone on my entire life and has not only affected my schooling but how I ended up in the career field I presently occupy.

I was a doer at St. Paul's Secondary School in Liverpool, a troubled one. The transition from the U.S., where I had lived until fourth grade, to England was a confusing time academically and socially. I was behind in most subjects, math in particular. I was so bad at math I was put in a special class with other low performing students. I hated it. We were labeled by our peers as the dumb kids and it crushed my self-esteem. This is probably why now, as a teacher, I focus on those students who struggle like I did. I am still not very good at math, but regardless of the subject, I can understand the frustration of not being able to understand a concept.

Things turned around in high school. I found the doer in me was not really a mischief-maker, and I found a way to get through school – stay busy. Playing sports, being active in clubs, and focusing on my homework took up a lot of my time. I discovered I was not a bad student. I have a gift for organization and like most things I do, I created a system to be successful. Pay attention, learn the facts I need to know, prepare for quizzes and tests, and forget about them later. This proved to be a very successful strategy for getting good grades. It was not always the best way to go about learning.

In college I continued the winning combination of short-term memorization with long-term *doingness*. This led me to something I never thought I would be interested in, teaching. At the beginning of my sophomore year in college I was in the Work Study office looking for a job. I spotted an ad for an elementary school looking for a co-director of a before and after school program. Ironically enough, it was the highest paying position I could find so I went to the school, interviewed, and got the job. It gave me exposure to working with elementary school aged kids, and I loved it so much I changed my minor from geology to elementary education. I was going to be a teacher.

I have been a teacher for a number of years now, but I noticed eventually I am not nearly as good a teacher as I would like to be. Naturally, because I am a doer rather than a thinker, I did what I typically did with my education classes – I learned what I needed to learn but did not always think about what it meant. Not that you ever really know what teaching is until you are actually doing it, but I was doing teaching instead of thinking teaching.

A few years ago I realized I may have some serious gaps in my teaching. I was taking a class called Matter Matters. I took the class because I needed some credits to renew my teaching license. The class did not have anything to do with any of the curriculum I was teaching, so I figured I would just take it and forget it like I usually do. However, a strange thing happened, I was fascinated by the subject matter. I finally had a teaching instructor who clicked with me, who made me think about what I was actually doing and the purpose for doing it. A very small light bulb illuminated in my head. Was I missing something? Was I doing my job the right way? I ruminated on this for a while, and despite not being related to my curriculum, I incorporated some of the lessons I learned in the Matter Matters class into my own classroom. It was the easiest way for me to duplicate the experience.

A couple years passed, with this dim bulb still alight in my brain, when a unique opportunity presented itself. A colleague of mine and a graduate of the Colorado College (CC) Integrated Natural Science (INS) program encouraged me to get involved. This person saw potential in me I did not see in myself. I was hesitant. The formula I had developed in high school for academic success was an effective one for me. I had been using it for over 20 years. I knew I was going to be pushed in a direction that would make me uncomfortable. Could I really let go? Being a doer is my specialty. Sometimes a person just has to just dive in headfirst. Now that I am nearing the end of my journey with the CC Master of Arts in Teaching (MAT) program, I can reflect and see that it has been like many other good-at-the-time ideas I jumped into – sometimes difficult, occasionally painful, and always challenging. Because this is something I jumped into with careful consideration, I found it to be one of the most rewarding things I have ever done.

Geology and Cosmology

My journey began in the summer of 2010 with my first class of the MAT program, two weeks after our regular school year ended. I realized I was in over my head immediately during the Mountain Matters class. The instructor was a master of inquiry, not that I knew that at the time. The class took place in New Mexico, and it was a very hot June that year. I was frustrated not only because of the weather and the fact that I did not know anybody on the trip but because of my teacher's instructional method. He never gave me an answer to anything. Instead he just asked lots of questions and expected us to just, magically, from my perspective, figure it out. Welcome to inquiry. Thankfully a student riding in the same suburban as me, a fellow MAT student, saved me. She let me in on what my instructor was doing, and that dim light bulb that first lit up in my head in my Matter Matter's class a few years before grew a little brighter. It also led me down the path of turning a Mars unit I had used in my science classes into something more than a simple Mars/Earth compare contrast. A week after my Mountain Matters class ended, I was knee deep into my first MAT course, Cosmology. In this class I was just as frustrated as I had been in my Matter Matters class but for different reasons. The mathematical concepts in Cosmology were overwhelming and the instructor's teaching method was mostly lecture and note taking. Math has always been a weak area for me and I have intentionally avoided it. During my undergrad years, I took the minimum math requirement and the easiest classes I could find. Even today, I stay as far away from math as possible. My teaching partner has always handled math as a core subject, for which I am always grateful. I am also not a fan of lecture or note taking, especially when it comes to science. As a student and as a teacher, I have always felt the best way to learn about something is to actually play with concepts and get a person's hands dirty. In this instance, some kind of visuals or astronomical manipulatives would have been useful. This led me to think about the teaching styles of my first two instructors of my MAT experience. Aside from poor math skills and an inability to sit still, I needed to know why I was struggling.

One of the first things I remember doing at the beginning of the MAT program was taking a learning styles test developed by Anthony Gregorc. The Gregorc Style Delineator is a self-scoring written test completed in three minutes or less that elicits responses to a set of 40 specific words. My lowest scoring style quadrant was Concrete Sequential which, according to Gregorc's book *An Adult's Guide to Style* (Gregorc, 1982, p. 15), has the negative characteristics of excessive conformity, unfeeling and possessive. For someone who scored high in areas where my environmental preferences are stimulus rich, competitive, free from restriction, active, and colorful, it soon became clear to me that I was feeling stifled under my current learning conditions.

As a student, I could not change any of this. I had to adapt my own learning techniques as best I could, and, more importantly, take this as a lesson on how I can improve my own teaching style. I decided to use what I was learning from a pedagogy standpoint from Cosmology and Matter Matters as an opportunity to be more focused on a lesson I knew lacked direction. I realized my Abstract Random/Abstract Concrete learning style was also my teaching style. That approach is great for students who have the same style as myself, but it might prove challenging for those who are more sequential.

Near the end of my Cosmology class I made five learning style goals for myself:

- Make the objectives of a lesson clear. With elementary students, there is not much room for ambiguity. Students need to know exactly what the expectations are.
- Give frequent feedback. Sometimes I have a tendency to think that if a student is not asking questions they are doing okay. This is a poor assumption on my part. A student could be struggling but I may not know it if I do not talk to them.
- More closely monitor student progress. I check on my students but I need to be more vigilant. I cannot let students slip through the cracks. If I constantly monitor student progress, I can guide them better.

- Make small goals that lead to a final concept. I did this with my daughter when she was first learning to ride her bike. She hated riding up hills so I set short goals for her. First we got to a mailbox. Then we aimed to reach a certain car. The next thing she knew she made it to the top of the hill. I use this same approach with my students.
- Give positive feedback. Students, even adults, need encouragement. Even if students are doing a project completely wrong, I should be able to find something good about it so they have something on which to build, and their confidence is not completely dashed.

For several years I had a space unit that lacked direction. It was part of a district science kit, and I was given little direction for what to do from the district. Each grade level in my district was given a space theme to teach, and my grade level was assigned the planet Mars. My goal was to take the existing five day lesson I had been using from the Space Foundation on comparing Mars and Earth landforms and adapt it so the new lesson did two things: (1) Make instruction more in line with the new Colorado Academic Standards for Science. (2) Make it more inquiry-based. For sixth grade in the district in which I teach, the focus for science consists of a number of specialized units of study. These units include Science Olympiad, Mixtures and Solutions (Foss), Plant Growth and Development (Foss), Landforms (Foss), and Mars (District Assigned).

The Mars unit is part of a district-wide Space Week for sixth grade and addressed the previous Colorado Model Content Standards for Science Standard 4: *"Earth and Space Science: Students know and understand the processes and interactions of Earth's systems and the structure and dynamics of Earth and other objects in space" (Colorado Department of Education (CDE), 1995, n.p.).*

With the revision of the Colorado Academic Standards in late 2009, however, where exactly Space Week fits into the current district mandate for Mars study is a bit unclear. There have been no changes to the district science curriculum, and none are anticipated any time soon. To ensure the new science benchmarks are addressed, as well as meeting the preexisting and still in-place Mars district guidelines, I adapted my existing Space Foundation Mars lesson to provide an appropriate bridge.

The *Benchmarks for Scientific Literacy* states that students should know that, "planets of very different size, composition, and surface features move around the sun…some of these planets show evidence of geologic activity" (American Association for the Advancement of Science (AAAS), 1993, p. 64). The Space Foundation lessons I was using did a sufficient job of helping students achieve a basic understanding of this concept but I felt that what I was teaching did not go deep enough for a true Mars/Earth comparison. It is important for students to realize how necessary water is in sustaining life, so I directed students look for not just geological features but evidence of water on Mars as well. When combined with Standard 2 of the new 6th Grade Colorado Academic Standard for Earth Systems

Science, "Water on Earth is distributed and circulated through oceans, glaciers, rivers, ground water, and the atmosphere" (CDE, 2009, p.97) the goal of meeting the requirements of both the district and state standard can be achieved.

My new, adapted lesson was built on students' prior knowledge of the Earth and its systems and created an understanding that similar processes have occurred on Mars as well. Before the Mars unit, students should have already completed the Foss unit on Landforms. Students were familiar with valleys, hills, rivers, and other geologic and hydrologic landforms so this could segue nicely into Mars.

