Teaching Science: My Journey

By

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The Way We Were Taught

"I think science is awesome because I love watching cool stuff like explorations." A.K. Age 10

"It is not the subject matter that makes some learning more valuable than others, but the spirit in which the work is done." (Holt, 1964).

There was nothing wrong with the way we were taught science in junior high and high school. We sat in class and took notes off the board. We went home and read the chapter for homework. We took a test over the notes and the chapter when all the material had been "covered". If we got a bad grade, it was because our notes were incomplete or we failed to read the chapter. Our performance had nothing to do with the teacher. This format for science class went on for years. Teachers in the United States had no idea there was anything wrong with American science classes until 1957 when the Soviet space program launched Sputnik.

This historic event caused many countries to take a closer look at how math and science were taught. In 1958, The International Association for the Evaluation of Educational Achievement (IEA) was created to look at how teachers taught and how that teaching influenced achievement. In the 1960s, there was tremendous attention in the United States on the development of new, inquiry-based and conceptually based science and math curricula. Eventually in the 1990s, this led to the creation of the Trends in International Mathematics and Science Study (TIMMS). This study was designed to examine test scores in math and science at each level of schooling for participating countries. The results of the TIMMS have not been encouraging, American students do not perform well. In 2001, with the creation of No Child Left Behind, politicians attempted to legislate educational policy so American students could catch up to other students around the world. Improvement, though slow, is happening. "The basic notion . . . is that an educational system should be guided by content standards defining what it is that students should be expected to know and do." (Schmidt, Wang, McKnight, 2005).

Children in elementary school like science. They are naturally curious and they enjoy learning about our world. In the late 1980s, Full Option Science Systems (FOSS) and Science & Technology for Children (STC) took advantage of that curiosity by creating hands-on science kits for elementary students, with all the materials and lesson plans gathered into a box. Teachers no longer had to lay out personal funds to purchase seeds and soil to teach a plant unit. It was already done for them. The kits were even split up developmentally by grade level so children were taught science topics at the right age. For example, kindergarteners are more interested in plant growth than fifth graders, but fifth graders can build a motor more easily. Teachers struggled to make the adjustment to kits, for they had not learned science this way. They liked textbooks and tests because they knew what to expect. When kits came in, textbooks went out, and this terrified some teachers. When children learned by using hands-on science, something wonderful happened. They actually learned science in a way that lasted. Active learning helped children remember what they learned. FOSS conducted brain research to investigate why this happened. Their research proved the validity of the old Chinese proverb: Tell me and I hear; show me and I see; involve me and I understand.

While students in the early grades were playing with their science, secondary students were not. Instruction continued to rely on the textbook and occasional lab. The innovative curricula of the 1960s were never widely adopted and then largely disappeared from American schools as districts and teachers reverted to text-based science and mathematics. Teachers were still asking all the questions and high school students continued to sit passively in class for note-taking while the lab tables gathered dust. I wanted to teach science to my students in a way that excited them, not bore students. Since I was taught science reading the chapter and answering the questions at the end, my science background needed a little help. To teach it, I needed to know it, as recommended by Robertson. (2005).

How I Learned: My Journey

My Bachelor of Arts degree is in business marketing. I worked in the business world for 22 years before I decided I wanted to do something different. I returned to college and earned a teaching certificate for secondary math in 2001. I am good at math, but I love science. I wanted to teach both and I wanted to do it well so my students would enjoy these subjects too. In an effort to teach in a more useful way, I joined classes and engaged in professional development to improve my instruction. A good place to start, I discovered, was journals.

An appalling statistic: 72% of American adults are scientifically illiterate! (Technology Review, MIT, 2007). When I first started teaching, I knew there had to be a better way to learn. When I was growing up, I rarely experienced labs, let alone anything remotely similar to inquiry. All I can remember was "sit and get": a passive learning method whereby the student sat in a seat to get instruction; worksheets and reading. I knew even then that something more could have been done; it took me years to discover a new set of new skills and strategies for effective teaching and learning.

In my original certification for math, I read about "inquiry" and "journaling". The district where I first taught in Texas was the premier district to learn and grow. One reason that they were the premier district in the area was they used one of the latest theories called "inquiry" to maximize student learning. It seemed innovative, and statistics seemed to support the district's contention that inquiry and journaling was the cure-all for lagging test scores in science. In implementing their inquiry lessons, I felt there had to be more. The inquiry lessons implemented by this district seemed more like an expanded "sit and get". Journaling, as they called it, consisted of writing notes about the assignment or lab, almost like a repeat for the answers to the assignment or lab. There had to be more.

When I moved back to Colorado, I was fortunate to get a job in one of the top two districts in the Colorado Springs area, based on test scores. They professed using both inquiry and journaling to keep their status as district #2 in the area. What I experienced at best was similar to guided inquiry but more commonly was more classroom lecture followed by writing the answers to the lab or lesson in a journal. If inquiry was addressed at all, it was the teacher or the text asking the question, and the students investigated. Again, I knew there had to be more regarding inquiry and journaling. I sought out other opportunities to learn more about inquiry and more specifically journaling.

My journey through the local Science Group meetings, called HUB, and Space Foundation classes only whetted my appetite for more inquiry learning and journaling. These meetings involved specific science content as well as pedagogy of teaching science. My first attendance at HUB was in 2006. The content at the beginning session was mining, how the Victor/ Cripple Creek Gold Mine processes gold ore through the final refinement into gold ingots. The mine tour was fascinating but what really caught my attention was the pedagogy for that session: journaling.

My appetite for journaling had been whetted. However, my attempts to have my students writing about learning in journals was not adequately understood nor implemented correctly. My review of their work was sporadic with no preset schedule of collection and reading. I could not use the information on a timely basis to help clarify any misunderstanding in student learning.

The brief lessons in journaling at the HUB meetings and Space Foundation Classes augmented my understanding and implementation of journaling in my next couple of teaching years. Regularly timed reviews of students' work allowed me to see students' understanding and their reflections on content gave *me* an understanding of what students needed from me to solidify their learning.

The math content in my students' journals really seemed to help my students across the board. Their reflections were really not much different than notes, and I did not have an adequate understanding on this portion of journals, nor were the classes at the time helpful in expanding my understanding of student mastery.

About the same time, Colorado College was invited to both HUB meetings and the Space Foundation classes to talk about their masters program in Inquiry science which included journaling. This program included inquiry learning and the best practices for journaling. Classes included both content information in science and pedagogy. Information provided in class gave a clear positive indication that inquiry and journaling helped student learning in science. My understanding grew in both inquiry learning and journaling and convinced me that a masters with a focus on content through inquiry/journaling would be of great benefit.

Fishing Through a Sea of Journals

Understanding the use of journals is key to successfully implementing student journals. While I had been encouraging student journals in my classes more than five years ago, my individual journey and understanding of journals started to mature during the spring of 2009. At the start of the 2008-2009, information presented in my professional development classes and my master degree classes convinced me that student journals could indeed increase student learning.

Previously, I encouraged student use of journaling but I really did not have a good understanding on what journaling entailed. With further reading and discussion in my master classes, I decided to require student journals in all my classes including math, science, and business classes. During Semester I, 2009, and before we had discussed formatting of journals in my master classes, I had no particular style or setup in mind to help guide students. Once I really reviewed comments by two of my professors in my journaling for their courses, my understanding started to grow.

Student journals were collected and read, but I had only my prior college skills in journaling and some reading material provided in master classes. I discovered my understanding was not what it could be when the professor and students met at the Colorado College Divide Campus (The Cabin). Both my instructors visited with me and provided both verbal and written feedback for my journals. Prior to my discussion, I used my journal to take detailed notes, but I never really considered it a form of reflection or useful assessment tool.

As my knowledge grew, I was more equipped to help my students use their journaling, not just as note-taking, but as reflections of content learned and the thought processes behind their learning. Reflective writing and writing about thinking (or meta-cognition) requires higher order thinking because synthesis, analysis and evaluation are required at this level. It is easier to provide effective feedback to students because they are no longer regurgitating knowledge level information. According to Glynn and Muth (1994), students develop metacognitive ability through learning science by assessing prior science knowledge, using science-process skills such as analysis and synthesis, and applying reading, writing, listening and speaking skills to learn content. Student responses in their journals demonstrated their thinking about thinking and, thus, fit my needs to determine the level of student learning.

The feedback provided really made me stop and think what else I could do to provide effective journaling with my students. During the summer of 2009, the Chemistry of Fire was our topic. This course included an in-depth look at the Hayman fire. During the course of the summer, I had ample time to visit with my professors and fellow students on journaling. With the instructors, the verbal discussions were actually more helpful than written feedback on the reflections. One thing my advisor told me that impacted me more than any other feedback was when she told me “reflections are nothing more than the discussions we were having regarding reflections written down”. Once I saw reflections in this light, it was easier for me to put my thoughts and learning into my journal.

Other students’ feedback was enlightening also. One of my colleagues, for example, with her English content background, read my reflections and helped me expand and actually make sense of reflections. English teachers generally require journals and reflections from their students. Observing effective, experienced writing in her journals provided a good example for me.

Another teammate reviewed my journal and reflections and helped me see how effective reflections were to the learning process. The use of writing to promote learning gives evidence the writer is actively reprocessing knowledge and writing is a tool of thinking in written form.

Writing provides a student with ideas for expressing ideas verbally to others. The ability to communicate with oneself and verbally with others is proportional to the students’ level of understanding. (Cervetti, Barber, Dorph, Pearson, Goldschmidt, (2012).

With my expanded understanding of journals and reflections, I required student journals in all my classes across the curriculum for the 2009-2010 school year. Students and I spent most of the first week looking at my journals and reflections as an example. Another key in effective journaling is to provide early and regular feedback to students about both their content and their reflections. I have done such throughout the years. When I graded their journals I provided specific feedback that could be used to improve their journal and improve their learning of the content. Points were given for complete journaling and reflections and over the year increased for each collection of their journals. By the third quarter, a journal grade was equivalent to a quiz grade. Fourth quarter, I used their journal as a test grade. My finding so far is that it is a rare student who does not improve their learning with effective journaling and reflection.

The key for me as a learner in journaling versus note taking is the thorough writing about my prior knowledge of the topic, new insights into topic, and reconciliation of old knowledge with new. In addition, collaboration with team mates helped compare prior and new knowledge. When the new and old was not reconcilable by me, someone in the team was able to bring together new and old knowledge and explain it in terms teammates could understand. Old fashioned note- taking was chapter knowledge as well as lecture notes. I, and eventually my students, had to demonstrate proficient understanding of the scientific process with steps such as follows:

- <u>Ask</u> a testable question.
- <u>State</u> a hypothesis in a complete sentence.
- <u>List</u> all materials.
- <u>Design</u> and complete the experiment.
- <u>Collect</u> data for results. Draw a valid conclusion.

My plan for the next year was to include target learning goals so students could plan for and provide feedback to me on the content learning. Students' levels of achievement vary with their skills and my ability to guide those individuals to greater understanding. Most students responded very well with content but had a difficult time with effective reflection. The students who excelled were very adaptable and used reflections to cement their learning content. Students with lesser skill in journaling and reflections generally had lower grades than those not using journals effectively. I was not sure if this was due to issues with science or proficiency with written communication. Compared to past years without journals, student grades (and learning) seemed to be much better. I plan to continue journals to see if what I perceive is correct…that student grades in general are higher than students and classes not using effective journaling. As I focused on student growth, I realized students needed focused instruction in short lessons to improve writing in specific areas. That led me back to my own coursework journals and learning targets.

Learning Targets

If a lesson serves a finite learning purpose or targeted learning goal, it is known as a learning target. I previously considered adding learning targets to my journal requirements. This teaching strategy involves the teacher teaching a focused lesson designed to reach a narrow goal, such as a lesson on the difference between results in a lab and drawing conclusions. Learning targets are no more than goals students can use to measure their level of understanding for a given content. Never having used this type of tool, I had to think long and hard whether I thought this would actually be beneficial to me and thus to my students. With our discussions in class, the information provided in class, and the clear examples of learning targets, I decided to experiment to get a feeling for implementation. We had discussed learning targets in previous college classes but actually used them for each level of investigations during the spring class: Chemistry of Smells. In this class, we experimented with different scents and how people react to them.

When I went back to my personal, previous class journals, I did not find any reference to learning targets, yet I remember completing them. I did have a couple of folders with materials in the folders, which reminded me why I now try to tape any handouts into my journals whenever possible. This also helps me remind my students to paste handouts into their journals to prevent loss of materials (one of the benefits of a journal). In reviewing my learning targets for the Smells investigations, I found I did move from lower learning levels to higher levels of learning during the course of the investigation. The self-assessment helped me see what more I had to do to thoroughly learn the content at hand. What I did not know, I could research on the web, ask a study buddy, or ask the teacher during the next class. This helped me prepare for both formative and summative assessments as I really focused on what I needed to learn. That experience helped me see what the students would need as they prepared for their assessments.

In researching learning targets on the web, I ran across a statement on the Iowa Department of Education: As assessment for learning, formative assessment practices provide students with **clear learning targets**, examples and models of strong and weak work, regular descriptive feedback, and the ability to **self-assess**, track learning, and set goals. (Adapted from Council of Chief State School Officers, FAST SCASS, 2006). While the bold is mine, this basically sums up what I hope to have my students accomplish by journaling, reflecting on their learning and using learning targets to maximize understanding of content. To be an effective science teacher, I needed to learn all I could about my subject. I went back to science class.