While making sure this new sixth grade Mars lesson was more in line with state standards, it was also important to implement some changes so that it was a more inquiry-based lesson. Since I was new to inquiry, I used the Biological Science Curriculum Study (BSCS) 5E Instructional Model (Bybee, Taylor, Gardner, Van Scotter, Carlson, Westbrook, and Landes, 2006, p.2), to help me.

The big idea that students should know by the end of this section of the Mars unit is that Mars and Earth have many similarities and differences. There is also significant evidence (http://www.daviddarling.info/index.html) that shows that the Martian surface had many types of water and land features just like the Earth. Being inexperienced with inquiry and the 5E Instructional Model (Bybee et al., 2006, p.2), I used it in a very linear way. The five phases of the BSCS 5E Instructional Model are designed to facilitate the process of conceptual change. Each phase of the model and a short phrase to indicate its purpose from a student perspective are:

Engagement - students' prior knowledge accessed and interest engaged in the phenomenon

Exploration – students and faculty participate in an activity that facilitates conceptual change

Explanation - students generate an explanation of the phenomenon

Elaboration - students' understanding of the phenomenon challenged and deepened through new experiences

Evaluation – students and faculty assess their understanding of the phenomenon

The first 5E lesson of the Mars unit included the ENGAGE phase. This is where teachers gauge their students' prior knowledge and use activities to promote curiosity. I started with a non-graded Mars/Earth pre-test that allowed me to assess prior knowledge. On the board, I wrote students' ideas about Mars and Earth, while students jotted their thoughts down in their science notebooks. Included in the notebooks was an area for students to write what they know, want to know, and what they have learned. This process is known as a KWL (Ogle, 1986, p.566). To further generate interest, I presented a brief power point presentation and an accompanying handout on the history of Mars exploration. I utilized Google Earth and Mars to study landforms on Earth that are similar to landforms on Mars. At the end of class students were placed in groups, and chose a Mars mission they had heard about from earlier in the day that could help them compare Mars to Earth.

The Space Foundation version of this lesson consisted of an hour long, teacher guided tour of Earth and Mars, using Google to show similarities of landforms on both planets. This portion has been shortened to be more engaging to students, and instead of taking place on just one day, the comparison of landforms using Google was expanded so students learned to use it on their own, allowing for more opportunities for guided discovery.

Days two through four consisted of the EXPLORE phase, incorporating a group poster project. During this time students worked collaboratively to find answers to their own questions from day one, conducted investigations to compare Mars and Earth, and researched the similarities between evidence of water on Mars and water on Earth for their respective NASA Mars missions they chose at the start of the day. For example, one group of students used photos from NASA's Viking program to show evidence of water erosion on the Martian surface and how it looks like something similar on Earth. Each class lasted approximately 50 minutes each.

At this point students were still in the early stages of learning about Mars and the Earth. To reflect on their learning, students completed a Three-Two-One formative assessment probe (Keeley, 2008, p. 197), writing to three reflective prompts; providing six responses that describe what they learned. This information was studied to see how well the goals of the lesson were being met. Students were provided with a copy of a reflection sheet (see below) and given time to complete their reflection.

Three key ideas I will remember:

Two things I am still struggling with:

One thing that will help me tomorrow:

To keep students in the mindset of comparing and contrasting, each group was given a set of two photos with one unlabeled landform feature from Earth and Mars**.** Groups worked with other groups in class to find its Earth/Mars match.

Lesson two had previously been used to show students Mars' landforms in 3D, but this lesson was a failure. The 3D glasses had been made for televisions and not overheads, which was the only material available. This lesson was replaced with a Mars/Earth comparison poster mini-project, where groups of students work collaboratively to research a NASA mission that found water on Mars. This is an opportunity for students to explore Mars and conduct their own investigation of the Red Planet. Upon completion students explained the new concepts and terms they learned and provided evidence for what they found. The poster also acted as an evaluation tool for the teacher to assess conceptual understanding.

Other inquiry-based methods that were implemented:

Recording and Reporting – In previous Mars units, students did not use their science journal. In the new lesson, students were encouraged to communicate their findings. By journaling students helped themselves to restate their questions and predictions, describe their investigation, and interpret results. This was also a great way for me to find evidence of conceptual understanding.

The new and improved science lesson allowed time for reflecting on the new information students learned every day. Students looked back on what they thought they knew, what they did know, and what new information they received. This provided evidence for the teacher to see if students had changed or improved their conceptions of a topic or to see if they acquired new skills or refined old ones.

With their research completed by day five, the EXPLAIN phase was split into two parts – assembling data and information into a coherent presentation and poster and the presentation itself.

I gave students 15-20 minutes to assemble their information on their poster and prepare it for their presentation. When presenting, students were reminded in their scoring rubric that:

(1) They must make sure each member of the group is a vocal and active participant;

(2) They must explain each part of their poster;

(3) Groups must be prepared to answer a minimum of one question per group from classmates and the teacher looks for evidence for the explanations provided; and

(4) Groups have to give a quick demonstration of one water and one landform from their mission that is the same on Earth as it was on Mars using Google Earth and Mars.

During presentations students in the audience had to work collaboratively in their groups to write three questions they could potentially ask the group that was presenting. After each presentation, groups wrote a brief reflection in their journals about their new understandings. Upon completion of the class, groups turned in their posters for evaluation. Students were then asked to reflect in their journal what they learned for the day, and look back on their KWL (Ogle, 1986, p.566) to see if they have changed their thinking in any way.

After spending so much time considering how I teach the Mars unit, I realized the importance of always following through with the learning style goals I was taught early in the MAT program. Regardless of the subject, making objectives clear, giving feedback, monitoring progress, and setting small goals that lead to a final concept are always good ideas.

Mars Action Research

I turned the Mars curriculum refinement from the first summer of the MAT program (described above) into my first action research project. If I had taken all the time and effort to theorize what may happen if I chose to make a lesson more inquiry-based, I decided I might as well test the theory.

This action research led to the revelation of one of my fatal teaching flaws, over preparation. Constantly over thinking is something I tend to do. It also showed me that I did not always have to follow an instructional model so rigidly.

My research question asked, "What are the effects of a more inquiry-based curriculum on the understanding of sixth grade students learning to notice the similarities of landforms when comparing Mars to Earth?" The big idea that students should know by the end of this section of the Mars unit is that Mars and Earth have many similarities despite being far apart and not looking very much alike. There is evidence that shows the Martian surface had many types of water and land features just like the Earth. The goal was for students to see past what Mars looks like currently and realize the planet at one point had much more in common with Earth than it currently does.

Not everything went as planned. From day one, I had to make changes. Some came after I realized mistakes in my plan; others were forced upon me by Mother Nature. Thankfully, I am flexible and was able to make changes in the best interest of my students, not that I did not make any mistakes despite all my careful planning.

For example, my day one Mars/Earth handout did not go over well. Most students did not understand it because it had too much information and it was written for adults. I wrote if for the previous year's CC summer session students for an action research presentation, and not for a sixth grade audience. It was a waste of time, and I think only one or two students got anything out of it. Instead of completing a five day lesson in five consecutive days, due to three snow days, it was completed over two weeks. Thankfully, based on the data I obtained, I believe the snow days did not have an enormous impact on my results. I planned too much for 50 minutes of class time. When asking students to spend 10-15 minutes of class on KWL charts (Ogle, 1986, p.566), three days is not really enough time to complete a Mars/Earth comparison poster with all the requirements I asked them to include.

I abandoned the Mars/Earth matching game with my experiment group very early. There just was not enough time in the day to include it. Thus, when I considered my planning mistakes plus the weather complications, I can see places where I can make changes for another year. A definite change for the future would be to simplify my plans. I confused many students with the Mars/Earth handout. It was intended to be background information but I would rather have students discover information on Mars on their own instead of being given answers. I will also be sure to use KWL charts (Ogle, 1986, p.566) in other subjects and not just in science. If I use KWLs in other subjects, students be more comfortable with them and will get more information from them by knowing what to look for. Since I use them so inconsistently, it was a time consuming process.

My teaching partner's class, the control group, was not originally supposed to do KWL charts (Ogle, 1986, p.566). However, I decided at the last minute to have them construct one anyway starting on day one. After seeing how useful they were in helping students reflect upon their work, I was glad I obtained the input of another class. Having a chance to reflect on what they were learning helped all students comprehend what they were experiencing in class

My students were pressed for time with their Mars/Earth comparison posters. However, they were completely dedicated to the task and took the initiative to find the extra time they needed to complete the assignment. Many students came in during lunch or afternoon recess to work on it.

This was the last lesson in the Mars unit, but because students were so surprised by how similar Mars and Earth are, they had questions they still wanted answered after the lesson was completed. This curiosity led to Mars being a topic of conversation for independent study. Students were reading Mars books and even writing about Mars in writing class weeks after the lesson ended.

Due to an unanticipated scheduling change, the Foss Landforms unit was pushed back. Instead of being before the Mars unit, giving students some prior knowledge that would have been beneficial when comparing Earth and Mars landforms, the unit came after we completed the Mars unit. The Mars unit did what the Foss kit was supposed to do by providing background information on the Landforms unit.

After the weeklong lesson was completed I gathered a significant amount of data. One of the first things I noticed was a difference in the quality of students' science notebooks over the course of the week. Science notebooks were not part of the original lesson done in years past but were added for both my control and experimental groups this year. What I noticed was an increase in student learning in written form. The difference was not only in the amount of content from day one to day four, the last day students filled out their KWL charts (Ogle, 1986, p.566), but the quality of the work was substantially better. When students initially filled out their KWL charts, their statements were short, simple, and direct. By the end of the unit, their exposure to Mars led them to asking deeper, more complicated questions and answers. An example of this was on day one when a student wrote under the Learned heading of her KWL, "Because of water Earth and Mars have similar landforms so they are really similar." On day four that same student wrote under the Learned heading, "Polygonal ground looks like dry cracking mud, river valleys look like trees they have branches that branch out, lava flows look like big globs put into the earth, volcanoes are mountains with lava flows around and a big hole in the middle, fractures are big cracks, and impact craters look like large or small circles on the ground and are found everywhere."

I used the science journals as an informal assessment that illustrated greater student understanding. A combination of KWL charts, the pre and post unit quiz, and both formal and informal assessments allowed me to gauge student comprehension. Other data also allowed for a number of quantifiable results.

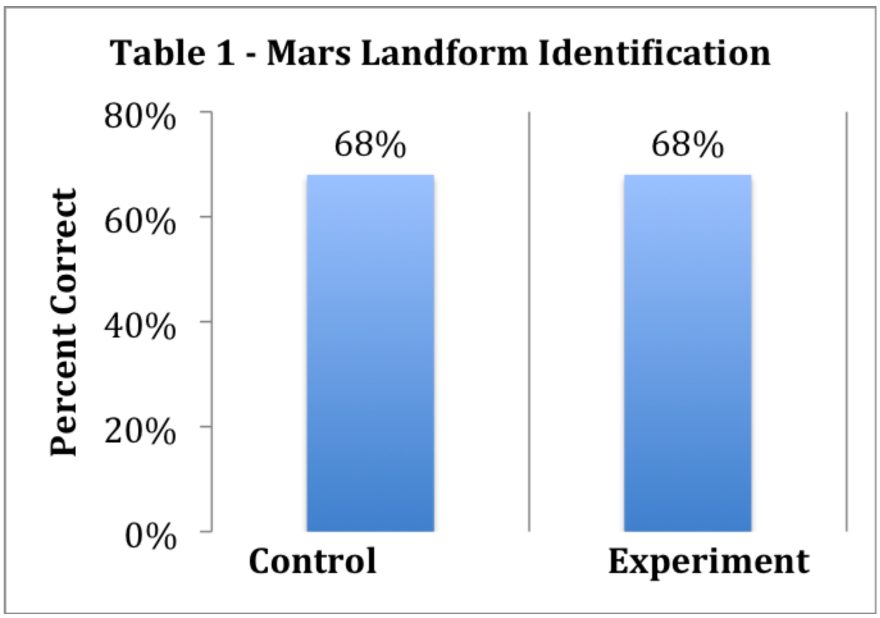


Table 1 (above) shows the results of the average score students received in both classes for the Mars Landform Identification challenge. What makes this result unique is that the control class had a full day lesson of looking at Mars satellite images before the challenge, while the experiment class had only minimal exposure through their one day of looking at two Mars and two Earth pictures from the Day 1 Mars/Earth matching game, and their own investigations from the Mars/Earth comparison posters. The experiment students learned just as much about Mars landforms through their own investigations as the control group did on a guided lesson with their teacher.

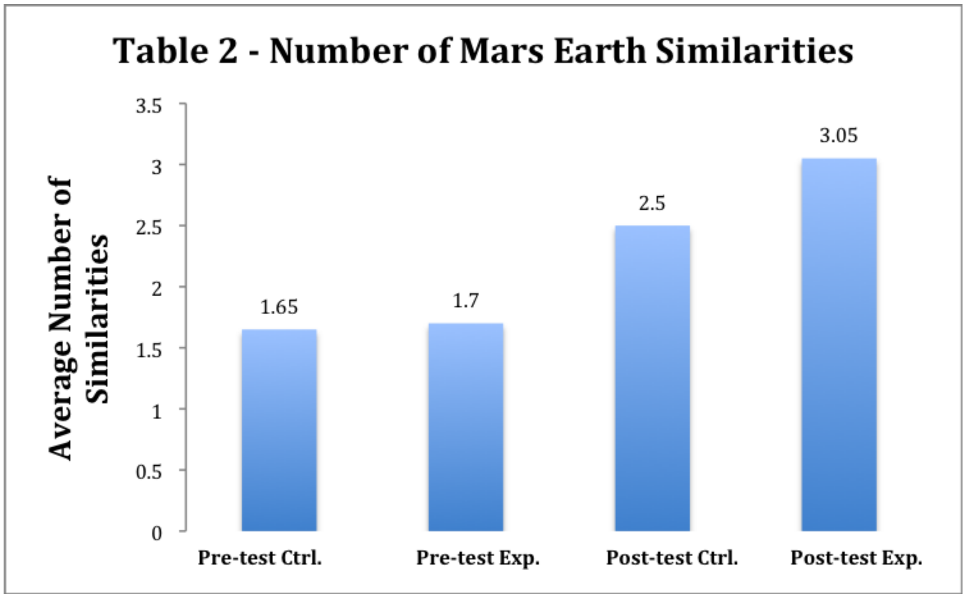


Table 2 shows the number of Earth/Mars landform similarities students were able to name pre and post lesson. Both the experiment and the control showed equal growth in this area.

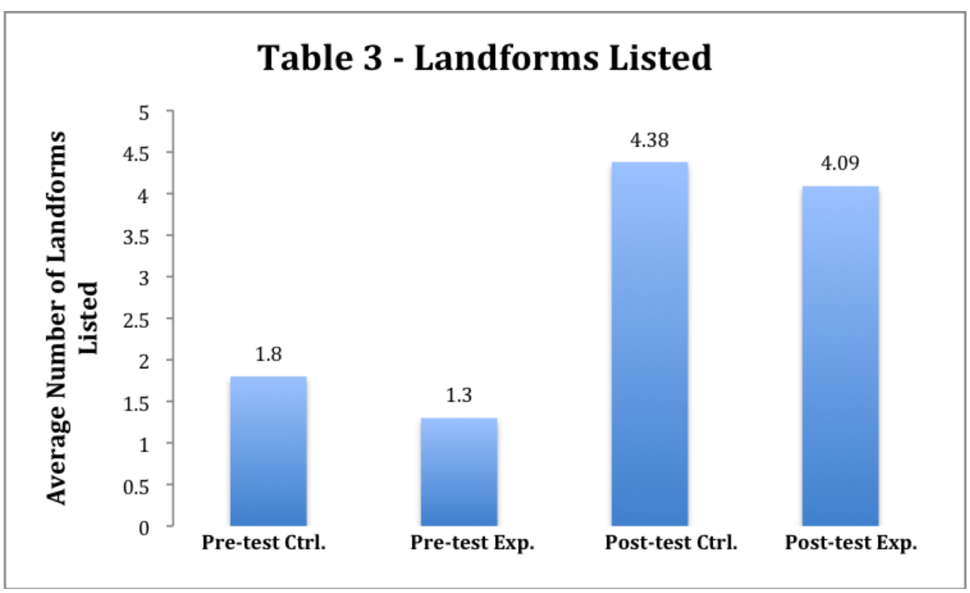


Table 3 displays the average number of landforms students were able to name on both Mars and Earth pre and post lesson. Once again both the experiment and control groups showed equal growth.

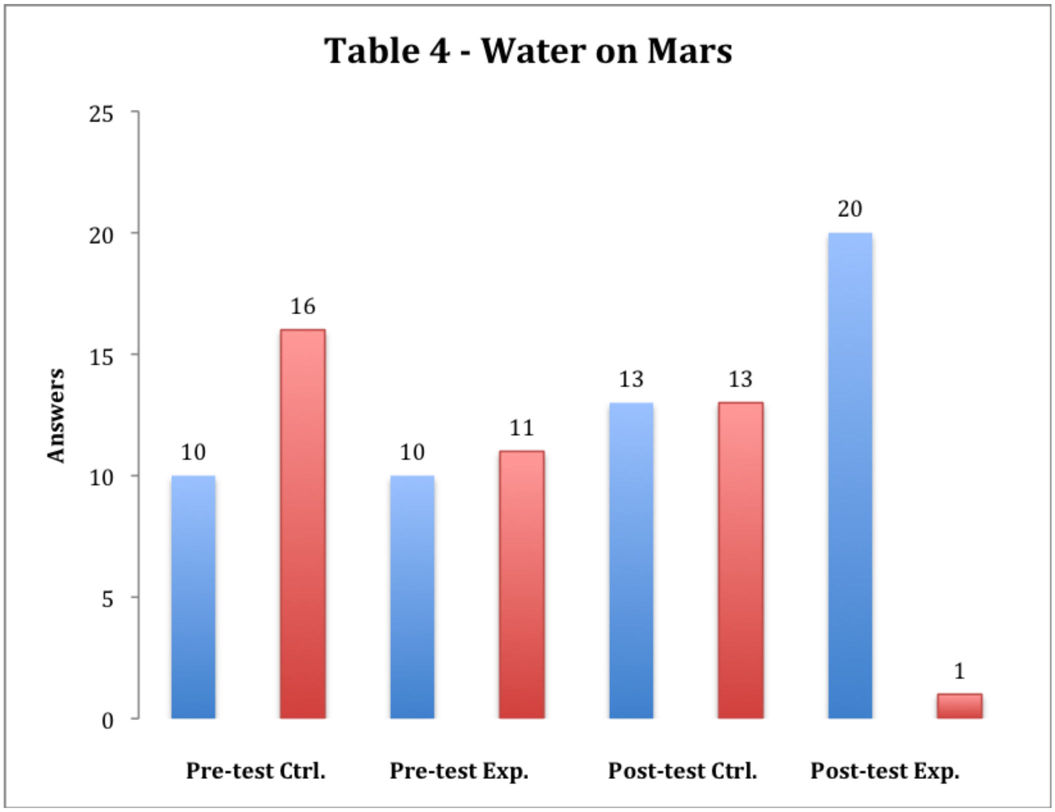


Table 4 is the most revealing. Students were asked on a pre-lesson assessment if there was water on Mars. Both classes were split almost 50/50 with yes and no answers. However, the post lesson results were significantly different. The control class was still almost evenly split on their answer, while the experiment class answered overwhelmingly that yes, there was water on Mars.