Inquiries into Matter

I entered the Master of Arts: Teaching - MAT program at Colorado College to learn more about inquiry in science so I could eventually **teach** inquiry science. My first course was <u>Inquiries into Matter</u>. Here are some notes I wrote in my journal:

Mixtures: What we knew and discovered. Mixtures are not pure substances; they are made up homogeneous or heterogeneous substances. These mixtures can be separated by various physical properties such as size (using sieves to sort), solubility (dissolving and filtering for example), magnetic properties (pulling iron from oatmeal), distilling (alcohol and water where alcohol has a lower boiling point), measuring density (metal vs. plastic for example); other ways including chromatography, evaporation, pressure differences, density columns, freezing etc. Questions we had about mixtures: Can a mixture that has been modified by heat be reversed? A **mixture** is a substance made by combining two or more different materials with no chemical reaction occurring. The objects do not bond together in a mixture, then no chemical reaction. A mixture can often be separated back into its original elements.

When observing sugar water with a magnifying lens, I could not discern the sugar in the water. A laser light does not appear to have any different effect than plain water. I do know from my lab class that sugar can be separated from the water using heat so no chemical reaction exists. Dirt and water is also a mixture as I can separate out the dirt with a filter paper. No chemical reaction occurred or I could not separate the substances. The particles of dirt are visible with a lens. Laser light is blocked by the dirt in the water (depending on how much dirt is added). By observation, the dirt settles and separates from the water without outside interference.

Creamer does not combine with water unless the water is warm. (From experience I knew creamer also does not dissolve in coffee without being warm). Once dissolved, I could not detect the creamer but it permeated the cup of water. Laser light did penetrate and appeared to diffuse throughout the cup. I think a chemical reaction occurred, as there was no way I could discern a way to separate the creamer from the water. I did not boil the liquid to see if I could get back to creamer only but the creamer did not settle. Next question: Is it a chemical reaction? Since I heated the water to mix in the creamer, I suspect the extra heat caused a chemical reaction.

A homogeneous mixture is one in which the substances are spread throughout the substance and appear to be uniform. They generally have a similar size structure. Sugar water and creamer could be such. A heterogeneous mixture such as dirt, have particles that have a different size and while can be mixed all together will settle out of the liquid. The density of the particles would determine if they dissolve or settle to the bottom.

The oil water mixture stayed a mixture no matter what I did with them. When agitated, they appeared to mix well but after a short time period separated into oil and water. Alcohol did diffuse within the water, but appears to be separate within the water. It seems like there is a structure of alcohol within the water as wavy lines are visibly spread throughout.

Miscible is a property where a substance diffuses proportionally throughout another substance. Immiscible is where they do not mix proportionally. I suspect the oil/water is immiscible since they will not mix proportionally whereas the alcohol allows more substances to dissolve. To mix proportionally, I suspect the particle size must be similar. To not mix, they are probably different sized substances where one is much larger than the other.

Mayonnaise is made by combining lemon juice or vinegar with egg yolks. Eggs which contain an emulsifier bind the ingredients together and prevent separation. Then, oil is added drop by drop as the mixture is rapidly whisked. Adding oil too quickly or not mixing rapidly will prevent the two liquids from combining. As all one substance, mayonnaise is a colloid, with the particles suspended evenly and do not sink to the bottom or separate.

In a secondary classroom, this sort of inquiry lab with guidance would be an interesting experience. If they were given a list of available materials, brainstorm ideas they already have, prepare a plan for three tests and let them go, authentic learning would happen. As I reflected on my notes from this course, I had some personal revelations about keeping a notebook that I can apply in my own classroom.

1. Notebooks can significantly help students. One way is to see what they actually think and understand about a concept. The other is to help dispel current thinking if incorrect and to find a description that is closer to the concept being investigated.

2. A table of contents enables a person to find specific information. Generally, as the amount of information increases it becomes a real chore to find specific information unless indexed in some way. Contents of knowledge become increasingly complex over time.
3. What it says (definitions, explanations, other notes), and what it means (reflections, evaluations, new questions), ties together the concept with what can be done with that topic. They work together to help a concept be fully understood. If a student writes about an experience on Monday, reviews it on Tuesday, revisits with another accompanying lesson on Wednesday, it will be remembered, learned.
4. Organization is critical in order to find specific topics. Organization also helps the learner analyze and objectively look at data. Without such, a person is not able make sense of what they are studying.

5. Time is one disadvantage of grading a science notebook. With an average of 150 students, it takes a lot of time to truly look at and understand what a person has written. On the other hand, usually I can tell whether a student has actually gotten a lesson or needs further understanding.
6. Students sometimes resist using a science notebook. They think they can grasp a topic without doing the work of a notebook. The easiest way is to make it a graded effort (a participation grading rubric can make it easier on a teacher to grade).
7. Writing about science saves time. "Student science notebooks, used well, not only provide opportunities for students to develop a deeper conceptual understanding of science, they also address other issues faced by classroom teachers today, most notably, time, through the integration of language arts and science." (Klentschy, 2008.)

Learning science so I could teach science continued into the summer of 2009 at a STEP-uP seminar covering physical science using inquiry teaching.

Physical Science through Inquiry

My interest in math and science dates back to at third grade when the Mercury-Atlas rockets were being launched. My first certification is in secondary math followed by certification in science. The two subjects go hand in hand and I incorporated science in my math classes and math in my science classes. The district I worked for previously proclaimed that they taught inquiry science. However, even in my early stages of learning about inquiry science, I felt there was more to inquiry than the district availed itself of to support student learning. My knowledge of inquiry math and science continues to grow with every class I have taken at Colorado College culminating during an institute in 2009. The activities really focused my attention on practical steps for inquiry learning. While studying and reading about inquiry lessons, the learning stations really helped solidify the various learning models in ways that just reading about inquiry did not. It was a hands-on lab that gave us three stations: 1) **guided activity** which walked us through the lab with tops with a lesson that told us what to do step by step; 2) an **exploratory activity** where we were able to select our materials and learn all about tops in any way we chose; and 3) the **challenge station** where we were somewhat guided and directed to see what variables we could use to see if the top could spin for 10 seconds or longer.

The guided activity is what I believe is used in most classrooms: a written lab designed with specific steps for students to follow. The challenge station was closer to what I had previously pictured as part of inquiry: some guidance with specific goals in mind, and using a given set of variables to explore. While these two stations have their uses at various times, I think the real value for student learning is to use an exploratory activity. These activities dovetailed neatly with the various learning models we had been studying. I do believe these models are similar but use different terminology to describe the various learning phases. As I learned about physical science through inquiry, I also learned about effective teaching models. I learned science through these models; active observation and participation was a hands-on learning method for how to teach.

As we were studying various concepts for inquiry, I continued to look for ways to implement inquiry-based learning activities in my Algebra II class. My first implementation of inquiry was to incorporate notebooks for my students. The classes I taught started with notebooks at the beginning of the 2008-2009 school year for Algebra II. Students were required as part of the course syllabus to maintain a journal or notebook. The composition journal I developed in the spring of 2008 in Chemistry of Smells institute was used as an example for my students. I started with notes and further refined usage to include what I see-"WIS", what it means- "WIM", and what more I want to know or understand- "WIK". Each student was required to periodically turn in their notes sometimes for suggestions on setup and use, and other times for specific thoughts the student had regarding a specific topic.

Some observations I found during reviews of student journals: first, some students would not keep a journal or notebook at all even with points attached. My solution was twofold: first, I increased the points associated with the journal; second, I allowed random usage of their notebook on a test or quiz (I would not tell them ahead of time so they had to maintain their journals) but only if they had previously earned full points for their journal entries. Students who do not perform well in school say they think no one cares. One of the best ways to connect with students is to write responses in the journals, ask questions, and connect with them. This worked really well for most of the resistant students. Evidence of their learning reflected in both their assessments and their journal entries. There were still a number of students who just would not keep any form of journal at all and generally these were students who were failing my class as well as most of the other teachers' classes. Perhaps they felt uncomfortable as writers; maybe they struggled with rules about writing. They preferred not to write. Moving forward, this is a great time to implement learning targets that provide focused instruction in writing skills to strengthen student confidence in writing. These students were generally referred to our Intervention Behavior Team or Intervention Academic Team for encouragement in school. I would have liked the journals to have been a successful tool for those students: if they thought they were writing for me, they might not have been motivated. If they had realized they were writing for themselves, maybe they would have been more interested.

The second discovery was that proficient to advanced students generally used some sort of notetaking methods, not journaling. My suggestions helped refine the proficient students' journal and increased their assessments by a grade point or more. Finally, it was fairly easy for the more advanced student to include WIS, etc. into their journals so I could more fully understand their progress in learning about the topic.

My greatest growth need for notebooks is taking the time at the beginning of the year to ensure journals reflect student thought processes, understanding and using action to apply their knowledge to a new situation. In August, student reflections tend to be limited to one or two sentences summarizing a lesson, and often sharing a personal detail, such as how tired they were, instead of reflecting on learning. In April, the reflections still have personal detail, but the learning reflections improve. I want to front load student learning on journals to make sure student journals incorporate best practices. The impact of journals seems significant. Helping proficient students grow toward advanced is great. Getting a less than proficient student to progress to proficient is a major step in learning. For an already advanced student, I use their notebooks to develop differentiated lessons that will further advance their thinking skills and their math understanding.

In addition, several reading strategies were implemented in my classroom. Historically, few students actually read a math book. Students expect teachers to feed them any necessary strategies and knowledge. I planned to use several tools learned during our content-area reading. The first is annotation of text. This can be implemented in several ways, one of which would require annotation on supplemental reading of the topic. Another tool is using "think aloud". This gives students more insight into solving problems by verbalizing thoughts while reading and performing a task. We know this to be "thinking about thinking" or metacognition.

My next learning opportunity in the MAT program was a summer institute on cosmology. My journal reflections follow.

Cosmology

I have always been fascinated by the study of the cosmos. How do orbits work? How do systems behave? Aristotle's observations of objects on the Earth was that they had a tendency to move. An important element of Aristotle's cosmology was his theory of *motion* which today we call *mechanics.* Aristotle believed that objects are composed of four basic elements earth, water, air, and fire. Each element moved differently: earth toward the center of the Earth, fire away from the center, while air and water occupied the space in between. Aristotle's casual observations caused him to conclude that all things moved to their natural place in the cosmos. One statement said earthly objects moved in straight lines, *linearly*, with respect to the center of the Earth since the Earth, being a sphere, was at the center of the cosmos. In contrast to earthly motion, celestial motions or heavenly motions were all circular since the heavens were perfect. This concept is one of Aristotle's most influential axioms: *primacy of circular motion.* He claimed lines are finite in length, having a beginning and end, whereas a circle closes back on itself and has no beginning or end, thus being continuous and infinite. Aristotle argued that the heaven was perfect in its structure, unchanging and eternal. The Earth changes, while the heavens did not. Conversely, the Earth did not move, while the heavens did. Perhaps most importantly, he did not recognize his own limitations, both as an observer and a theorist. He needed better observations. With our current technology including the Hubble Telescope we are able to make accurate observations and show that Aristotle's observations were not accurate.

Space is an ideal place to observe Newton's third law: bodies at rest….will remain at rest or in uniform motion unless acted upon by a net **external** force. Whatever force occurred to bump an asteroid from the belt toward Earth was an external force and caused it to move this direction. To stop this movement and reverse direction, the object would need an external force applied to it in the opposite direction from the original force, to put us out of danger. Regarding swimming, Newton's third law helps us understand whether the astronaut could cause movement by his action of swimming. Newton's third law states: For every action, there is an equal but opposite reaction. On Earth, a swimmer applies a force to push him away from the water (behind him). There is an opposite but equal force applied to the swimmer, thus propelling the swimmer forward.

One of the tenants of the scientific method is simplicity. "All the things being equal the simpler explanation is favored." If I apply "Occam's Razor" to the two different approaches between Ptolemy and Kepler, I believe that Kepler's three laws of planetary orbits provided the first simple, predictive description of celestial motion. Kepler's three laws are much simpler then Ptolemy's circles within circles, within circles, within more circles. Kepler's final three laws use significantly fewer calculations than Ptolemy's which had a calculation for each of the circles up and beyond the fifty-five circles that Aristotle used. Thus Kepler's equations provide results from much simpler equations. This led to the thinking behind the movie *The Matrix.* Could a world exist within a world, and if so, could it be proven?

The Matrix is not a tenantable hypothesis because of the scientific steps. The scientific process includes the following protocols:

- Relevant
- Falsifiable
- Consistent

- Simplicity
- Predictive power

The Matrix hypothesis does not meet any of the five characteristics of a working scientific hypothesis. It is not consistent with previous theory, data, or observations. There is nothing that would support the idea of a Matrix anywhere so it is not consistent. It is not falsifiable as one cannot prove or disprove the Matrix any more than prove or disprove faith in God. The Matrix is not the simplest model. The Matrix is a world within a world just like Ptolemy's model of circle within circles. It is simpler to believe in one world than to believe multiple worlds. With the Matrix model there are no predictive properties. The Matrix has relevance only in Philosophy. It could explain our world just as faith in God can explain our existence. Science requires a crucial experiment to provide baseline data and observations whereas the Matrix cannot provide such. Therefore, the Matrix is not a valid scientific hypothesis.

At last, my favorite topic: Astronomy.

This institute gave me an opportunity to revise and fine tune my curriculum for Astronomy at Peyton HS. My previous curriculum for 2009-2010 was "borrowed" from an astronomy teacher friend from Lewis-Palmer HS in Monument. It was three weeks before class started in 2009 I was informed one of my requested classes was approved and I should order books. Curriculum needed to be put together in a very short time period also. Making do with another teacher's plan was a survival tactic.

With the Chemistry of Smells class, I had concentrated on curriculum writing for solar energy class which was one-third of my astronomy/alternate energy class. With this opportunity, I concentrated on the two-thirds portion of my class instead of relying on borrowed curriculum for astronomy.