The experiment class's three-day Mars/Earth comparison project proved the difference in students building a greater understanding of the two planets similarities. Despite repeated evidence provided by the teacher to both groups, only the experimental group, through their own investigation, was able to connect the similarities between Earth and Mars.

After completing the lesson and analyzing the data, I determined that my research question, "What are the effects of a more inquiry-based curriculum on the understanding of sixth grade students learning to notice the similarities of landforms when comparing Mars to Earth?" was able to be answered.

I concluded that students understood the *big idea* and recognized the similarities between Mars and Earth. They displayed an increased knowledge in naming specific landforms that detailed those similarities. Most importantly, my experiment group showed that through an inquiry-based investigation, they connected how the effects of water on the surface of the Earth show that water had once existed in liquid form on the planet Mars as well.

My first action research led me to taking my first big step toward becoming a more inquiry-based instructor and to using inquiry to fit my teaching style and personality. Yes, I was following the 5E Instructional Model a little too literally, thinking I could only do one of the 5Es a day, but I was getting an understanding on how I could involve my students more in the learning process and how I could take steps forward. At this point, I had the experience of two different instructors with two different sets of inquiry teaching techniques. I knew their style was not for me, but my Mars lesson gave me a chance to experiment with inquiry and see how I could use it. I realized no instructional model is a step-by-step teaching method. I found I was using the steps of the 5E interchangeably. I was evaluating the entire time, not just at the end of the day or of the unit. Students can be engaged at different points of the week, not just at the beginning. I was also beginning to learn to let go, to not always feel the need to bail a student out with an answer when they are left with questions. As it turns out, my learning style goals of making clear objectives, giving feedback, monitoring progress, and making small goals that lead to a larger final concept meshed wonderfully with what I was learning about inquiry and led to my students being able to accomplish the goals I had set for them.

Wetlands

In each class of the MAT program, I learned something new. From the summer wetlands institute I learned the importance of having students work with one partner on a project instead of working with many partners. My wetlands professor had the class work in pairs, a strategy with which I was unfamiliar. Pairing proved to be much more effective than I thought possible based on my own teaching experience.

My science classes are all collaborative. Students work in groups of four or five and there are a few different reasons for this. Guides for science kits typically recommend four students working together with each having their own role. As a new teacher I followed this example. One student was the recorder, one student was the person who gathered supplies, one student was the leader of the group, and the final student was the person who actually did the experiment. Since I thought this was how science was supposed to be taught, I never changed the way I ran my groups. My wetlands professor opened my eyes by pairing me with only one other person. With only two of us doing work, we both learned more and became more confident about the subject matter.

Something else I learned about during my wetlands class was how to scaffold a lesson and ask effective questions. During the MAT program I had been given several articles on the subject of asking effective questions but struggled with implementing it into my own class because I had never seen it done in person. My learning style requires that I see something in person and not just read about it to help me understand it. One day during a Saturday class we watched a video from the 1970s of a science teacher who used effective questioning techniques, but it was not done in a way I felt comfortable imitating. The teacher in the video was asking too many questions and watching it left me as frustrated as my Mountain Matters class instructor had done.

As for scaffolding, it is something we had discussed during the program but not at great length. To be honest, even if we had gone into it in more depth I would not have been able to grasp it during the early parts of the MAT program because I was focused on so many other new things to which I was being exposed. Now, however, I noticed the scaffolding the instructor presented and I also understood it.

The website http://k6educators.about.com/od/helpfornewteachers/a/scaffoldingtech.htm defines scaffolding as, "specialized teaching strategies geared to support learning when students are first introduced to a new subject. Scaffolding gives students a context, motivation, or foundation from which to understand the new information that will be introduced during the coming lesson. Scaffolding techniques should be considered fundamental to good, solid teaching for all students, not just those with learning disabilities or second language learners. For learning to progress, scaffolds should be gradually removed as instruction continues, so students will eventually be able to demonstrate comprehension independently." What this actually meant became much clearer to me during the wetlands class.

Teachers often scaffold without even thinking about it; I know I do. However, seeing scaffolding done so purposefully in the MAT class made me really think about how I used it in my own classroom. I have come to the conclusion that what I have been learning during the MAT program has been implemented more in my writing classes than in my science classes. I believe I do this because I feel more confident as a writing teacher than as a science teacher. Recently I was working with my students in writing and I noticed how independent they are now that they have been in my class for three quarters. Having a class of self-sufficient students is a goal for any teacher. However, that was not always the case with this class.

At the beginning of the year, I break students down into groups. From my perspective they come to me unprepared to write more than one paragraph and they have a lot to learn. My mission is to teach them to how write multiple paragraph pieces as well as short constructed responses. A good elementary school writer can tackle any prompt and write it in long or short form. To get students where I want them to be by the end of the year, I monitor each person closely and this requires a lot of progress monitoring on my part. This is very time-consuming and exhausting work. It is also counter productive. If I want students to be self-reliant, I need to let go. During the wetlands class my professor modeled for me how I can do that with my own students. In the first quarter of this school year I was available to answer every question, and I hovered over students' shoulders to correct every mistake. As the school year progressed, I gradually decreased my assistance and let the students use the lessons I had taught them to fix their own work. By scaffolding my writing so that students are more independent, they have become better writers than any group I have had before. Students catch their own mistakes because they rely on themselves to find them and not someone else. Major assessments and big writing projects are coming up soon but I am not concerned because my students are prepared.

For the wetlands class my partner and I did a study on our professor's obsession, the tamarisk plant. I saw more tamarisk plants in the summer of 2011 than a human probably should be exposed to, but my instructor's passion and enthusiasm, not just for the subject matter but for working with other teachers, was infectious. If my Mountain Matters instructor was at the student-focused end of the inquiry spectrum (his instruction put teachers in the role of their own students), my Wetlands instructor was at the teacher-focused end (his instruction showed teachers how to use inquiry to instruct students). This is not to say one instructor was better than another but it was great to be exposed to a wide range of inquiry teaching styles, especially ones that felt very similar to my own. During the previous

2010 summer institute my growth as a classroom teacher came through my action research project. I came to understand how to use the 5E Instructional Model, that asking questions led to greater comprehension than giving answers, and that it was okay to modify curriculum if it was not working. During the wetlands class I grew as a classroom teacher in a completely different way, through the eyes of a student absorbing and closely monitoring the techniques of a master teacher. I learned the importance of scaffolding lessons and grouping students in pairs, but I also was finally able to see what an instructor was doing and view it from a teacher's point of view instead of just thinking of what I had to do as a student.

The first day of the wetlands course set the tone for the summer. The instructor pointed out how the class was going to be tiered and gave students clues on how the class was going to be structured. I think it is important for teachers to inform students of the process they are going to go through. Knowing what to expect can relieve the stress of the unknown, help students prepare for what is ahead, and help students understand why they are learning what they are learning. In my own classroom I do my best to keep my students informed. At the beginning of the day my class has a morning meeting where we go over what is going to happen that day. I also inform students about what is coming up in the next week or two. For individual classes such as writing, reading and science I do the same thing on a smaller scale. When students have to complete a project I always provide a rubric, a deadline, and give clues to where students should be in the process as it progresses.

By using this method students can pace themselves and rely on their own accumulated information instead of asking questions of their teacher.

Very early during the wetlands course the class took a field trip to Garden of the Gods and to the CC cabin. At the Garden, my partner and I created a transect line on a hill and made three quadrats to investigate the type of plants in the area. One of the things I learned from this lesson was how the instructor gave us some basic information, allowed us hands-on time in the field trying to use it, and then let us apply what we discovered into what he called a *story*. What was interesting about us telling our story was that the instructor let us tell it without being interrupted and at the end positively reinforced what we got right. Later after all groups had presented, the instructor talked about things we missed.

This strategy of introducing an area of study made me pay more attention to groups because I wanted to see how the other groups discovered their findings. The instructor illustrated a process I started implementing in my own teaching – giving background information, letting students explore, revisiting, and helping students to connect the new information to the background information. For example, in reading my class has recently been studying poetry. Poetry is not something easily understood because most of the subject matter relies on the use of symbolism and imagery. To get students comfortable with poetry I presented a poem, put students into pairs, and saw what ideas they came with for what a poem meant. Groups shared ideas and we came together and had the most fascinating conversations about the meaning of a poem. This idea on how to stimulate interest in poetry was inspired by my wetlands professor. In the wetlands class I clearly observed the 5E Instructional Model (Bybee et al., 2006, p.2) being used by one of my teachers for the first time. This proved to be a consistent theme for the class.

Gradually the wetlands instructor introduced new elements. He gave us botanical terms we tried to define on our own, and I began to notice how the instructor was scaffolding lessons. Having students define scientific words by themselves is a great device. Students start thinking about what words mean and move them into the topic of discussion on their own terms. Defining words also gives students the ability to read primary source materials so they can do their own research without a teacher explaining everything.

My instructor's gift for scaffolding is what caught my attention at the beginning of the wetlands unit. The instructor built on prior knowledge to get students to search and find an answer. Students learned that what they are doing today builds toward what they will be doing in the future. I call this structured inquiry because the learner is given possible connections and must use what they've done before to finalize those connections. On table 2-6 (NRC, 2000, p. 29), this leans toward the teacher giving more direction side but is useful in helping students understand how knowledge builds on prior experience. This sounds like something a teacher should already know, that previous lessons build on new lessons, and I was aware of it, but only as a teacher. Being aware of scaffolding as a student was a completely different experience and gave me a new perspective on an instructor's impact on learning. Most importantly, it led me to work harder at asking effective questions. My wetlands instructor was excellent at asking effective questions.

In the article “Asking Effective Questions” (Lowery, 1972, p.1) the author states that, “Instructors should ask students questions that directly affect the thinking of students. Another part is the recognition and avoidance of statements and questions that are trivial, misleading, confusing, or manipulative”. This was the approach my wetlands instructor took. Because I knew he never asked a question without a reason, I knew the question itself led to a new understanding.

While I am still working on my goal of being a better questioner, I am using questions much more frequently and effectively, especially in science. For example, during this present school year we were working on a Science Olympiad event called Clay Boats where students get a piece of clay the size of a large marble and have to build a boat that will float on water and support as many pennies as possible. Using effective questions I provided a scaffold so students came to their own understandings about how to use the clay to get a good result. I asked students about different shapes they could make their clay boat. Many students made a bowl, thinking it could hold more pennies. Then I asked students to think about the possible impact having more of the clay touch the surface area of the water would have, getting them to think about another shape they could use to distribute the weight of the pennies. I asked questions that encouraged and gave hints, with never an obvious answer. These questions helped students focus their attention to the task at hand and look for a solution.

The culminating activity for the Wetlands course was a Tamarisk research project. My partner and I examined tamarisk performance in a moist floodplain vs dry forest environment. My partner and I studied both areas; measured soil moisture, nitrate levels, soil salinity, and light exposure and compared and contrasted the two areas. After successfully completing our culminating activity I had a level of confidence I had never had in a larger group. I learned more working with one partner than I ever had when working with the traditional group of four. I always believed, because it was the only method I had seen used, that larger groups help share the workload. During wetlands I discovered that while that statement may be true, being in a large group also reduces the amount of learning an individual student absorbs. By being equally accountable for all the parts of an activity, a pairing gives both partners support as well as responsibility.

After working with a partner for so long, one of the biggest lessons I took away from the wetlands summer institute was how important collaboration is. In a classroom this would seem obvious, as most science classes have traditionally performed in groups. From elementary school through college, every science class I ever had was always done with at least one lab partner. But there were two things I discerned from my collaboration with my partner. The first is that it is impossible to hide in a group of two. In a group of three or more, one person can get away with not doing any work, and, consequently, not learning anything. I noticed this in my own classroom groups but could never figure out a way to correct it. My instructor gave me a simple remedy, using smaller groups where students work in pairs. Pairing is something I use as often as possible so that all students learn.

The other thing I noticed was that I began asking more questions because I felt it was safe. I attribute this to two different factors: (1) the instructor's encouragement to ask questions and (2) I was not working on my own. I had someone I could rely on and someone who relied on me. When I did not have an answer, I asked my partner. When we could not arrive at an answer together, we went to the instructor. Again, this seems self-explanatory, but I think this process is useful in all subject areas. I was pleased with the results of the collaboration with my partner, as we were very different people from different backgrounds, but these differences were not a detriment. Instead we were forced to find ways that both our differing learning styles and differing personalities combined to successfully complete our task. When my next school year began, I started giving students more opportunities to work in pairs on assignments. No longer was working together only good for science, but students paired up in reading and writing as well. I believe students' writing has improved. Through peer editing, something I rarely did before, students help identify common mistakes in their partner's writing and are more objective of their own. I could not be more pleased.

Weather

My last institute class focused on weather. By this time I felt very comfortable with inquiry, particularly the parts that appeal to my analytical nature. Oddly enough, the weather class ended up bringing things full circle for me. In this class I immediately knew what I wanted to do. I wanted to take the lessons I had learned several years before in the Matter Matters class and make them more inquiry-based. I had been using these lessons as discrepant events in science at the beginning of the school year, and both the students and I liked them. What made this a Circle of Life moment for me was that the Matter Matters class and Weather class had the same instructor.

At the start of every school year I like to get my students excited about science. To do that, the first three days of school are dedicated to a series of discrepant events. Typically what I do with students are activities I learned in science classes I have taken as a teacher that are both educational and have a high wow factor. Previously, these lessons have been very loose and unstructured since they are not part of my regular curriculum and, in most cases, students only used science journals during these lessons to tape or glue in a lesson summary they would later forget. But, after doing these lessons for so long, I realized I needed to give them more meaning, to actually put some educational value inside lessons that have up to this point just been fun. I wanted to use the first three days of school to set the tone for what my expectations were for the rest of the school year. By setting an example early, I would get much more educational value out of these lessons.

My learning targets were to introduce the concept of liquid and gas density to students and to introduce the concepts of sublimation (a solid going straight from solid to gas, skipping the liquid phase) and triple point (a substance co-existing as a solid, liquid and gas at the same time). Since my science olympiad unit begins right after my discrepant events, I used these beginning of the year lessons to get students acclimated to what is to come. I placed students in randomly selected groups of two. Because the school year just started, I did not know any of the students in a classroom setting. Seeing them work in pairs helped me spot their strengths and weaknesses. Pairing lets me know if students work well with others, if they are able to stay on task and not get distracted, and how well they follow instructions.

Each of the three lessons I taught, two on density and one on sublimation and triple point, required students to complete a task. Completing the task for each lesson – creating a wave bottle, making a Cartesian diver, and making an illustration on how sublimation and triple point work – along with a rudimentary explanation of the new concepts in students' science journals, provided the information I needed to assess student understanding. Besides physical tasks and using science notebooks, I also used different formative assessments from the book *Science Formative Assessment: 75 Practical Strategies for Linking, Assessment, Instruction, and Learning* by Page Keeley. I also applied the 5E Instructional Model (Bybee et al., 2006, p.2), formal and informal assessments, interviews, and the book *Predict, Observe, Explain: Activities Enhancing Student Understanding* by Michael Bowne and John Haysom (2010, p. 54) to help guide my instruction and assessment.

For the first activity, students created wave bottles to demonstrate the difference in density between liquids. Before making a wave bottle, students predicted what would happen when the elements of the bottle were mixed together. They observed and explained what they saw and drew a detailed model of their bottle in their science journals. Since there can be some confusion as to why the water and oil do not mix, I used Agreement Circles (Keeley, 2008, p. 51) to discuss their initial position and give them time to change their initial thinking. In an Agreement Circle, students form a large circle and the teacher gives a few true and false statements about the topic being studied. Students step into the middle of the circle if they agree with the statement being made by the teacher. Because it required movement, it was a fun way to check a classes' conceptual understanding and the students really enjoyed it.

Many of the students knew where I was going from the start. When it came to the *predict* portion of the questions, several of the students knew the differences in density or were close in concept but did not quite have the vocabulary down. This really surprised me, as I do not believe any students have been taught density this way at my school. Despite many students having a heads up, the lesson went well.

The students were excited to make the wave bottles, were able to do the Predict/Observe/Explain without much trouble, and were also able to communicate what they were doing. They will not be using the word *immiscible* in their everyday conversations, but they got the point. This lesson, which is just an introduction to a much deeper concept, but it was good to see that students picked up on the concepts I was teaching them.

There are some things I will change for the future. I just did not have enough time. My penchant for over planning continued to get in my way. I talked too much at the beginning instead of letting kids get to it, but I felt I had to explain my process and expectations since this was my students' first science lesson with me for the new school year. Something else I will consider changing is giving everyone a handout instead of using my projector to show instructions on the board. I think it might have made answering Predict/Observe/Explain questions easier if they were right in front of them instead of squinting at the board. Despite these issues, I was pleased overall with how the lesson went and feel confident that with a few minor tweaks, it can be even better.

The second part consisted of students creating Cartesian divers to demonstrate how the density of gas can be manipulated. Before making a diver, students predicted what would happen when they squeezed their wave bottle. Next, they observed and explained what they saw in their science journal.

Because the concept of manipulating air is a complicated one, I used the Fist to Five formative assessment (Keeley, 2008, p. 93) throughout the lesson and had a handout for students to help explain how Cartesian divers work. In the Fist to Five formative assessment students indicate the level of their understanding by holding up their hands and displaying a range of zero to five fingers. A closed fist would indicate a student has no understanding while five fingers would indicate a student completely understands a concept and could easily explain it to someone else. Fist to

Five is a simple way for all students to indicate how well they understand a concept or skill.

During this activity students once again were able to make accurate predictions about what would happen to the bottle once it was squeezed, but I was not surprised this time. Cartesian divers are a pretty well known science activity and easy to do, so the chances of my students either making one at home with a parent or seeing it on a show like Bill Nye the Science Guy are pretty high. I again used the Predict/Observe/Explain model to structure the lesson and it worked well, much better than day one, as they knew what to expect. For example, on the first day of using discrepant events students were able to make a prediction but did not really know what to write down in the Observe and Explain sections. Now that they had done it once and knew what my expectations were, students worked in pairs, helping each other write observations and collaborated to come up with possible answers for how the Cartesian diver worked. I decided to also use Agreement Circles again, as they are just so quick and easy to use. I do not use them all the time, of course, but using one type of formative assessment a week, I believe, works better than using a different one every day.