The first item I wanted to produce was an overall outline for my class. I knew the Roman numeral format, so I used this formatting for my macro view for astronomy. As time permitted, I could extend the outline all the way down to the micro level with inquiry learning methods, activities, and individual lesson plans. (See Appendix A).

Many of the text books I reviewed started with the planets as their first lesson inviting students to become excited about astronomy. Second chapter often discussed the history of our world, starting with mankind's view of the heavens and their speculations on the origin of mankind. My preference was to start with the history of our inquiry into the origin of mankind and the heavens. The logical extension leads to earth as the geocentric model as it is something that can be studied first hand. Next came the study of objects that can be observed from earth. This progression is similar to our Institute book: Modern Cosmology by Hawley and Holcomb. Verbal feedback from my students in 2009-2010 seemed to coincide with this order of study.

Using the Atlas, National Science Standards, and Benchmarks books, published by such highly respected organizations as AAAS and the National Science Teachers Association, as guidance for what students should know, the first content studied was the history of the "heavens". Secondly, the tools of science and tools of astronomy were studied.

With the above in mind, I did find understanding by my students as evidenced in formative assessments as well as a summative assessment and final grades showed significant gains in understanding. My goal that year was to further extend this in 2010-2011 by adding learning targets to the above work. By comparing student performance in classes for two school years, students should confirm it was inquiry teaching and notebooks that enabled my students to excel. One area I was expected to teach in science was energy.

Instruction in Energy

A second grade teacher hands each pair of students a bag containing two wires, a flashlight bulb, a "D" cell battery, and engages them in the task to make the bulb light. Student exploration into a functioning circuit comes with trial and error. The delight on the students' faces as they succeed races like wildfire through the classroom. Students explain their work, why they had light, and what efforts were unsuccessful. The evaluation step was easy: everyone had made light. The big question becomes, "Now, what?" What do students need to learn about energy in between making light and graduating high school as competent energy consumers?

Based on recommendations made by the American Association for the Advancement of Science in Project (AAAS) 2061, (AAAS) 2007, the newly revised (2009) Colorado Model Content Standards have prepared vertically aligned competencies in science that guide a learner from preschool through high school graduation. For the future energy consumer, the two competencies relevant to this curriculum include the prepared graduate:

- can apply an understanding that energy exists in many forms and its transformation and conservation occur in processes that are predictable and measurable
- can describe how humans are dependent on the diversity of resources provided by the Earth and Sun.

On this vertical continuum, a kindergarten teacher has curricular materials to provide instruction on how the Sun provides heat and light to Earth; the fourth grader can learn that energy comes in many forms such as heat, light, sound, magnetic, chemical and electrical. A fifth grade teacher can teach students the Earth and sun provides a diversity of renewable and non-renewable resources by using a hands-on science kit on solar energy. A middle school science teacher can increase student understanding that there are different forms of energy and these forms of energy can be changed from one form to another. The limitation of current high school curriculum in this topic is the shortage of ideas to guide students in the next step of the vertical alignment: There are costs, benefits, and consequences of exploration, development, and consumption of renewable and non-renewable resources. Energy exists in many forms such as mechanical, chemical, electrical, radiant, thermal, and nuclear, that can be quantified and experimentally determined. I created my own scope and sequence in Alternative energy to provide appropriate instruction until materials approved by the district could be published or purchased. (See Appendix B.)

Looking back to the delighted, successful second grader who made light and progress toward elaboration, these curricular adjustments answer the question, "Now, what?" But the "D" cell has become the solar cells, the light has become the power being used in the child's home, and the vertical alignment of the Colorado Model Content Standards, creating scaffold instruction, has led the child to become a competent energy consumer.

Educators often find it necessary to investigate new methods by trying them out in class with students. A teacher with a classroom full of students has a pool of candidates on which they may research. This type of research was required of MAT candidates. I wanted to know if teaching my students to use journals would be as effective a learning tool for them as it was for me. I chose this topic to engage in action research.

Action Research Project: Journaling for Knowledge

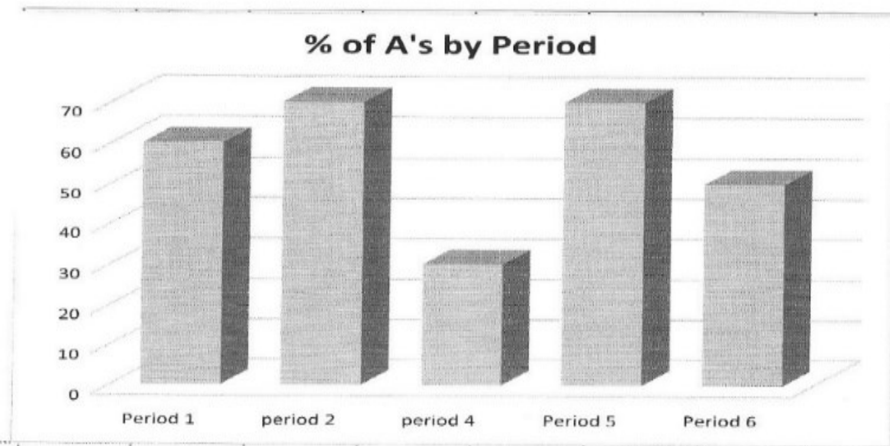
The instructors in the classes for my science coursework in the MAT program helped me deepen my content understanding through inquiry, pedagogy, and also brought me into a better understanding of reflections. It did take considerable guidance through face to face instruction, in addition to the written questions and comment by my teachers. Never having had to do any journaling or diaries in my previous school years blocked my understanding of reflections. One item mentioned by a fellow student (English teacher) and professor was to write down the same thoughts and discussions we engaged in verbally during class. This breakthrough in my thinking about reflections really got me excited. With practice and feedback in class, my ability to think about thinking was evident in my journal. Increasing awareness led to my ability to teach students to reflect better on our content areas. How to show students were learning additional ways to think and reflect in content resulted in my 2010 Phase I Action Research. Action research is an excellent way for teachers to investigate instructional ideas and the impact on student learning. Teachers identify a question with their teaching and how it affects students. The teacher implements changes, observes results, reflects on the outcome, and starts again (Mertler, 2009).I wanted to know if journaling made a difference in student growth.

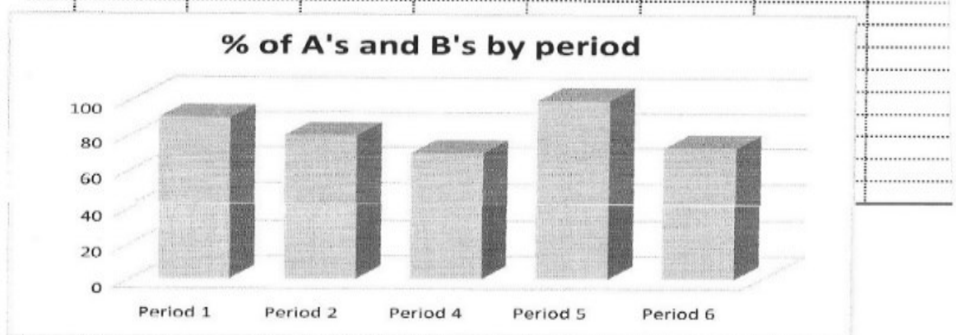
During my action research Phase I, 2010, the data I gathered gave me a strong indication a majority of my students benefited from journaling. The original question asked how *my* astronomy students would benefit from using journals. The second situation I wanted to measure and tied closely with the first portion of the question was: How does journaling help students in all subject content classes?

The data from students' scores in homework and assessments showed a reliable positive correlation in all my classes. Journaling and proper reflections increase student scores in all my classes. Computer applications (Microsoft Office Suite, Adobe and other software), Astronomy, Accounting, and Computer Tech (computer hardware) all showed an increase over previous year. Students who used their journals appropriately with both content and reflection earned more As and Bs versus my previous years' equivalent classes. I suspected part of the increase was due to my diligence in reviewing each journal at least twice a month with an actual grade. However, without prior year consistency, I could not say for sure the results were from proper journaling or my additional efforts to review each journal.

The next year, which I call Phase II, kept the same consistency on my part with regular and timely feedback to each student. I reviewed each student's content understanding by their content notes and reflections regarding the subject matter. While there was probably some influence by me in teaching proper journaling, I do not feel the journaling grades were significantly affected by increasing experience in journaling. More is not always better. Sometimes it is just more. My instruction needed to grow so their journaling could grow.

One idea was the suggestion of using control groups to compare students' averages of those journaling versus classes not journaling. So while I might have had a better understanding teaching students journaling, the control group could help isolate this part of students' overall grade averages. I selected a student group as a control group that did not journal. While the student control group was normal in that the class had a normal distribution of under-performing, average, and gifted students, the grade average for that class fell below of all the other classes. The control group had 16 students, while the regular class had 18 and 20 students but was otherwise similar in nature, in class work, and performance. All three classes were computer applications and content and as identical as I could provide. The graphs below show the two journaling classes had a one grade point average increase over the control group.





I looked at student work through journals through the scientific process:

QUESTION: Does journaling in a science notebook increase student achievement?

Definitions: Journaling refers to information students write in a science notebook, including content and reflections.

Hypothesis: Because journaling is authentic written response to classroom experiences in scientific inquiry, rather than "read the chapter, answer the questions", student understanding of concepts should improve, thereby increasing student achievement. A control group, with no journaling component, will not experience a similar increase.

Materials: Composition style notebook for each student

Procedure: Every time we do a class activity, students write about it in their journal. If a jar of organic materials is prepared so students observe decomposition, the steps are recorded.

Results: Students in the control group who did not use journaling exhibited performance on classroom assessments consistent with the read, study, test method. Students who were in the classes using journaling exhibited higher growth in achievement.

Conclusions and Observations: Asking secondary students to write authentically in journals for science was challenging, as they had already become accustomed to passive learning, and they preferred to be told what to do, fill-in-the-blank style rather than having to prove what they thought. Once the transition was made, however, student performance increased, thus demonstrating the value of the strategy.

How I Can Teach Science: The New Journey

Accepting journaling as a part of inquiry teaching in nearly every subject, I cannot go back to the old way of instructing where journaling (including reflections) is not a part of instruction and not a part of assessment where instructors make demands of students to think, reflect, and inquire. This is outside most instructors' comfort zones as we were not taught this way. Secondary students are already accustomed to passive learning. "Just tell us what you want, Mr. Cole". This is a call to action for educators to back off from old style teaching and step into the new. Implementing instructional models that encourage students to be active learners was a great place to begin. Using new methods, such as questioning, STEM and collaboration, and integrating model and method became my focus for teaching my classes.

Instructional Models

We studied the following instructional models:

The Learning Cycle: Robert Karplus and Mike Atkin; "The learning cycle is a research-based instructional model that focuses on ordering phases of an activity to support learning. The model presented in this session is based on a five-phase cycle: invitation, exploration, concept invention, application, and reflection". (Atkin & Karplus, 1962). As a research-based start on improving classroom instruction, it looked like the researchers were moving in the right direction because later models incorporated or adjusted these steps.

The 5E Model: Biological Sciences Curriculum Study: The five phases of the BSCS 5E Instructional Model are designed to facilitate the process of conceptual change. The use of this model brings coherence to different teaching strategies, provides connections among educational activities, and helps science teachers make decisions about interactions with students. The 5E learning cycle is an instructional design model that defines a learning sequence based on the on experiential learning philosophy of John Dewey and other philosophers, as well as the experiential learning cycles proposed by David Kolb. Attributed to Roger Bybee of the Biological Science Curriculum Study (BSCS), the model presents a framework for constructivist learning theories and can be effectively used in teaching science.

John Dewey's philosophy proposed that each experience builds upon previous experiences and influences the way future experiences will affect the learner. The role of the educator is to provide experiences that will provide learners with meaningful experiences that will enable the individual to contribute to society.

Engagement - students' prior knowledge assessed and interest engaged in the phenomenon. Here the task is introduced. Connections to past learning and experience can be invoked. A demonstration of an event, the presentation of a phenomenon or problem or asking pointed questions can be used to focus the learners' attention on the tasks that will follow. The goal is to spark their interest and involvement. This information helps the teacher plan to meet students where they are in terms of the topic.

Exploration - students participate in an activity that facilitates conceptual change. Learners should take part in activities that allow them to work with materials that give them a hands-on experience of the phenomena being observed. Simulations, programs, or models, whose parameter can be manipulated by learners, so they can build relevant experiences of the phenomena, can be provided. Questioning, sharing and communication with other learners should be encouraged during this stage. The teacher facilitates the process.

Explanation - students generate an explanation of the phenomenon. The focus at this stage is analysis. The learner is encouraged to put observations, questions, hypotheses and experiences from the previous stages into language. Communication between learners and learner groups can spur the process. The instructor may choose to introduce explanations, definitions, mediate discussions or simply facilitate by helping learners find the words needed.

Elaboration - students' understanding of the phenomenon challenged and deepened through new experiences. Using the understanding gained in the previous stages, now learners should be encouraged to build and expand upon it. Inferences, deductions, and hypotheses can be applied to similar or real-world situations. Varied examples and applications of concepts strengthen mental models and provide further insight and understanding.

Evaluation - students assess their understanding of the phenomenon. Evaluation should be ongoing and should occur at all stages, to determine whether or not learning objectives have been met and misconceptions avoided. Any number of rubrics, checklists, interviews, observations or other evaluation tools can be used. If interest in a particular aspect or concept is shown, further inquiry should be encouraged and a new cycle can begin that builds upon the previous one. Inquiries may branch off and inspire new cycles. (BSCS, 1994).