While the lesson went smoothly I still ran into some issues that need resolving. First, and I cannot believe I did not notice this before, my instructions were poorly written. As someone who writes professionally part time, I was embarrassed. My instructions were so bad I even forgot a step. I did not mention the part about putting a nut at the end of the pipette. Since my instructions were poor, I again performed a demonstration with a student to show how to properly construct the bottle. This went fine but I ran into another familiar problem - running out of time. A lack of water sources hampered this lesson. I only have one sink in my room and it took forever for everyone to fill in their bottles. Looking ahead, I will ask for volunteers to fill bottles at recess next time.

Problems aside, I was very pleased with how the lesson turned out. Even though many children had a good idea what would happen when the Cartesian diver was squeezed, they could not explain why. When I informed students how it actually worked, there were several “ahh, I get it” whispered in the room, which made me feel pretty good. This told me students were able to connect what they were seeing visually to what they learned.

The final discrepant event used dry ice for students to learn about sublimation and triple point. I broke the lesson down into three parts. (Part 1) Students added dry ice to a closed balloon to learn about sublimation. (Part 2) Students added dry ice to a closed pipette to learn how using temperature and pressure can bring dry ice to its triple point. (Part 3) After discussing both lessons, I used the Four Corners formative assessment (Keeley, 2008, p. 97) so students could discuss and clarify their thinking on sublimation and triple point.

I was first shown how to use Four Corners by my school counselor. We co-teach a social skills program called People Smarts. This program helps give our students, who unlike other sixth graders are still in elementary school, an idea of how to handle some of the pressures of junior high. One day in class, the counselor put four different emotions in the four corners of my classroom. She gave different scenarios and asked students how they would feel if that situation happened. Children went to different corners of the room. Students were really engaged during this activity but I never used it. After seeing this formative assessment described in the Keeley book, I started thinking how I could use it for science. I replaced the emotions from People Smarts with science responses. Students moved to a corner designated to match their response or way of thinking. For example, when I put the dry ice into the balloon I had students go into a corner with a sign that had an explanation for what they were seeing. In one corner I had "the air is getting colder inside the balloon so it expands". In another corner I had "the gas released by the dry ice has nowhere to go and it is expanding the balloon". In a third corner I had "I do not know". I only used three corner for this lesson.

Originally in part one of this lesson, I was going to have the children, in pairs, use a balloon to help explain sublimation. Students were to trap dry ice in a balloon and tie it closed and watch it expand. But since I was having time issues with my first two lessons I decided I would lead a group experiment instead while students filled out their science journals. This turned out to be a very good idea as it saved a lot of time. This was most noticeable when we were able to complete the entire lesson despite losing valuable minutes to a lock down drill.

However, I was not completely pleased with cutting this activity down to save time. I am constantly learning ways to be more effective with the way I use the limited time I have. I know that student understanding is more important then time, so there are situations where I need to be flexible with how I present information. Because I altered my plans to save time students did not get the hands on experience with sublimation I wanted to give them. I did the work for them. In the future I will set the lesson up for the students and give them time to think and discuss with a partner what they are seeing. For example, instead of explaining and describing how dry ice makes a closed balloon expand, I will have students watch me put dry ice inside a balloon, close it, and then ask them to explain what they are seeing to me. By handling the set up I save time, but by letting students explain the process they are being more proactive learners than if I just described what they were seeing to them.

Much like the Cartesian Diver and Wave Bottle lessons, several of my students had seen the dry ice activity already. They knew what was going to happen, but they could not actually explain how it worked. The sublimation portion, part one, worked well and students seemed to grasp the concept rather easily. I was very pleased by many of their explanations in their journals. The triple point portion, part 2, was not quite as successful. First of all, it is a somewhat complicated concept for students to comprehend. I think there are just too many things for them to take in. Secondly, we were pressed for time due to the lock down drill so I did not have as much time to discuss and check for understanding. The students also found it more effective to blow up the pipettes using cups of water, a process that speeds up sublimation and therefore the resulting explosion when the pipette is closed, so this obstructed their view. But most importantly, the exploding pipette was so fascinating students were more interested in blowing up a pipette than actually understanding why it blew up. I cannot totally blame them for that last part. It is pretty cool.

When I do this activity again I plan to spend more time on the triple point portion and will probably do a class demonstration first before allowing students to do it themselves. That way, children can fill out their journals and I can check for understanding before they begin blowing stuff up. Another thing I would do differently is have some wet ice on hand. It would have been useful with both the balloon activity and for students to witness the difference when I leave both types of ice in a clear cup throughout the class.

Overall I was very happy with the results of my weather curriculum refinement. It gave previously loose lessons more structure, helped build a basis for better and more complete science journals, and gave me more practical experience with formative assessments and how they work for me in class. My refinement also made me more reflective. Like most teachers I make little notes in my planner about what did and did not work. But since there was an assignment involved I was much more cognizant of the effects my lessons had. I will follow through with this more effectively in the future. What pleased me most, however, was that I was able to take the mistakes I learned from these lessons and apply them to the rest of my science classes for the quarter.

Since the first quarter at my school we do experiments for Science Olympiad and the lessons are very similar to what I did for my beginning of the year discrepant events, I took this weather curriculum refinement and used it as a template for the remainder of the first quarter. I gauged this particular group of students' background knowledge, how well they worked as a team, and their strengths and weaknesses when it came to science journals. I acquired a better understanding of my own teaching techniques, which helped me determine when I needed to be more flexible.

Water Bottle Rocket Action Research

My final Action Research was the one for which I felt the most prepared but also the one that gave me the worst results. It proved two things to me. I am always going to be learning, no matter how much I have already learned, and reflecting upon my work is a good thing. If I did not reflect, something I had never done prior to starting the MAT program, I would have continued making the same mistakes and not realizing them.

In my final action research, I focused on water bottle rockets. This is an activity we do at the beginning of the school year during our Science Olympiad unit. An attention to statistical analysis and student notebooks is incredibly beneficial to students. The Atlas of Science Literacy suggests the usefulness of compiling, studying, and understanding summary characteristics of data sets, rather than just individual data (American Association for the Advancement of Science (AAAS) & National Science Teachers Association (NSTA), 2001, p. 122). In the article Five Good Reasons to Use Science Notebooks (Gilbert and Kotelman, 2005, p. 29) the authors explain that the science notebook is a tool for students to construct his or her own conceptual understandings. Not only do science notebooks help guide teacher instruction and enhance literacy skills, but they also support differentiated learning, and foster teacher collaboration.

As a classroom teacher, notebooks guide instruction because looking at them lets me know what students' level of comprehension on a topic is. Notebooks enhance literacy skills by giving students a way to communicate their thoughts through their writing instead of verbally. Notebooks support differentiated learning. Every student notebook is different. Some students have better writing skills than others so they can express themselves in their science journals through words. Other students are better at explaining through illustrations, while still others use a combination of pictures and words. Forcing students to conform to one way of using their notebook stifles learning by preventing a student from using their best practice and conforming to my ideas. Science notebooks also help foster teacher collaboration. Many times I have modified the way I used a science journal because of the clever techniques I have seen other teachers use.

Science notebooks are an important tool in student and teacher metacognition. When students have notebooks set up with two complementary goals – one focused on content and another focused on the recording strategies used in the notebook itself) – they are better able to use the information in their notebook and understand the importance of documenting their own work.

(Campbell and Fulton, 2004, p. 27). My goal is to help students use the information in their notebook and understand the importance of documenting their own work.

Formative Assessment - To make more efficient use of statistical analysis and student science notebooks, several formative assessment techniques were employed. Formative assessments help determine students' comprehension of key concepts and lead to opportunities for students to share their varied ideas in the classroom. Formative assessment classroom techniques (FACTs), from the book *Science Formative Assessment: 75 Practical Strategies for Linking, Assessment, Instruction, and Learning,* aid in the use of statistical analysis and notebooks. They provide a valuable assessment tool before, during, and after instruction. FACTs help elicit prior knowledge. FACTS assist in marrying the concepts of factual knowledge with conceptual understanding, and aid students in taking a metacognitive approach – a student thinking about their own learning and thought processes – to science instruction (Keely, 2008, p.5).

When I used the Fist to Five FACT (Keeley, 2008, p. 93) I determined how many students understood a new skill and what specifically their comfort level was. In a FACT such as I Think We Think (Keeley, 2008, p. 117), where students use a two-column paper in their journals to record their own ideas and then record the ideas of the class or group after a group discussion, I use science notebooks to assess individual student comprehension.

Unlike most summative assessments, FACTs are very flexible. Most FACTs can be adapted to fit any subject of study. Not only are they not limited to a particular grade level but they are also just as effective if modified to meet a classes' needs. I have used the Four Corners FACT (Keeley, 2008, p. 97) in almost every subject I teach. In spelling I use it in a game where students have to go to a different corner of the room depending on how the word in that corner is spelled. And in reading students go to a corner with the name of their favorite character from the book we are reading and have them share with the class what makes that character so special.

To allow for quantitative analysis of the data gathered by students, my water bottle rocket curriculum study was performed on two separate sixth grade science classes. The control group received the exact same instruction that had been given for the water bottle rockets lesson for the past five years. The experimental group used inquiry-based instruction with their science notebooks, formative assessments, and statistical analysis. My belief was that through the refined curriculum, the experimental group would create more efficient and ergonomic rockets, students could show evidence of metacognitive thinking in their science journals, and rockets might have a greater average flight time for their rockets than the control class.

One class was given a set amount of materials and told to make a rocket that would stay up in the air for as long as possible. The other class was recording flight time data in their science notebooks, completing several different formative assessments to check for understanding, comparing results from flight times to modifications and looking for clues as to how variables affected their rocket. My plan was to use what I had learned in my MAT classes – the importance of science journals, the usefulness of formative assessments, and the reflective thinking that science notebooks offer – and pass that knowledge to my students.

What I wanted to know was, "How do formative assessments affect the students' comprehension of the amount of time a bottle rocket stays in the air?" Students used formative assessments to analyze the construction of their bottle rocket. Students examined three variables: the parachute, the amount of water used in the rocket, and the overall weight of the rocket. Partners were allowed to use different amounts of materials at their own discretion. Overall bottle mass was considered a factor to maximize the flight time of their rocket. While both the control and experimental group were aware of all three factors at the start of the bottle rocket unit, the hope was that through formative assessments the experimental group would have a deeper understanding of these three variables and would therefore have more success.

I created a detailed daily lesson plan for the Water Bottle Rocket portion of the Science Olympiad unit. Over the course of five days students were introduced to bottle rockets, constructed rockets, and interpreted data to improve rocket performance (time aloft). Statistical analysis, science notebooks, and formative assessment all played important roles in this lesson, as did the 5E instructional model.

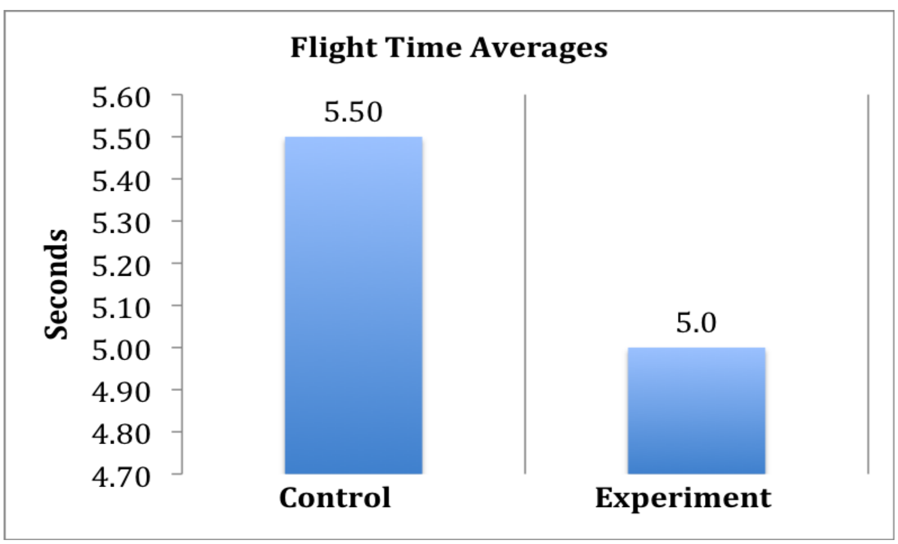
The goal was for students to use statistical analysis through the measurement of bottle rocket time aloft, measuring the diameter of their parachute, and by weighing their rocket. By measuring these things and seeing how it affected the length of time their bottle was in the air, students could adjust variables and improve their rocket. Science notebooks were an integral part of statistical analysis. Without recording their results, students could make the same mistake twice and be unable to determine what variable affected their flight time. Formative assessments were used to see where students' level of understanding was when it came to manipulating variables. For example, I used a Concept Cartoon (Keeley, 2008, p. 71) to show characters with differing points of view on a topic. Students decided which character in the cartoon they agreed with the most and explained why.

I had the question, "How much water should I have in my rocket?" on a poster with a picture of three different characters with different answers. One character, a dog, believed he should have a lot of water because it was fuel for the rocket. Another character, a tiger, said he should have a little bit of water but not too much. The third character, an elephant, said he would have no water in his rocket because it would weigh it down. Students chose an animal and explained why they thought their choice was correct.

To my surprise, several students strongly defended the idea that much like a car, the water bottle rocket would go farther if it had more fuel (water). During the discussion, these students were unable to be convinced that this was an incorrect assumption by either their classmates or myself. To settle the debate we did a quick demonstration of all three amounts of water mentioned in the Concept Cartoon.

Afterwards, I heard the leader of the dissenting group tell his friends who had agreed with him, "I get it now. Too much water makes the rocket too heavy."

Throughout the lesson students built on what they knew through the 5E Instructional Model (Engage, Explore, Explain, Extend, Evaluate) (Bybee et al., 2006, p.2). In my action research from last year, each day's lesson was a different E and lessons went in sequential order. As a teacher more experienced with the 5E, I still used every level of the instructional model, but I was now more comfortable using it out of sequence to meet students needs. I no longer made sure the first day was an ENGAGE day. Every day had a little bit of each of the 5E in it, as some groups did more exploring, others were better at explaining. As a more experienced teacher, I no longer felt the need to structure my lessons so that they only focused on one E a day. I understand that I need to keep the structure of the 5E in order, but as I became more familiar with it I realized I used multiple Es in a day, not just one.



After all the time I spent with both classes, I was surprised to find that the flight times for both groups were almost identical. In fact, the control group would even appear to even have done a slightly better job. There are a number of possible reasons for this. For some unexplained reason, I only had the final launch count for my control group, while the experimental group was directed to average their scores over the course of the lesson. Some averages included a launch time that counted as zero because if part of their rocket fell apart, an automatic disqualification by the rules of Science Olympiad, their flight time would be recorded as a zero. This resulted in a slight lower average flight time for my experimental group.

What the table above shows is the average final flight time of the control group's last launch compared to the average overall flight time of all four of the experimental group's launches. This is not a straight one-to-one comparison but my goal was to be able to show improvement over time. This should have been done with both groups, but since my experimental group did not seem to show any improvement from launch 1 to launch 4, I still feel Table 1 is a valid comparison.

Water usage and parachute radius were two other assessable factors measured by my experimental group. However, since the control group did not record this data I have nothing to compare this information to. The average launch times were almost identical anyway, so neither water usage or parachute radius seemed to be a determining factor in how long a rocket stayed in the air. My informal observations, where I noticed students in both classes using similar techniques for the parachute design and the amount of water used in rockets, would confirm this.

In some ways I was disappointed by the results of my experiment. I am not sure whether it was my hubris or the success of last year's action research project, but I truly expected to see a significant improvement in the launch time of my experimental group. I believed focusing on water usage and parachute diameter with one group while letting another group play with different ideas would lead to a better rocket aloft time for the more focused group. I was wrong.

After giving this experiment considerable thought, I have come to the conclusion that the control group did just as well as the experimental group for two different reasons. (1) Water is not as big a determining factor as I originally thought. While it is true that having about 1000mL of water does boost the height a rocket initially flies, it never really made a significant difference. (2) Parachute designs for both classes were identical. Students did not grasp the concept, despite a brief lesson for both classes where I demonstrated that a parachute should be round and flat, on what an effective parachute should look like.

Students were *convinced* that because they waved around the plastic bag I gave them to use for a parachute in class and it caught air that it would work as an effective parachute. Their own hands-on experiment with the plastic bag superseded their teacher's model of a toy paratrooper because it was something they did instead of watching an experiment I conducted.

Despite not getting the results I wanted and hoped for, I came away with several different ways to make this lesson more effective. First, I need to only focus on one variable. Students were given tag board to help build fins to help straighten their flight, but because the tag board was not firm enough it ended up being ineffective. I will remove this part entirely. Second, I will be sure to do a live launch demonstration with different amounts of water. Bad weather prevented me from doing a demonstration for this lesson. Despite telling students that too much water would weigh the rocket down and students witnessing the results of other students putting too much water into a rocket, they kept adjusting water levels anyway. A live demonstration, before students are preoccupied with their own rocket, should alleviate the water issue so students are not fretting over whether they should be adding 800 or 1000mL of water to their rocket. I will focus solely on parachute construction next year. This should have been my focus from day 1. After doing this Science Olympiad event for six years, I knew the winning team has always been the one that develops the best parachute.

The primary goal of making a bottle rocket is to get the rocket to stay in the air. The one variable that has the biggest impact on how much time a rocket stays aloft is the parachute. There are other variables at play but it was irresponsible of me, because I was having students manipulate so many variables at once, to expect students to be able to differentiate which variables really made a difference in their flight time. Concentrating on the parachute will allow students to direct their energies onto the one variable that has the greatest impact on longer flight times.

Besides channeling the lesson to parachutes I will also give the students new materials - plastic grocery bags are out, trash bags are in. This should alleviate the misconception that comes from waving around a plastic bag. I will also pick up more toy soldier paratroopers so students can play with them in class. I only had one this year, which is not nearly enough to go around for students to play with. They are easy enough to grab at any dollar store and are an effective model students can get hands on time with. All of these changes lead to a more effective use of time, which brings me to my formative assessments. Because I did not use them consistently, the FACTs I used were not as effective as they could have been. My plans for this lesson were made before the school year started. Once I returned to school I learned that my science time was cut in half and I did a poor job of modifying my own curriculum refinement. By narrowing my formative assessments to analyzing parachutes only, students should have an even deeper understanding of how they work regardless of how much or how little time I have.

While I am not sure these changes will lead to any greater success at the district Science Olympiad competition, I do believe this unit gave students a better opportunity to achieve the goal of the lesson. I am certain that being able to focus on one variable instead of three will lead to longer flight times.

The results of my water bottle rocket experiment reminded me of the importance of play. During a recent Saturday MAT class there was a discussion on the first few chapters of the book *The Young Child as Scientist* (Britain and Chaille, 2003, pp. 3-26). Chapters one and two of the book discuss how young children build theories on how things work by playing with things. For example, a very young child can push a round object and learns that all things roll. Then that same child pushes a square object, notice that it slides instead of rolls and modifies his thinking. For my water bottle rocket lesson I gave my control group permission to play. With my experimental group I bogged them down with paperwork and never truly let them play. I need to make sure I always give students some play time to help them build their own theories on how things work.