I chose Alice® when I used the 5E Model in my classroom. Alice© is a program developed by Carnegie Mellon University for student use as 3D Object Oriented Programming (OOP). Students use this program to learn a computer programming language to design their own worlds in games. Part of the Colorado State filing for community college credit in a multimedia class, Alice is an easy, popular, and engaging program as implemented with the 5E. The first step in 5E is Engage. Students were drawn towards Alice as most students played video games for years. The program began with an introductory tutorial so students saw how easy the programming language was to implement. The second step is Explore. Learners were fully engaged making animations, trying them out, and deleting them if they did not like them. Students made 3D cartoon videos or animations that were acceptable for a school environment. The third stage involves communication in an Explanation. Because the students were so motivated to use the programming language to make worlds of their own design, they were too excited to keep quiet, Conversations erupted around the classroom inviting peers to come see what they had done, offered input so adjustments could be implemented. Stage 5, Elaborate/Extend, students grew beyond basic, simple designs to more advanced, unique videos.

Complex individual work emerged as their understanding and application continued. Finally in stage 6, evaluation, I went around the room visiting each computer station to observe the work. Student videos must have a world that can survive long enough to demonstrate student mastery of the program language. Most students had no idea how hard they worked because they had so much fun.

The Conceptual Change Model (CCM) (Stepans, 1991). This model begins with the idea that the learner has knowledge on a topic that has errors that need to be corrected. This is particularly relevant in science because so much of what learners think they know about science is hypothetical. Fracking is an example I chose for this model because it is so politically and environmentally charged. Students argue for what they hear at home and in the media.

Step 1 Commit to a position or outcome. Students become aware of their own thinking by answering a question or attempting to solve a problem. This could be done with a formative assessment probe question. *Does fracking affect groundwater?*

Step 2 Expose beliefs. Students share and discuss ideas, beliefs, and predictions with peers before beginning an investigation. Allowing students to turn and share with a neighbor their ideas before they begin can help them clarify their own thinking. *Fracking affects ground water (or does not because . . .)*

Step 3 Confront beliefs. Students confront existing ideas through collaborative experiences that challenge their preconceptions; working with materials, collecting data, consulting resources. *Fracking DOES (or does NOT) affect groundwater.*

Step 4 Accommodate the concept. Students accommodate a new view, concept, or skill by summarizing, discussing, debating, incorporating new information. *Then what is everyone arguing about when fracking is the topic? What are the points of view?*

Step 5 Extend the concept. Students apply and make connections between the new concept or skill and other situations and ideas. *What are the other environmental impacts of fracking?*

Step 6 Go beyond. Students pose and pursue new questions, ideas or problems of their own. *Is this in any way related to seismic activity as carbon quakes in Oklahoma? (Forcing excess carbon dioxide underground to alleviate effects from greenhouse gases)*

This model allows for instruction to correct misconceptions.

The Teaching Model: NCISE : (1987) This model led to the creation of the IDEA^2 which I worked with more than any other and it was easy to remember.

1-Invite;

2-Explore, Discover, and Create;

3-Explanations and Solutions;

4-Take Action:

IDEA^2: Paul Kuerbis

Of these models I favor the description from IDEA^2 but the diagram from The Teaching Model is also useful. From IDEA^2, students are first invited into a learning activity that provides a focus for the student. At the same time, the teacher is using a variety of observation and pre-assessment of student prior knowledge. The Discover step further engages the students and gives them a framework for the concept, usually with a hands-on activity, but could also include other research from the computer or library to learn more about a topic. Third step is Elaborate where a student interprets data from the activity, asks questions they are wondering about regarding the topic, and discusses with their team, classmates, and teacher. The Action step is extending their understanding of the topic in different but similar activities. Throughout the activity the teacher is assessing student knowledge and making a judgment of a student's actual knowledge and skills. I believe The Teaching Model diagram more clearly shows all the interactions and flows of the IDEA² steps. Perhaps this method appealed to me because it was the model used in the MAT classes I attended.

As my understanding of inquiry increased, and as my search for inquiry math lessons became fruitful, I developed a lesson for Algebra II Conic Sections using the IDEA² model. A cone and its parts can be analyzed by cutting a through a cone (conic cross section) resulting in four possible shapes. These shapes include: circles, ellipses, parabolas, and hyperbolas.

The Invitation for the lesson was to explore shapes that could be made from a single sheet of paper (8 ½ X 11). Materials included paper, tape, scissors, rulers, compass, and protractors. A formative assessment involved students listing shapes they thought they could build with paper. After generating a list, students could readily make various nets (two-dimensional shapes) folded into cubes and rectangular prisms. Triangular pyramids were much more of a challenge, while circles were easy only using a compass. Cones presented a challenge as the bottom of a cone must be perfectly flat. I showed them a cone that a woodworking parent had made. The Discover step was to learn as much about a cone and parts of a cone they could find using the library and computers. Their goal was to create a paper cone and determine how they could cut their cones into the parts they discovered: circles, ellipses, parabolas, and hyperbolas. Cutting their cone parallel to the base through the cone created circles; perpendicular created hyperbolas, and diagonally (not cutting the base) created ellipses, and lastly diagonally (through the base) created parabolas. To Elaborate on their shapes we delved into the math behind the various shapes, such as area of an ellipse: Area = Pi * A * B, A being the short radius, B, the long. One improvement I am in the process of developing is to find a way to measure the four shapes and learn how to actually develop the math from the shapes. At this time, there is little I can find to support this Elaboration at the high school level, but there has to be material that can be adapted or developed for students who are not in college-level geometry class. Perhaps this is a chance to explore student inquiry. The Action could involve an invitation to an architect or engineer to come as a guest speaker. Students use the different cross-sections of a cone to analyze all curved geometric shapes to construct 3-d models for architecture.

Now it was time for me to apply those steps in my own lesson plan about the planets. Invite: an anticipatory set as students are invited into a learning activity. It also provides a formative assessment for the teacher. What experiences do students have with astronomy? Probes are helpful at this stage and I used them regularly to provide a formative assessment of students' frame of reference. For example: I have three different probes (See Appendix C.) to guide me in understanding students' knowledge regarding the methods we use in science. Last year five of my students professed little knowledge of these methods. This allowed me to backtrack and discuss the processes involved in solving problems.

Discover: the teacher provides activities to further engage students. I think of this as the hands-on stage. Library exploration, computer searches, and simulations, all of which help students explore the topic at hand, can be engaging. One example of this is the study of the planets. What are the physical characteristics of each of the planets in our solar system? I started with one of the probes on planets. This gave me a better idea of student knowledge. Students did research on their planet of choice. A hands-on activity regarding planets involved the student working with a Styrofoam ball, painting it as it appeared in their research. Different sizes were available for relative size.

Elaborate: students were thinking more deeply about the topic with opportunities to describe and interpret previous research or activity on their planet or sky object. They had time to ask questions and share thoughts with team partners. Students were doing the thinking and wrestling with conceptual ideas thus accommodating new ideas. They shared their ideas with partners and produced a display object such as a poster board or power point.

Action: students developed understanding at a higher level than they started. This allowed students to refine their understanding, improve and extend their skills in the given topic. Actions at this step included a scale model of the solar system including all the planets the students made along with a travel guide for a trip.

Assessment: both formative and summative assessments needed to be used regularly, spaced intervals where the next topic was more challenging than the last to see if they were ready to move forward. This is ongoing throughout the above steps. Do students understand the conceptual ideas? This information will aid me in determining what they do know and give me an idea of where to head with the next lesson. Self-assessments by the students are important in both their understanding and what I know about the student. Is the assessment reliable for use in determining the next steps? Does the student's knowledge, skills and understanding show proficiency? Besides the above formative assessment, I generally interview the students in my astronomy class. If they can explain the concept to me, great. If not, they must return to the group for further clarification. By this time the student should really know the concept and be able to explain on a summative assessment for the topic.

I taught an accounting business class and I implemented IDEA² with the lessons required by state standards. I invited students to consider the possibility of owning their own business. The business would have income from customers buying goods or services. The business would have expenses, such as rent, utilities, merchandise, and employee payroll. In order for the business to be profitable, income needed to exceed expenses, and all students wanted a profitable business. Keeping track of accounts paid and received is a large part of accounting.

To discover the world of business possibilities, the online component of my curriculum resource allowed students to explore business accounting procedures using case studies. Students got hands-on experience working with simulated businesses and their accounting requirements.

In the elaboration stage, students moved from the simple documents required of a small business to the more involved forms for a large business, and paperwork needs became more intricate with increased business demands. The simulations became more complex with greater demands for student performance with added documents.

For the Action stage, students presented the adjustments to their business plan each week, and their plan was picked apart by their peers in a collaborative form of assessment.

Now that I could use the models effectively, it was time to implement new methods.

Classroom Inquiry

"Inquiry is the centerpiece of good science teaching." (Keeley, 2005).

People are inquisitive as a whole. Children employ trial and error as a learning method as they grow. When confronted with an unknown situation, children learn about the world by trying to understand what is happening. By watching, playing, and observing, the child can see what affects the item at hand to find what works and does not work. Remembering and thinking about outcomes help the child understand the world as they know it and provide information on the next confrontation of unknowns. Reflecting on what we have observed helps us as adults determine how to satisfy our wants and needs just as we did as children. Observing, and interacting with our world helps guide us in the actions we take for those wants and needs. Things that affect the outcome help us determine what will happen next. Adults still inquire and reflect on what affected what we expect as an outcome. In the classroom, teachers guide the inquiry. Teachers can listen to student answers and look to provide opportunities for students to investigate those topics they do not understand or that make them curious. (Donovan & Bransford, 2005). While there is a dearth of inquiry math lessons in existence for high school, I see more opportunity to develop further inquiry math lessons as my knowledge and growth in inquiry learning has advanced. In addition, the next time I teach science, inquiry lessons will be easier for me to recognize, develop and present. If classes develop as expected at Peyton High School, I will be teaching astronomy/solar energy class, and a computer hardware/ programming class, in addition to my normal math or business math classes.

Hands-on Science

"Hands-on experience is so important that some educators now reject the very idea about teaching young children about science from books." (Hirsch, 2004).

Until a system-wide change in science instructional upgrade could be implemented, science as a reading class continued. Exceptions included teachers who had access to lab materials for experiments (picture the lab done during the film, October Sky) or those who were willing to spend their own money on supplies for hands-on science. A teacher I worked with used to buy seeds, soil, and pots for all her 24 second-graders to plant flowers for Mothers' Day while teaching about seed germination and plant parts. A fourth grade teacher told me about buying wires, bulbs, and batteries to teach electric circuits.

Enter the age of hands-on science through kit-based instruction. Full Option Science Systems (FOSS) out of Berkeley and Science & Technology for Children (STC) from the Smithsonian brought experiences to the elementary and middle school classrooms all over the country for elementary student to engage in lab investigations with the materials and curriculum packed in a ready-to-go kit for teachers to use for instruction. Kits were implemented for grades k-6. They were vertically aligned so that students who experienced the kit on landforms in grade four would be building on learning they received in the soils kit in grade two. Fourth graders who completed the kit on electric circuits received prerequisite learning for motors and magnets in grade five.

The kits required the creation of science kit replenishing centers in the school districts. (My daughter was actually employed in one of these centers.) These centers were necessary to take all the kits back after each three month classroom rotation. Seeds were added. Batteries were changed, Wires were measured and cut. Everything was made ready for the next teacher to use the kit. Districts stopped spending money on science textbooks to buy kits and supplies instead.

The teacher edition for each kit had everything a teacher needed to teach the lessons for the entire kit. All labs and lessons were scripted so a teacher new to the program would know what to say and how to proceed. Each kit had approximately sixteen labs. The labs were chosen by the kit designers. The students were delighted because they were “doing” science. The fifteenth lesson in the kit was usually a lab created by the students so they could investigate a question of their own from the previous concepts covered. The last lesson was an oral presentation by the student of the lab implemented. A third grade teacher once shared with me that lessons 15 and 16 were the easiest to skip because they had run out of time and it was time for the kit to be sent back to the refurbishing center so they would be on schedule to give it to the next teacher. The opportunity was there for student inquiry if a busy teacher took the time. A literature component included reading materials and recommended reading lists for the library. An assessment component was included in the teacher edition. The materials had both objective (A,B,C,D) test items and performance tasks. While many teachers agreed the performance tasks were more authentic, they confessed to using the objective items more for two reasons: first, they were easier to score, and second, they mimicked test questions students might see on state tests.

Teaching with a kit was a definite improvement over reading about science, but drawbacks soon became noticeable. Imagine a generation of teachers who had been teaching science as reading throughout their careers. Many had decided science was the most difficult to teach because they themselves had never learned it well. How would a frog dissection in high school help a first grade teacher teach science better? My wife was a kit instructor in her district in Texas. She remembers telling a group of fourth grade teachers at training not to shoot the messenger. They were either delighted – this would save them money. OR they were terrified: they would have to <u>learn</u> it <u>before</u> they could <u>teach</u> it. There were icky things involved, like dirt, and bugs, and mud, and crabs that smelled bad, and aquatic frogs. The science director in the district had an aquarium full of those frogs in her office; there was simply no place else for them to go. One second grade teacher was horrified when she had to share with her school one morning that her millipedes had gotten loose overnight. (They were eventually located and returned.) Students and teachers eventually began to perceive the investigations as contrived. The kids were "doing" science, which was an improvement, but they were not "thinking" science. It was an expensive adventure, and certainly headed in the right direction, but the thinking still rested with the adults. The labs were designed by adults. The questions were still asked by adults. The vocabulary lists were created by adults.