During this lesson I was reminded of the importance of reflection and flexibility, something the MAT program has really made me focus on since I began it two years ago. Even if a lesson goes perfectly, I always ask myself what I could do better and what I need to change during a lesson to be more effective. In years past, I am not sure I would have been so mindful of the impact of what I was doing. I would be *doing* teaching instead of *thinking* teaching. I do not do that any more. In some lessons the areas of improvement are obvious, like this one. I still find, even when not working on an MAT project, I am reflecting on how well a lesson did or did not work. It has been built into my thought process now.

Leadership

I never really considered myself a leader, at least not in the traditional sense. When I hear the word *leader* I think of a Winston Churchill, Steve Jobs, or John Elway. I think of someone who has done something brave, done something innovative, or has displayed incredible willpower and overcome great odds. But when it came to thinking of myself as a leader, I never pictured myself as that kind of person.

When I first became a teacher I used to think that I would one day become a principal. I just thought that was what teachers did. A teacher taught for a while, gained some experience and wisdom and then became a principal so he or she could pass their knowledge on to other teachers. After teaching for a few years, however, I quickly discovered that being a principal did not appeal to me. A principal's life is full of politics, dealing with challenging teachers, dealing with parents, and dealing with students who get in trouble. That did not sound enjoyable to me.

After a number of years in the classroom I did begin to see myself as a leader but as a specific type of leader. I was a leader of children. I taught children how to read and write. I also told students what to do, what not to do, what they could and could not say, and when they could go to the bathroom. In retrospect, I was essentially a dictator of 20-27 young people from 8 a.m. to 3 p.m. If I were to look at the Essential Features of Classroom Inquiry and Their Variations (National Resource Council (NRC), 2000, p. 29), which was lovingly referred to as Table 2-6 during my time in the MAT program, I was certainly on the far right side of the table. This means that during my early years as a teacher I allowed for a very small amount of learner self-direction and gave a lot of direction from the teacher. At the time this seemed like an effective approach to teaching but as the years passed I struggled with my job for reasons I did not yet understand.

Six years into my teaching career I was not certain about my career path. I needed a break from teaching and took a job as a Youth Director. I was still indirectly working with children but my role was much different. Instead of monitoring children directly I was in charge of a staff of about 20 supervising adults.

I had no prior experience managing adults, but my reasoning at the time was that if I could be the leader of 20-27 children, I should easily handle 20 adults who were much more self-reliant. This proved to be a mistake. Taking the Youth Director job made me a de facto principal, not of an elementary school but of a large day care center. It was the one job in education I knew I did not want to do and it was what I inadvertently ended up doing anyway but in a different field. I hated the paperwork, I hated listening to whiney employees, I hated dealing with grumpy parents, and I never had any time to spend with the children that I was indirectly overseeing. I was miserable. Needless to say, I was not very good at my job. I missed teaching and found what would be my current teaching position the next school year.

When I returned to the classroom I was reinvigorated. I had a greater appreciation for my profession but I still swung far to the right when it came to Table 2-6 (NRC, 2000, p. 29). I still leaned toward giving more direction than giving students a chance to be self-directed. However, the light bulb that was dimly lit from my Matter Matters class had more potency now that I had a finer appreciation for teaching. I knew that dim bulb needed to shine brighter. To make the bulb brighter I applied to the MAT program.

When I first discovered I could be a true classroom leader, and not a classroom dictator, was during the wetlands class. My instructor demonstrated trust in his students. The instructor gave us background knowledge on the tamarisk plant. He let students come up with questions we would want to answer and helped us think through the process of how we would go about answering it. The instructor was there to provide guidance but my partner and I were the ones learning by doing, instead of learning by listening to our instructor lecture. My wetlands instructor was clearly the leader of the class even though we talked just as much as he did. My partner and I went to him with questions and while we knew we probably would not get a direct answer, we knew we would get something better – a clue to help us figure out what the answer was.

The absence of an ego from my wetlands instructor was refreshing. The instructor did not feel the need to be the man with all the answers. The instructor was no longer the center of learning, an all-knowing being with mystical, unreachable knowledge. Instead he was a conduit of knowledge, someone who helped students become what all teachers really want, self-reliant learners, or discoverers.

As I began to realize I did not need to be the center of attention in the classroom, I took notice of what my school counselor likes to call *allowing others to shine* as demonstrated by my other instructors. My weather instructor and my MAT program leader both showed me that I controlled my own learning. They demonstrated this not through lecture or by even saying “you control your own learning” verbally, but by modeling how to let students be more self-directed. My MAT program leader provided a wide variety of materials to read, never telling me what to think but letting the answers come to me through the text. My weather instructor had a similar style to my wetlands instructor. She provided guidance, but discoveries were made through student-led experiments, not through a handout or a tedious lecture.

Looking at Table 2-6 (NRC, 2000, p. 29) I now know that I am closer to the middle of the inquiry spectrum thanks to my experience in the MAT program. I am now giving students opportunities to be more self-directed and take less direction from their teacher. For example, I recently taught a math lesson that examined how the way questions are asked influences data. An example I gave was, “Are you in favor of the city providing more opportunities for youth?” That is not a fair question because most people would not say they were against providing opportunities for youth. After I gave some other examples, I wanted students to get a truer understanding of the concept by having them conduct a poll themselves to prove the point of the lesson. The class worked together to come up with two questions on the same topic, one that was fair and one that was unfair. Two students went to two different fourth grade classrooms. One student asked the unfair question, “Do you agree that video games are harmful?” The fourth graders asked that question answered yes by a 12-8 margin. The other student who asked the fair question, “Are video games harmful?” got the exact opposite response. The fourth graders he asked said no by a 12-7 margin. Through an activity designed and carried out by the students, they were able to understand more thoroughly how the way questions are asked influence data. This activity, which took only 5-10 minutes, went so well I shared what I did with my teaching partner, and he performed it with his class too.

Prior to my experience in the MAT program I probably would have let the examples in the math textbook be the only examples of how the way questions are asked influences data. Or as the instructor, I would have come up with the questions to ask a different class myself. However, as I become a less teacher-centric instructor, I understand how important being a leader who can help facilitate learning as opposed to being the center of learning can be. I realize now that being a leader does not always mean you are front and center. Being a leader in the classroom is like being a coach, the students/players are the ones who decide the outcome but there is always someone on the sideline to give a guiding hand.

Conclusion

At the beginning of this paper, I stated I was more of a doer than a thinker. I believe after my experience in the MAT program that I am now both a doer and a thinker. Now that I am both a thinker and a doer, I would like to take my experience in the MAT program and be more involved in helping other students who might struggle with the concepts that I once did.

One of the first moments of clarity I experienced in the MAT program was when a fellow student/colleague helped me understand what an instructor was really doing and how that instructor was using inquiry. I would like to return that favor and help other MAT students. The purposes for this are twofold. First, if I could work as a volunteer teacher's assistant or mentor in the MAT program I would be able to continue to be around people who had similar skill set as myself. It would be as if I was extending my own MAT experience, and I think that would be beneficial and enjoyable. While I have come a long way on the Table 2-6 spectrum

(NRC, 2000, p. 29), I know I can go ever further. Even though I am finishing the MAT program, I want to keep learning and I believe that continuing to be a part of the program, even in a small way, could assist in fostering even greater understanding. Secondly, there were times during my MAT experience when I needed another voice besides my instructors. I needed support and people to whom I could bounce ideas. I was fortunate to have that in a number of my other classmates. The challenge of making it through the MAT program without the support of those classmates would have been almost impossible. I want to be that support system to someone else and pay back the kindness that was given to me.

In the next few years I would like to take an active role in being a part of the MAT program. During that time I want to continue to grow and develop as an instructor. I see myself working as a teacher's assistant, helping quality instructors such as the ones I had for my weather and wetlands courses. During that same time frame I plan to refine my own school curriculum, going quarter by quarter, first with science, building on the curriculum refinements I have started already and continuing to make them more inquiry-based. I will then share my new, more inquiry-based curriculum with my fellow sixth grade teachers. I have seen first hand, both through my interactions with classmates in the MAT program and by sharing the results of inquiry-based teaching methods with my teaching partner, how important it is to share what I have learned with others. Sharing knowledge and experiences passes understandings to others, which is at the heart of being a teacher.

In 10 years I would like to take my experience and become a mentor to student teachers. When I was given my first teaching assignment, teaching fourth grade, I felt ill prepared despite completing an elementary education program and serving as a student teacher. I would like to take my skills and experience and help new teachers not just understand about curriculum and classroom management, but all the little things that no one ever mentions in a teaching program. Things such as making sure to always be on the school secretary's good side, never take school custodians for granted, and always be proactive when it comes to dealing with parents may not be addressed in a teacher's education program, but they are very important concepts for new teachers.

In 15 years I would like to like to work as an instructor for students in teaching programs. By that time I will have seen several great instructors and incorporated many of their techniques as my own. I can then pass that knowledge on to future teachers. From my time in the MAT program and my experience refining my own curriculum, I can also help explain to new students how they too can take whatever curriculum they are given and make it more effective for students. In 20 years? By then I will be in my 60s so I hope to be getting close to retirement. While I may start to slow down when I am older, I would like to become more focused on one of my passions – writing. If I am not writing myself, I would enjoy working with students who are struggling with writing. Who knows, maybe I will even design my own writing curriculum.

Completing the CC MAT program is the hardest thing I have ever done academically. It was frustrating, challenging, and stressful. But like most things that take determination and sacrifice, the end result was well worth the effort. I can honestly say that I am a better teacher now than I have ever been and I have the MAT program to thank for it. That dim light bulb glowing in my mind has grown a lot brighter.

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