The Science Notebook

One skill the kits helped both teachers and students was the addition of a notebook. The students kept science notebooks which were used to record their lab write-ups. The script told the teacher what to say to the students to have them write in the notebook. Teachers could even photocopy charts and tables for students to glue into their notebooks for data recording. The children learned how to set up their notebooks with table of contents and numbered pages. The first lesson was usually a form of pre-assessment: the students filled out a K-W-L chart. The chart gave the teacher information about what children already knew, what they wanted to learn, and how much they had learned by the end of the kit. The K column sometimes created a problem for teachers because sometimes the children thought they knew something, but their understanding was flawed creating misconceptions. How should a teacher deal with the problem? Should the teacher correct the child, or let the child engage in the investigations to discover the error themselves? As evidenced in Stepan's (1991) conceptual change model, letting the student figure it out has merit. If the teacher tells the child about the mistake, the child is embarrassed. But if a child discovers the corrected learning through research and experimentation, new learning to replace the misconception has occurred.

Each time a lab was in progress, students were supposed to write about the steps, vocabulary, data recording, and results. Teachers had to go to in-service training to learn to use a rubric to score the notebooks to give students a science grade. (See Appendix C for a sample of a scoring rubric for a notebook.). Although it was a whole new world for teachers as far as student work was concerned, the things students were writing in their notebooks seemed more real and a lot different than reading a chapter and answering questions. In the meantime, children were having a wonderful time. They were out of their seats, touching, doing science, and that was good. “Once the habit of active involvement is entrained, experience will take over and those stimulated minds will do the rest for themselves in surprising and delightful ways.” (Diamond & Hopson, 1998).

Districts started looking at the results of hands-on science through a kit and a notebook as needing something more. The children were doing science and writing across the curriculum, which was good, but more and more, the need to get the students thinking about the science was becoming very important. What if they asked the questions? What if they chose their own recording format, instead of gluing a chart designed by an adult? What if the end of a lab was not the end? What if it generated even more questions from the kids? If the K-W-L chart showed a child already knew a lot about the topic, did they still have to do all the labs? What if their questions were better than the ones in the teacher edition? And what about the scoring? If a child was a good science student, and a terrible writer, could that be taken into account? The kits and notebooks were a wonderful new step, but it looked like science instruction still needed to grow. And should the books be passed by? NO. “Both kinds of experiences are needed to ensure that gaps in knowledge will not hinder later understanding.” (Hirsch, 2004). Students benefit from hands-on learning in science. Students benefit from learning that matters to them. If they want to learn, they needs to ask questions.

Who is asking the questions?

The teacher!

It happens every day, in every classroom. The students complete an assignment, and the teacher stands at the front and asks students questions. Much of the time, the questioning was supposed to indicate to the teacher the students had learned the expected material by doing the homework, finishing a lesson, reading the chapter. There was supposed to be a right answer for each question, and teachers would sometimes get irritated with an answer that was different from the answer key, but could still be correct. If a student answered incorrectly, that meant the lesson was not learned and the student could end up in trouble. All the children had to do to be ready to answer the teacher's questions was to remember. "Posing narrow questions for which one seeks a singular answer denies teachers the opportunity to peer into students' minds."(Brooks, 1999).The questions were usually written by the publisher of the textbook, but even a pedagogy book from 1884 encouraged teachers not to rely on the published questions but instead recommended changing things up. "When the question in the book is used, let it be changed in form; if, for instance, the question is, "What cape is at the southern extremity of South America?" put it in this way: "Where is Cape Horn?" (Hewett, 1884)

Then Benjamin Bloom came along. He had the idea that questions could be adjusted so children would be expected to do more than just remember; they needed to think. In 1956, his taxonomy of questioning was published. (Echevarria, Vogt, Short, 2000). His research gave teachers levels of questioning that required students to think at deeper levels. The questions teachers asked before were considered <u>knowledge</u> or recall questions because children did not have to think, just remember. The second level was <u>comprehension</u>; the child needed to remember information, and also understand. The third level was about <u>application</u>. If a student understood how to add fractions, a question at this level had the child adding fractions for a real purpose, such as cooking or measuring wood for a project. The fourth level was <u>analysis</u>.

Students were asked questions to compare and contrast, and to make connections between new information, and old. The fifth level concerned synthesis. The thinking at this level required the student to take information learned and conceive something new and creative. Finally, the last level was about evaluation. Could the child judge or critique information in the lesson? If a student read about oil drilling, then could the method be evaluated for environmental impact? In the 1990's, a team of researchers led by L. Anderson and D. Krathwohl (2001), revised the taxonomy. The levels were renamed, and teachers were given suggestions about verbs they could use for questioning and planning activities that demanded thinking on higher levels. The levels are now called remembering, understanding, applying, analyzing, evaluation, and creating (The top two levels were reversed in the revision.).

The practice of analyzing the types of questions teachers ask continues to grow. One study investigated the hypothesis that asking higher-order thinking questions increased student achievement: It did. (Marzano, Pickering, Pollock, 2001). Now we have questions that are called closed-ended, which means students must have the right answer. There are also open-ended questions, which give students the freedom to answer in more than one correct way. `It is better to ask open-ended questions because the kids have to think harder. Even high stakes testing has begun to include open-ended questions which are scored with a rubric instead of just looking for one right answer.

In 2012, BSCS (Biological Sciences Curriculum Study) held trainings for teachers. Certain types of questions yielded certain types of answers so teachers were learning to use the answers they received to decide what type of question to ask next. Teachers may begin a lesson with questions to elicit student thinking. These are formative assessments, as the teacher is just trying to get an idea what students already know about the topic. These can be planned in advance and directed to the whole class. There are no right or wrong answers, so there is no correcting of misconceptions; it is just a survey. Probe questions are used during an activity or lab. A student shares learning or an observation, and the teacher asks the student to “tell me more”. This is asking the learner to dig deeper, to think harder, and to give more explanation. Probe questions are harder to plan because the teacher has to react to an explanation and question at the spur of the moment. They are intended to help students think more deeply so they can explain. The third type of questioning is challenge questions, and these are the most difficult to plan because they involve guiding the student toward new understandings, possibly because of misconceptions. If a child says it is warmer at the equator because the equator is closer to the sun, then it is a good time to challenge their thinking. We can ask them to explain until they realize the equator is not closer. It just gets more direct light.

Asking a survey style question at the beginning of a unit in science helps teachers know what the students know. If the whole class is asked the question, ones who raise their hands usually get called on, but that makes it hard to know what the quiet students know. Sometimes a formative assessment survey question can be given on paper for all students to answer individually. Students who never raise their hand can share their knowledge too. In 2007, Paige Keeley began publishing a series of books to help teachers give formative assessment “probes” and they are all about uncovering student ideas in science. These books are helpful because they cover many topics in life, earth, and physical science. Questions from teachers to students have changed so much over time, but the idea is for us to work smarter, not harder. If the questions we ask motivate students to think more deeply, that is smarter.

But NOW . . . for the 21st century, teachers are expecting the STUDENTS to ask the questions. “The questions your learners ask often reveal a great deal about the effectiveness of what you have taught. . . .Insights you gain from learner questions can be an invaluable aid as you plan lessons that are responsive to their instructional needs." (Armstrong, Henson, Savage, 2001).

My wife and I raised four children, two daughters and two sons. On Saturday mornings, I let my wife sleep and I took all the children downstairs for breakfast. Here came the questions. "Daddy, how do you know the light in the fridge goes off when you shut the door?" "Daddy, what is happening to the seeds under the dirt in the garden?" "Daddy, why does the kitty hate dogs?" "Daddy, why is the sky blue?" "Daddy, can I ask just one more question?" Little kids ask questions. That is how they learn about their world. "Children develop ideas about natural phenomena before they are taught science in school." (Driver, 1994). Sometimes they even asked questions I could not answer. Thanks to the internet, answers are getting easier to find, but back then, no internet, so I had to wing it. The important thing is: they had questions. "In some instances, these ideas are in keeping with the science which is taught. In many cases, however, there are significant differences between a child's notions and school science." (Driver, 1994). They thought going to school would be fun because they could get answers to even more questions. I imagine it came as a shock that in school, the teachers asked all the questions. Luckily, that is changing because motivation for learning takes a big hit if the learner is only allowed to learn what adults tell them to. Students ask about things that interest them. "If a student is interested in what she is learning, she will never question why she must learn it. " (Finkel, 2000)

Many elementary science teachers start out a unit with a K-W-L chart. This graphic organizer is also a form of formative assessment because the column for K is what they **know**, or what they think they know. The column for W is what they **want** to know, and the L column is so they can write what they **learn** along the way. (Tate, Phillips, 2011) (Erwin, 2004). That middle column needs more time. What do the children WANT to know? If the unit is about insects, what wonderful questions would they ask? BUT, how often are the questions the students ask covered in the unit? They would still learn many things. Teachers thought if they took the time to include the children's questions, the unit would not get "covered". That kind of thinking is getting another look. If the things learners want to know are more important than what the publisher thinks they need to know, then the time would be valuable. If students built on their knowledge about insects, that knowledge could become something that matters in the real world: ecosystems, environments, entomology; not just information for a class or a worksheet; knowledge of insects for life. (Scardamalia, Bereiter, 2006). Asking questions requires thinking. High stakes testing is even asking children to ask questions. Letting the children ask the questions and investigate the answers is called **inquiry**.

Science classrooms all over are trying to adjust instruction for inquiry learning: letting students ask the questions and investigate. This is risky business because the questions might not be under what is to be covered. Some students even ask questions we cannot investigate. The NSTA Science Scope had a lesson in the December 2015 issue providing a lesson plan just to teach students how to ask testable questions, showing students how to ask a question that has "observable, measurable variables". (Tarjan, Nesnera, Hoffman, 2015). If the questions do not go where we want them to, what can be done? If a teacher asks the students what they want to know about astronauts in space, someone always wants to know, "How do they pee?" It is hard to have a 100% inquiry classroom when there are standards to cover with around 25 bodies in the room. Some kind of structure needs be involved. Teachers are now working with the idea of guided inquiry. If the standard involves certain expected learning goals, the teacher can share those goals with the students and allow their inquiry to fit under the umbrella of those goals. (Rather than having the horses run in all directions, they are corralled.) Some classroom days can be set up for textbook work, films, guest speakers, and simulations. But when it is time to investigate, students can use what they have learned on working days to set up investigations that answer questions **they** have asked. Students who have asked similar questions could be lab partners.

STEM: What is that?

In 1957, the Soviets launched SPUTNIK, and suddenly, science was very important to Americans. In the movie, "October Sky", Homer Hickam and his classmates entered a science fair in hope of getting scholarships to go to college because that was the only way to escape working in the coal mines for the rest of their lives. Both Presidents Eisenhower and Kennedy urged Americans to get more science education. We needed to get a man to the moon before anyone else to show we could make it to space too. That meant we had to have more people learning about science in a practical way: "doing" science instead of just reading about it.

The disciplines of math, engineering, technology and science were treated as individual subjects until the 1990s when the National Science Foundation (NSF) suggested they all merge into one for a more complete and integrated discipline. Employers look for candidates who are proficient in the integration of these disciplines. (STEM Workforce, 2007). Engineers use science and math to create technological tools to increase man's ability to explore and solve problems. "STEM stands for Science, Technology, Engineering and Mathematics. Children are presented with a problem and design something that solves the problem." (Reyes, 2012). It seemed like an interesting idea, but difficult to manage. Math teachers taught math; science teachers taught science; engineering was taught in college; students went to the tech lab to work on keyboarding skills and slide shows.

In 2001-2002, I was the Robotics Club sponsor at a middle school in Irving, Texas. It was my first exposure to STEM-related teaching. The students had to use math and science to engineer Legos to follow commands to complete certain tasks, such as follow paths or colors, pick up objects, and respond to white lines. Students wrote commands into a computer program and built the robot to follow the commands. They had to sign up to come; it was held after school; and we had a blast. They WANTED to be there because it felt like play, and they really did not equate what we were doing as work. They were having too much fun. A box of Legos was an invitation to play. Students discovered many ways to design, build, and program their robots. Conversation, elaboration continued through each phase of the tasks. Each time the robots required adjustments, student action changed the outcomes. Assessment, did they learn the material, was exhibited every time a student's robot succeeded at the task.

When I moved back to Colorado in 2005, I knew I wanted to include more STEM instruction in my classroom, but I needed to learn how. The Space Foundation offered summer classes to teachers, and I learned and played with their robotics program as a student. I learned about rocketry through hands-on approaches. I completed my first science notebook, but it was difficult because I had never done that before. I experienced weightlessness in a swimming pool, and we performed tasks underwater to see what it was like for astronauts. We got to "play" with materials inside a viewing box while wearing special gloves. I even became a certified moon rock participant, and I showed my astronomy students' samples brought back from Apollo. In 2001 and again, in 2007, the American Association for the Advancement of Science (AAAS) published "The Atlas of Science Literacy". Teachers had always understood they had to teach children to read and write: to be literate. But what is science literacy? The creators of these books designed a series of maps showing how learning is integrated, and segmented from simple concepts to higher level concepts by grade level approximations (K-2, 3-5, 6-9, and 10-12). Rather than teach science as an isolated subject, science and writing belong together, as with the lab and the notebook. Science and reading belong together as in science with research. Science and reading and writing belong together as in lab work, research, and written communication about the results and conclusions. Math and science belong together because math is a science. The map-makers believed we should treat science as an integrated subject. If we teach it that way, students could learn it like that, instead of unrelated bits and pieces.

Science is supposed to be about thinking and asking questions; forming and testing hypotheses; recording and interpreting data; sharing conclusions, then asking new questions. Science is not separate from math because math is a science and is part of the whole process. Scientists depend on technology every day: for research, tools that analyze and record data; machinery and equipment to help scientists investigate. By adding engineering to the problem-solving, design is added: making things, inventing new tools, solving problems, have been added.

Teachers have so much to cover now. How are they going to cover STEM? Using STEM is not supposed to be about working harder, but working smarter. If these subjects are no longer taught in isolation, students learn more because tasks are hands-on, inquiry-based, and cross-curricular. It is believed by many science educators that STEM employs the new and best way to get kids engaged in science. Even in elementary classrooms, teachers are already teaching math, science, and technology. All that needs to be done is add the engineering component.

Four years ago, I helped in a fourth grade class when students were learning about Colorado history. They were engaged with examination of old buildings and hypothesized how those buildings withstood the weather extremes here. After exploring weather, geography, and available resources, students designed and built models of sturdy structures that could withstand rain and wind. They worked in design teams. They researched structures (Reyes, 2012) that native Coloradans created. They had a limited supply of materials, such as wood, clay, fabric, paper, leaves, sticks, and moss. During Explanation, they made their buildings, placed a brown paper "person" in the structure (hoping he would stay safe and dry) and then they used a watering can to "rain" on their houses. Then a fan was set up to imitate wind. Students put their buildings in front of the fan, hoping their structure remained upright in the "wind". During the Evaluation stage, it did not look like any test I had ever taken because those students cheered every time a structure met the criteria for success. Weather, geography, and resources were all topics covered in class. The research for history was also taught. Using measurement tools was the main math focus. But with the added engineering assignment, all the work was integrated, and the students learned. One boy, Joshua, a committed someday-engineer, wanted to put a thermometer in his house, shut the door, and put it in the refrigerator to see if the clay was good insulation. It was too large for the experiment to be tested, but the idea of his inquiry was a good example of the Elaboration stage in the 5E model.

Teachers are interested in using STEM principles in class. Now they need the resources to do it. Materials are now being published for teachers at all levels to use STEM applications in their classrooms. Pearson has published textbooks for middle school science using Colorado's standards, and STEM has been added as an integral part of the new resources (Thornton, Buckley, Miller, Michael, Wysession, 2016). I decided to bring STEM, IDEA², and solar energy together in my Astronomy/Alternative Energy class with a hands-on investigation of house design and sunlight.

Objectives

1 Students will explore to discover heat temperatures inside boxes.

2 Students will observe heat differences through the light spectrum.

3 Students will measure and graph temperature.

4 Students will investigate variables that affect heat transfer and absorption.

5 Students will construct a model house demonstrating understanding of appropriate use of construction materials to preserve heat in a colder climate or release heat in a warmer climate.

Suggested Grade Level 6th – 12th grade Subject Areas: Science & Math

Timeline: Six classroom sessions of 50 minutes each to investigate solar energy, design and create a product and present their products to the class.

Science Standards: Scientific Measurement (metric and standard); Graphing; Electromagnetic Spectrum (Physical Science); Solar Energy: the sun lights and heats our earth and we need the heat and light to survive; Science inquiry and process including oral, written communication;

Background: Students need to know we need the sun to heat our earth and that we can use this heat to keep us warm. They need to be familiar with reading a thermometer and graphing results on an x-y axis. They need to know about houses and construction – why are houses built facing certain directions, why homes are insulated and have attics, windows, carpets. Light spectrum, especially visible light and UV light (most of our heat absorption), is important to our world and all living entities: tie into previous biology knowledge.

Materials: Cardboard boxes, cellophane in clear and in colors, carpet and/or fabric remnants, foam pieces, thermometers (digital thermometers preferred, or analog) graph paper, lab sheets, spectrum sheet;

<u>Session 1: Invitation</u> to Learn: Heat and Light

Activate and assess prior knowledge: What do they already understand about radiated solar heat and structures? What do they already know about reading the thermometer and making a graph using time on the x axis and temperature on the y axis, as well as input on increments and trends?

Light Spectrum: examine how a prism works and the resulting light spectrum.

Discuss project, what is "heat" and how it is absorbed; how it can be excluded: UV filters; Discuss the application of these heat and light concepts in buildings.

Invitation for the next session: If building a structure and occupants need heat and light, what would need to be done?

Session 2: Discover Investigation (on a sunny day)

Students are given a box, a thermometer, lab sheet, and graph paper. They also have cellophane in clear and various colors, and yesterday's notes. What question or investigations would they seek? Guide them, if necessary, to investigate the temperature of the inside of the closed box in the sun over a 20 minute time frame and graph results. The second test would include a window in the box with graphed results.

Session 3: Discover Inquiry (on a sunny day)

Students explore with a color over their window and graph results. They explore individual colors of cellophane in single layers, then in multiple layers to see if these "filters" block light and/or heat; Students investigate the use of insulation materials, running two trials with their selections.

Session 4: Elaborate: Student Models

When tests for this session are complete, students receive a descriptor for their model house. How would they insulate? What color paint and how many windows? Are they trying to keep the house warm in a cold climate or cool it in a hotter climate? (Have the class create the scoring rubric for the task, with emphasis on real-world application.) Why do contractors build houses the way they do?

Session 5: Action: Students construct models and test variables

Session 6: Assessment**:** Students display and discuss their house models with the class to show their learning for this topic. This includes their hypotheses, conclusions, and graphs.

Extension**:** Invite students to complete a photo journal of their home or other structure, explaining and describing their learning for the structure in the task.

Integrating the subject with the teaching model and the new strategies of hands-on learning and STEM provided students with an authentic, real-world learning experience that taught them more about solar home design than reading from a chapter ever could. Observing designs created by classmates afforded another opportunity for learning because they saw a variety of designs interesting to them, but did not have enough time to investigate for themselves.

Assessments

When I was in school, it was not called assessment. It was called a test. They were nerve-wracking. I had to take the book and the notes home to study. I had to sit in a silent room and answer the questions written by the publisher, the teacher, or both. It was graded, and if I got a bad grade, I got into trouble. Luckily, I liked math and science, and I had a good memory. I tested my students the same way when I was a new teacher because that was the only way I knew. How can a teacher tell if student "got" the lessons being taught? Modern society's needs have resulted in various methods to document and measure the extent of student learning. This type of documented test is summative in nature. Only the final result is displayed as a summary of student learning and the result is either total points or letter grade such as a "100 %" or an

"A". Parents and administrators all expect summative assessments to judge, in their minds, whether or not student learning has occurred.

My former district, as one of the premier districts in the State of Colorado based on test scores, is in the process of converting student measurement of achievement from grades to descriptions of achievement such as not proficient, partially proficient, proficient and advanced. The State of Colorado tests students in core areas of English/language arts, math, science, and social studies. If a student earns an advanced score, they have demonstrated work above grade level. A proficient score means the child exhibited performance at the level all students in that grade should show. Partially proficient performance shows a student performance near, but not quite, on grade level, Not proficient means the student is performing below grade level. The children take the tests in the spring, and the results come back in August. This does not help me know where my students are performing, so I need something I can use in class for faster results. Two categories of testing, formative and summative, are the two I work with in class.

Formative assessment helps me to know where my students are. "Formative assessments are one of the most powerful ways to improve student achievement because they provide real-time feedback to you and your students on their progress toward their learning goals." (Jackson, 2009). There are several ways to do formative assessment. Miller (2008) includes conferring, listening, observing, examining student work samples, charting, and reflecting. All of these are another useful way to incorporate journals because the evidence is there in their writing. It was confusing at first: a test BEFORE the unit, but it gave me useful information about what they knew so I could build on that. "In the assessment-centered classroom environment, formative assessments help both teachers and students monitor progress." (Handelsman, Miller, Pfund, 2007). Then with the information students revealed in the formative probes, teachers can "build a bridge from where their students currently are in their understanding to where they need to be as science learners" (Tugel, Porter, 2010). Then when the unit was over, it was time for summative assessment. (See Appendix C for probe samples.)

Summative assessments are given at the end of a chapter or unit. Teacher materials have the same end-of-chapter questions as in the past, (Ostdiek & Bord, 2000), but now the option for other ways to see if the students understand the content are with alternatives such as projects, models, reports, demonstrations, experiments, videos, and slide shows. A variety of project formats has been recommended for multiple intelligences. (O'Connor, 2002; Armstrong, 2001). It has also been recommended for differentiation. Children with different learning needs, ELL, and gifted students, for example benefit from alternative assessments that allow students to show what they know. (Tomlinson, 2003; Eisenberger, 2000). The recommended way to grade these projects is with a scoring guide or rubric. Wong (2009) explains that "Effective teachers give students a scoring guide that spells out how students can earn points or a grade for accomplishing a lesson." These usually have rows and columns with descriptions of increasing quality of work from 1 – 4. Students work to earn 3's – Proficient, and 4's – Advanced. The completion of a product is considered more "authentic" because a test is something to memorize; a project or product (something the student makes) is more "real." I have found this is especially helpful for my students who have special needs. An alternative to the old test allows these kids to do something that shows their learning and still fits their learning and assessment needs, as suggested by McNary and Glasgow (2005). My students present their projects, and their classmates learn from them, which they tend to like better than learning from me. Presenting hones communication skills which is another critical part of the new way to teach science.

Communication

If a student goes to the trouble to ask good questions, form realistic hypotheses, design investigations, gather data for results, and draw valid conclusions, what should happen next? When I was in school, we sat at the dinner table and communicated with the family. Green (2003) strongly recommends collaboration in class for this very reason. This is a job skill. The standards have taken written and verbal communication from language arts classes and added them to science. This makes sense as scientists in the real world have their work published to contribute to the scientific community. Scientists try to provide good information, and they expect criticism. Students need to be ready to share their work with their peers. In fact, Green (2003) feels students will work harder to do well in front of their peers to avoid feeling stupid. In the past, this presentation was once a year for competition in a science fair. Once a year is not enough. It should be a habit so students think on those higher levels more often.

Communication can begin with collaboration. A team of students working under a topic umbrella decide they want to investigate a question. If their questions are similar, they can work together to ask the questions and do all the steps of scientific experimenting. "We have here, not the blind leading the blind, but the curious seeking to make discoveries. They will bring questions to their meeting so their search will have direction" (Finkel, 2000). Some students hear collaboration and they think, work in a group. My work in class has not always shown this to be good. Some students love group work because they do not have to work hard and they let the rest of the group take over. There is always a smart student who takes over because if there is a group grade, that student wants it to be an "A". Harvey and Daniels (2015) reported on research that collaboration can be taught. If students learn the socials skills they need to work together, they can succeed at the assignment. These skills will help them in the job world because those skills are what employers are looking for in job candidates. They do not just need to be knowledgeable in engineering, they need to work well with others.

> A professor explained that her team was doing cutting-edge biomedical research, bringing together thinking from engineering, biology and technology. She confided that the center is one of the most prominent and best funded of its kind in the nation. Recently, the team hired a promising young academic researcher with sterling credentials and publications, and moved him across the country to join the project. But within three months, he was fired. It turned out the young academic couldn't work with anyone. He lost what might have been the coolest job in his field because he lacked the social skills to contribute to a team."(Harvey & Daniels, 2015)

The skills students need to have to collaborate well include:

"Be responsible to the group

Listen Actively.

Speak up.

Share the air and encourage others

Support your views and findings

Show tolerance and respect.

Reflect and correct." (Harvey & Daniels, 2015)

This book included lessons to help teachers teach these skills. (Hoffer, 2009). These skills can be broken down into smaller skill sets and taught through activities such as learning targets or role-play. Teachers and students can practice these skills using *looks like – sounds like* charts as well as brainstorming examples of things students should not do in group work, such as sitting back letting others do the work, or dominating discussion and taking over.

Once students have had instruction on working together, they can practice in science, collaborating on ideas, questions, designing research, interpreting results, and presenting findings. That is what science should be.

Argumentation is also a critical attribute in communicating about science. When a student asks a question, they often already have a hypothesis in mind. The new way of thinking is the hypothesis needs to be testable. If students claim something will happen, they need to be able to support the claim with evidence. "We must avoid the temptation to be the "answer giver" or "explainer" and reinforce students' efforts to ask and ultimately answer their questions by making a claim and justifying it with evidence collected from their investigation." (Hand, Meier, Staker, Bintz, 2009).

Career and Technical Education- Hands on Life Lessons

My search for inquiry lessons, led me to a new source: Career and Technical Education (CTE) lessons, at one time called "shop classes". These classes used lessons and instruction which included most if not all inquiry learning modules we investigated during my degree courses in inquiry science. CTE as we know it today, started long before the founding of the United States. The original schools of thought during the Greek times included many of the most important inquiry doctrines included today in the learning model of the 5E's developed by BSCS and the IDEA^2 model by Paul Kuerbis. While those ancient learning theories are interesting, my goal is to help promote understanding of a learning model I feel is important to the future of our country by keeping it economically viable.

Our current view of CTE includes not only ancient learning ideas, but also has its roots in the founding of the United States. From the start, our founders considered a strong knowledge base and skill set for all male citizens and was considered extremely important for the future of the country. The first mass acceptance of career and technical education came during and after World War I and the movement spread in the years that followed. Career and technical education expanded to include adult education and retraining citizens to re-enter the workforce. World War II caused a surge in career and technical education as technical skills were needed for defense purposes. On December 4th 1975, Congressman Carl Perkins introduced HR 11023, The Elementary and Secondary Career Education Act of 1976.The Act was intended to provide funding for career education throughout the Nation. This is still a major funding source for schools, particularly Peyton School District. The Perkins Act has greatly impacted my school district. We took to task many parts of the act as it regards Peyton School District. As the only teacher certified for CTE, I have helped my school's administration organize their duties for CTE programs and articulation of CTE classes.

As I continued with my coursework, I learned and implemented changes for the betterment of our Peyton programs. First, my counselor and I discussed our program and found common concerns regarding who knew what and how the program has been administered in the past. We also discussed articulation - get them registered for dual credit with the community college. During our communications, we found many more questions than answers especially in light of my knowledge gained in the MAT coursework. At this time, we have regular meetings scheduled. We already discussed additional budget requests, uses of funds internally, and our consortium. The consortium consists of rural schools in SE Colorado to leverage funds from both the State of Colorado CTE and Federal Perkins funds. Additional classes connected with the community college are already planned which would benefit our students. We now have a standing CTE committee including our counselor who is the CTE certified administrator, the principal, and myself. We have a clear path for the future, including budget requests, equipment requests for our soon- to- be submitted articulation for electronics, robotics, broadcasting, and other programs. All four of us will meet with our industry and parental Advisory Committees, and keep open written records of our discussions, budget requisitions, filings, and any other pertinent information.

I am the only CTE person on the faculty and will be included in anything related to CTE. Our counselor and another representative will obtain credentials in CTE. I am also the department chair for our approved CTE courses and our FBLA (Future Business Leader of America) advisor. I will also chair the additional classes we plan for articulation such as electronics and robotics. We had additional cabinets ordered to be manufactured, and a work bench installed for building robots, computers, and electronic projects.

Our administrator, counselor, and a staffer are responsible for VE-135 reports, data entry, and any follow-ups. Contacts with all the different state, CCCS, CTE contacts have been updated by me and all of us will be included on the mailing lists from these entities. Our CTE committee has created a public calendar in Outlook so we will display an up- to- date record for credentials and other filing requirements. This will also help keep our industry representatives, such as manufacturers or other employers in southern Colorado, and parents informed regarding CTE. We will also invite additional industry representatives to maintain current information on the workplace.

FBLA (Future Business Leaders of America) will continue under my oversight with our administrator as my co-advisor. This will help with our CTSO and CTE requirements. Program approval and renewals are the responsibility of our committee. This afterschool program involves the students preparing for competition at regional, state and national levels. Students prepare to compete in business related tasks they will use as business candidates in future employment opportunities. Included are cybersecurity, job interview, game simulation, and public speaking, as well as many others. What better way to prepare for employment than to engage in job related skills in a competitive arena, just like the real world?

I have two classes currently articulated, or registered for dual credit with the community college: accounting, and computer applications. Regarding the accounting class, we are using the Glencoe First Year Accounting, and our accreditation was just renewed. Students engage in hard copy and online simulations of situations requiring accounting skills they learn in class. Glencoe provides both a hard copy curriculum resource and software curriculum resource, and I use both during the year. This aligns with the State and National Standards. The class is designed to provide a basic business foundation and the accounting base knowledge which allows students to continue with a second year accounting as well other business classes. Articulation was renewed for the accounting in support of our original filing. The material and assessments I use match Pikes Peak Community College's (PPCC) curriculum chapter by chapter, as required for articulation. Both formative and summative assessments are used. In addition, I required a business article to be submitted and presented to the class every two weeks. This allows an additional formative assessment of accounting as students reflect on the current business information of the week. This prepares them for a common format in business meetings.

My Computer Applications class, (Microsoft Office, Photoshop, InDesign etc.) is also currently articulated. Students use the programs that businesses use, such as Microsoft for email, excel for spreadsheets, power point for slideshow presentations. First semester is the Office

Suite, and the second semester is Multimedia, such as Alice©. The Office portion was renewed, while we had to ask for a reinstatement to renew the second semester class. Apparently, we did not renew the Multimedia portion as the person filing thought it was a combined two semester class. I also "interview" each student at least once each week and have them show me a variety of skills they learned from that week's assignments. In addition to the formative assessments, I also use the resources provided by the publisher for summative assessments. These generally involve what I call "show me" assessments. Can the student use the specific tools in Microsoft to create a given memo, invoice, or other document regarding that week's assignments? Many of the assessments have been reviewed by our principal and counselor. They have observed me during formative assessments as well, and think I do a good job with both formative and summative assessments. Since I am the only certified faculty, and since I am my own chair, the role of our administrator and counselor confirm that my assessments are adequate. At this time, we do not have anyone else on the advisory board who reviews these assessments.

I have one more class, and while it is not yet articulated with the community college, it has become one of the most intriguing for students. We build computers. The class is called computer technology. We order individual components, and the students assemble the completed units. This technological endeavor led to the curiosity students have for other components. We have investigated the parts of televisions, coffee pots, even an old 110 camera. The students love to take these things apart to examine their parts, and often are able to repair the items, providing hands-on experience in inquiry, engagement, and problem-solving. This class provides another opportunity for the IDEA² instructional model and it flows so naturally. All I have to do is bring in some gadget such as an old computer as an invitation. The students discover the inner workings of the old computer and take it apart. This step allows them to elaborate on the functions of the parts, why the computer no longer functions, why the technology is obsolete. Students engage in the action step by applying the learning from the old computer to other technological items and repair some of them. This class offers an interesting challenge because it is not standards-based, but student performance is assessed through successful implementation of hands-on knowledge and skills.

Businesses want employees to bring skills in to the workplace. The money a business needs to spend as well as time used to train employees is very high. When a person brings these skills to the workplace, it gives them advantage over someone else that is applying. I have had numerous students come back and tell me both these classes have helped them in college to continue their studies. As Peyton follows up with former students, we see many are using the skills learned in my classes.

My accounting class is an elective. Since I had an extensive business background prior to teaching, I am a good role model for teaching business skills young people learn to value as they become job seekers. I am also the only CTSO organization advisor at Peyton School District – Future Business Leaders of America (FBLA). My FBLA people help me recruit other students for FBLA student competitions.

FBLA and I have worked on our program of work so we have specific time frames for different activities including recruitment. We have also developed Peyton FBLA pamphlets, accounting pamphlets, and for the fall, robotic pamphlets and flyers. I personally ask students to join FBLA, and interview them to see where their interests lie for future careers. Teamed up with my students and FBLA members we have a successful recruitment campaign yearlong. Peyton has had several students eligible for state and national competitions, and we have had students place in state competition each year.

My Computer Applications class is a required course for one year. Students are required to have two computer - related courses, one of which could be my second year technical electronics/robotics class or journalism. While we are planning articulation for both, the electronics course should be an easy articulation as I basically teach the 101 PPCC course plus other material. However the journalism class has not been articulated in 5 years, and we do not have a CTE certified journalism teacher yet.

I have given several teachers brochures and pamphlets to distribute in their classrooms. As they start a new school year and teach their classroom rules, regulations, and discipline procedures, I request they discuss with their classes what goes on in my classes as well as the Robotics Club. I also offer to present to each grade level as the teachers will allow me to give a brief demonstration of my course offerings and extra-curricular activities and how we can benefit all students. I find that 8^{th} graders (who are now eligible for FBLA) and freshmen, are most receptive initially early in the year and the older students as I can fit them into our schedules. The FBLA members also actively recruit their friends and other students. One example is the freshmen seminar teacher. He allows me to talk to his classes so I can pitch the benefits of my classes and FBLA. Eighth grade teachers allow me to recruit in their classrooms.

During my evaluation this year (using the new forms), my principal did tell me students gravitate toward my room. When they are finished with other class assignments, they come to my room for additional attention, help, and new learning opportunities with microcomputers and programing (Arduino, for example) to learn other life skills. This is one way I positively affect school climate.

I am relieved to have had all these resources for CTE, as I (and our school) really did not know most of the materials. The previous teacher who was involved would not and did not share any of her power or knowledge. We did not know what was available and did not necessarily know where to look for additional information. The only thing I was aware of was we submitted and received approval to purchase our 2012 accounting book in 2011. No one was aware how that worked except that is was purchased with CTE money. Most of the information provided in my CTE training was new to me and Peyton. In particular the web sites were beneficial. I can now refer to published material regarding CTE. So the funding knowledge and our membership in our consortium were new to our current staff as well as me, the counselor, and administrator. This was one specific area of knowledge I acquired with CTE coursework. We have followed up with contacts in our consortium, and new budget requests for classes, materials, and FBLA travel expenses to state competitions (several schools in the consortium have received funding for their FBLA Chapters) were requested. I believe I know what can be requested due to this class, how articulation works, and the paperwork involved; not as hard it seems and as told by our prior person. Regarding articulation, I found that our on-line accounting program (Peachtree by Sage) can be articulated allowing additional college credit for students. The business staff at PPCC is reviewing this to see if it matches their program and if so will allow articulation. I am seeking additional information regarding how I can earn accreditation in other areas such as woodworking and metalcraft. While I am a great woodworker, if I was certified in this area, I could further our students' education. My other interest is the metalcraft…again looking to learn how to become certified so we can expand on these areas also. The best part of the CTE learning experiences is the hands-on component. Everything about these classes provides real world experiences for the students, nothing theoretical. When students who have graduated return to visit, they often share the difference these classes made once they entered the job market.

Four years ago, I taught a young girl I'll call Kate. She really did not want to enroll in accounting class, but that was the only offering available. She did not like math. She did not want to be in the business class. She barely passed the first semester. To her credit, she tried. She did not care for the hard copy work of accounting, but the online component inspired her, and she experienced success. She thrived under the IDEA² instructional model because her learning was hers, not mine. She enjoyed self-direction and personal discovery. By the end of her senior year, she had earned an A. She came to visit recently and told me she was an upperclassman at a Colorado university with a business major in accounting. She is currently employed as the accountant for her parents' contracting business.

In past generations, the only reason to do well in high school was to prepare for a college education, and once students had a degree, employment was almost assured. With the prohibitive costs of a post-secondary education, a degree is out of reach for many, particularly in rural areas. There is no guarantee of a good job, so students need a plan B, now more than ever. With the job market and economy in their current condition, CTE programs, can, and should, be able to strengthen, step up, and give students another possibility for a successful career. "Teaching methods, and the organizations which support them, can never stand still. As society changes, so also do the needs and reactions of all its peoples, whatever their age. Psychological and sociological research inform us, over the years, about how children learn . . . teaching technique must reflect this growth. . "(Taylor, 1972).

So, What is Next?

As I reflect on this journey I have traveled, to go from teacher to student and back to teacher again, I realized these teaching strategies were not just about teaching good science. I have used them in all my classes, all subjects. These are not just good strategies; this is good teaching. I have seen and used these new methods and found them to be so effective, I can never go back to the old way of teaching. In the coming years, I do not want my students to think of my elective classes as easy enough to fly through and still earn an A. I want them to be engaged learners who go into their future, perhaps to pursue the same dream.

REFERENCES

Alice© www.alice.org (2016). Carnegie-Mellon University, Pittsburg, Pennsylvania.

American Association for the Advancement of Science. (2007). Atlas of science literacy. Washington, DC,

Anderson, L.W. (Ed.), Krathwohl, D.R. (Ed.), Airasian, P.W., Cruikshank, K.A., Mayer, R.E., Pintrich, P.R., Raths, J., & Wittrock, M.C. (2001). A taxonomy for learning, teaching, and assessing: A revision of Bloom's Taxonomy of Educational Objectives (Complete edition). New York.

Armstrong, D., Henson, K., & Savage, T. (2001). Teaching Today (6th ed., p. 201, 260). Upper Saddle River, New Jersey: Merrill Prentice Hall.

Armstrong, T. (2009). Multiple intelligences in the classroom (3rd ed.). Alexandria, Va.: ASCD.

Atkin, J. M. & Karplus, R. (1962). Discovery or invention. The Science Teacher 29(2), 121-143

Biological Sciences Curriculum Study The 5 E Model for Science Instruction. (1994) Lecture, Colorado Springs, CO.

Brooks, J., & Brooks, M. (1999). In search of understanding the case for constructivist classrooms. Alexandria, Va.: Association for Supervision and Curriculum Development.

http://bscs.org/bscs-5e-instructional-model

Cervetti, G; Barber, J.; Dorph, R.; Pearson, P.D.; Goldschmidt, P. (2012). The impact of an integrated approach to science and literacy in elementary school classrooms. Journal of research in science teaching (49).

Colorado Department of Education: file:///E:/CTE/History%20of%20CTE.htm#.Vm4D-18lKqU

Colorado Model Content Standards (2009).
www.cde.state.co.us/standardsandinstruction/coloradostandards-academicstandards

Council of Chief State School Officers, (2006). FAST SCASS

Diamond, M., & Hopson, J. (1998). Magic trees of the mind: How to nurture your child's intelligence, creativity, and healthy emotions from birth through adolescence. New York: Dutton.

Donovan, S.; Bransford, J. (2005). How students learn history, mathematics, and science in the classroom. Washington, D.C.: National Academies Press.

Driver, R. (1994). Making sense of secondary science: Research into children's ideas. London: Routledge..

Echevarria, J.; Vogt, M.; Short, D (2000). Making content comprehensible for English learners: The SIOP model (Third ed.). Bostin: Allyn and Bacon.

Eisenberger, J. (2000). Self-efficacy: raising the bar for students with learning needs. Larchmont, NY: Eye on Education.

Erwin, J. (2004). The classroom of choice giving students what they need and getting what you want. Alexandria, VA: Association for Supervision and Curriculum Development.

Finkel, D. (2000). Teaching with your mouth shut. Portsmouth, NH: Boynton/Cook.

FOSS full option science system. (1993). Berkeley, CA: University of California;.

Glynn, S., and D. Muth. 1994. Reading and writing to learn science: Achieving scientific literacy. Journal of Research in Science Teaching (9): 1057-1073.

Green, P. (2003). Peer instruction for astronomy. Upper Saddle River, N.J.: Pearson Education.

Hand, B; Meier, L.; Staker, J.; Bintz, J. (2009). Negotiating science: The critical role of argument in student inquiry, grades 5-10. Portsmouth, NH: Heinemann.

Handelsman, J., & Miller, S.; Pfund, C. (2007). Scientific teaching. Madison, Wisconsin: Wisconsin Program for Scientific Teaching ;.

Hawley, J.; Holcomb, K. (2005). Introduction to modern cosmology. 2nd ed. Oxford, United Kingdom: Oxford University Press

Harvey, S., & Daniels, H. (n.d.). (2015). Comprehension & collaboration: Inquiry circles for curiosity, engagement, and understanding (Revised ed.).

Hewett, E. (1884). A Treatise on Pedagogy for Young Teachers (p. 211). New York, New York: American Book Company.

Hirsch, E. (2004). What your fourth grader needs to know: Fundamentals of a good fourth-grade education. Revised. New York: Doubleday.

Hoffer, W. (2009). Science as thinking: The constants and variables of inquiry teaching, grades 5-10. Portsmouth, NH: Heinemann.

Holt, J. (1964). How children fail. New York: Pitman.

http://poweredbysolarpanels.com/solar-thermal-systems/

http://www.solarbuzz.com/Consumer/Solarthermal.htm

http://www.discountpv.com/solar_water_heating/asw-58a.htm

http://www.solarpanelsplus.com/

http://64.82.101.14/solar/solar-roadmap/solar_how-to/solar-how_solar_works.htm

http://www.nrel.gov/docs/gen/fy04/36831m.pdf

http://www.myteacherpages.com/webpages/CCPHS/smells.cfm.

https://www.wested.org/project/national-center-for-improving-science-education-ncise/

http://saiwood.com/the-conceptual-change-model/

https://www.insights.com/2119/validating-insights-discovery.html

Jackson, R. (2009). Never work harder than your students & other principles of great teaching. Alexandria, VA: Association for Supervision and Curriculum Development.

Junior great books an interpretive reading, writing, and discussion curriculum. (1992). Chicago, IL: Great Books Foundation.

Keeley, P. (2005). Science curriculum topic study: Bridging the gap between standards and practice. Thousand Oaks, Calif.: Corwin Press.

Keeley, P., & Eberle, F. (2007). Uncovering student ideas in science. Arlington, Va.: NSTA Press.

Klentschy, M. (2008). Using science notebooks in elementary classrooms. Arlington, VA.: NSTA Press

Kuerbis, Paul; (1990). IDEA². Colorado College, Colorado Springs.

McNary, S., & Glasgow, N. (2005). What successful teachers do in inclusive classrooms: 60 research-based teaching strategies that help special learners succeed. Thousand Oaks, Calif.: Corwin Press.

Marzano, R., & Pickering, D. (2001). Classroom instruction that works: Research-based strategies for increasing student achievement. Alexandria, Va.: Association for Supervision and Curriculum Development.

Mertler, C. (2009). Action research: Teachers as researchers in the classroom. Thousand Oaks, Calif.: SAGE Publications.

Miller, D. (2008). Teaching with intention defining beliefs, aligning practice, taking action, K-5. Portland, ME: Stenhouse.

National Science Resources Center, Science and technology for children. (2002). Washington D.C.:

National Center for Improving Science Education (NCISE) at WestEd (1987).

O' Connor, K. (2002). How to grade for learning: Linking grades to standards (2nd ed.) Arlington Heights, IL: SkyLight Professional Development.

Ostdiek, V., & Bord, D. (2000). Inquiry into physics (4th ed.). Pacific Grove, CA: Brooks/Cole.

Reyes, S. (2012). Engineer through the year, grades 3-5: 20 turnkey STEM projects to intrigue, inspire & challenge. Peterborough, NH: Crystal Springs Books.

Robertson, W. (2005). Electricity and magnetism. Arlington, Va.: NSTA Press.

Scardamalia, M., & Bereiter, C. (2006). Knowledge building: Theory, pedagogy, and technology. In K. Sawyer (Ed.), Cambridge Handbook of the Learning Sciences (pp. 98 118). New York: Cambridge University Press.

Schmidt, W., Wang, H., & Mcknight, C. (n.d.). (2005). Curriculum coherence: An examination of US mathematics and science content standards from an international perspective. Journal of Curriculum Studies, 525-559.

STEM workforce challenge the role of the public workforce system in a national solution for a competitive Science, Technology, Engineering, and Mathematics (STEM) workforce. (2007). Boston, Mass.: Jobs for the Future;.

Stepans, J. (1991) Conceptual Change Model

Tarjan, M.; Nesnera, K.: Hoffman, R. (December 2015) Authentic science investigation in the classroom: tools for creating original, testable questions and graphical hypotheses. The NSTA Science Scope. (39)

Tate, M., & Phillips, W. (2011). Science worksheets don't grow dendrites: 20 instructional strategies that engage the brain. Thousand Oaks, Calif.: Corwin.

Taylor, J. (1972). Organizing the open classroom; a teachers' guide to the integrated day. New

York: Schocken Books.

https://www.technologyreview.com (MIT 2007).

Thornton, K., Buckley, D., Miller, Z., Michael, P., & Wysession, M. (2016).Interactive Science. Boston, MA: Pearson.

Trends in International Math and Science Study TIMMS, (1995). International association for the evaluation of educational achievement IEA. Hamburg, Germany.

http://timssandpirls.bc.edu/

.Tomlinson, C. (2003). Fulfilling the promise of the differentiated classroom: Strategies and Tools for responsive teaching. Alexandria, Va.: Association for Supervision and Curriculum Development.

Tugel, J.; Porter, I. (2010). Uncovering Student Thinking in Science through CTS Action Research. Science Scope.

Wong, H., & Wong, R. (2009). The First Days of School: How to Be an Effective Teacher (Second ed.). Mountain View, CA: Harry K. Wong Publications.

APPENDIX A

Scope and Sequence Astronomy 2010-2011

I. The Birth of Modern Science: Charting of the Heavens (Chap. 1 & 2)

- Our Place in Space
- Ancient Astronomy
- The Geocentric Universe
- The Heliocentric Model
- Modern Astronomy

II. Tools of Astronomy (Chap.1 &2)

- The "obvious view"- angular measure
- Celestial coordinates
- Time measurements
- Distance measurement- Parallax
- Telescopes (Chap. 5)

III. Planetary Motion (Chap. 2.5+)

- The laws of planetary motion
- The dimensions of the Solar System
- Newton's Laws
- Newtonian Mechanic The Solar System (Chap. 6)
- Inventory of the Solar System
- Measuring the Planets
- Layout of the Solar System

- Terrestrial Planets
- Jovian Planets
- Interplanetary Matter

IV. Earth

- Earth's overall structure
- Earth's atmosphere
- Earth's interior
- Earth's Magnetosphere
- The Tides

V. Moon

VI. The Inner Planets: Mercury, Venus, Mars

VII. The Gas Giants: Jupiter, Saturn, Uranus, Neptune

VIII. The Pluto Question, Dwarf Planets and Solar System Debris

IX. Semester I Review

X. The formation of Planetary Systems

XI. Information from the Cosmos- Radiation

- Spectroscopy

XII. Stars and Stellar Evolution (Chap.16)

- Our Sun

XIII. The Stars

XIV. The Interstellar Medium

XV. Star Formation

XVI. Stellar Evolution

XVII. Stellar Explosions

XVIII. Neutron Stars and Black Holes

XIX. Galaxies

- The Milky Way
- Andromeda Galaxy
- Galactic Center
- Galactic Spiral Arms

XX. Galaxies in the Universe

- Hubble’s Classification
- Hubble’s Law
- Redshifts
- Time-Space dimensions

XXI. Galaxies and Dark Matter

XXII. Cosmology

XXIII. Full Circle –The Beginning of Time

- The Universe on the largest scale
- The expanding Universe
- The Geometry of Space-Time

- The Fate of the Universe
- Dark Energy, Cosmic Microwave Radiation
- Big Bang
- Nuclei and Atom formation

XXIV. Life in the Universe?

- Other Planetary Star Systems
- Intelligent Life in the Galaxy
- SETI

In looking at the above outline, it was a good roadmap for teaching and I knew I could go beyond the book learning to use journals and inquiry, but then I had to prepare to teach a unit without a textbook.

APPENDIX B

Scope and Sequence Alternate Energy 2010-2011

I. While a comprehensive curriculum for all the above subtopics would be a book itself, what follows are curriculum suggestions for three topics: photovoltaic (PV) panels for solar energy, wind energy, and thermal energy.

II. Research the following terms and ideas and add to original research on PV panels and how they operate. Students research terms, draw or print pictures, diagrams, charts, and maps where appropriate to explain the item and definitions. These are only some of the major topics regarding PV panels. Many more exist: you can include other topics as extra credit at the end of this research.

III. Concentrating Solar Collectors.

1. Specifically PV panels but can also include concentrating thermal panels;
2. Solar irradiance (definitions, maps and charts are appropriate);
3. Total insulation (definitions, maps and charts are appropriate);
4. Insulation on horizontal PV surfaces; (definitions and generally a graph);
5. Insulation on "normal" PV surfaces; (definitions and graph; "normal" as used in geometry);
6. Total "mean" hours of sunshine (mean as in averages)
7. All the above referenced to the country in general and our area of Colorado specifically: what areas of the country have the most sun energy? What is the sun energy (irradiance and insolation) here in Colorado and our area? What other questions are generated while researching all of the above? Must include several paragraphs of questions

generated and reflections of those questions- what do you think, why, and what research could you do to if those questions are testable?

IV. Tracking PV Arrays

1. Mounting methods used in tracking mechanisms;

2. What could you do to keep them "normal" (see above) to the sun?

3. What does longitude and latitude have to with sun angles reference to solar panels?

4. How do angles relate to the efficiency of the electricity produced including the concentrating panels in I. above and in III below?

V. Fixed mount PV Arrays

1. Optimal angles for fixed arrays (does this affect items I. and II?)

2. What does longitude and latitude have to do with efficiency of fixed arrays?

3. How does weather such as snow affect your array? (include other weather related phenomenon);

VI. Other

1. You might look at sun angles for different times of year in Starry Night;
2. Does Starry Night have any of the above definitions or information on any of the topic or definitions? How about your astronomy book?

Select the method or product desired to share learning for a PV Energy presentation in class.

Topics in Wind Energy and other Alternate Energy Sources

These are only some of the major topics regarding Wind Energy- many more exist. You can include other topics as extra credit at the end of this research.

I. Mechanical Wind Usage.

1. Historical usage: including grain grinding, and water pumping
2. Wind obstructions: including buildings, trees, geographical obstructions
3. Instruments for measuring wind, solar energy and obstructions;

II. Small Wind Energy Turbines

1. Is wind energy practical for home use?
2. What size of wind turbine do I need?
3. What are the basic parts of a small wind electric system?
4. What do small energy systems cost?
5. Where can I find installation and maintenance support?
6. Is there enough wind on my site?
7. How do I choose the best site for my wind turbine?
8. Can I connect my system to the utility grid?
9. Can I go “off-grid”? What is net-metering?

III. Large Wind Energy Turbines

1. What is the standard for determining “Large Wind from Small Wind”?
2. What are the basic parts of a larger wind electric system? Is there any difference between the small and large systems?
3. What is the average height for a Large Wind System?

4. Where are large systems installed? (list several "local" Colorado locations as well as out of state, and out of country)

IV. Other Topics for both Small and Large Energy Turbines

1. Zoning: for Small Wind and Large Wind Systems
2. Grants: Federal, State, Local (who is your energy provider? There are likely at least two energy suppliers that may provide a grant. A popular reference organization is DSIRE.)
3. Height of Towers
4. Wind energy charts: local and national

   All the above referenced to national resources in general and our area of Colorado specifically: what areas of the country have the most wind energy? What is the wind energy here in Colorado and especially in our area?

5. What is a watt and kilo-watt?? How your current home energy usage charged for? Do you know what your home usage is and what you pay for electricity? What is your "rate"? (Is there other energy sources besides electrical?)
6. There will be a separate project on item #5.
7. What is conservation regarding electrical and energy usage? Is conservation more important than generation of energy? On a historical level, what were previous energy sources that people developed and used? A time-line with dates should be part of your research.

8. What about financing your wind system? Could you finance a system in Colorado? What changes in financing has occurred in Colorado?
9. What about “transmission” problems as related to alternate energy and specially wind energy?
10. What other questions are generated while researching all of the above topics? You must include several paragraphs of questions that you have while you researched, and reflections of those questions. What do you think, why, and what research could you do to answer your questions? Are your hypothesis’ testable? How would you do such?

Sources to try: US Department of Energy; American Wind Energy Association; Bergey Windpower Co.; Two books in my library: Wind Energy Basics by Paul Gipe, and Wind Power for the Homeowner by Donald Marier

Select the method or product desired to share learning for a Wind Energy presentation in class.

Topics in Solar Thermal and other Alternate Energy Sources

Research the following terms and ideas regarding Solar Thermal Topics. Please research terms, draw or print pictures, diagrams, charts, and maps where appropriate to explain the item and definitions. These are only some of the major topics regarding Solar Thermal Energy- many more exist. You can include other topics as extra credit at the end of this research.

Two general types of solar thermal: Passive Solar and Active Solar systems

Historical usage: how did our European and Asian ancestors use solar thermal to improve their lives?

Native American Indians- the Anasazi used passive solar. A couple of topics to include in your research: buildings, trees, geographical location

Passive Solar Thermal Energy- Green Buildings

1. Window sizing (aperture)
2. Overhang angles
3. Trombe wall
4. Climatic design - local climate, solar energy resources, building orientation, and landscaping
5. Building orientation
6. Natural Ventilation
7. Day lighting
8. Thermal mass: solarium and sunspaces
9. Direct and indirect gain

Active Solar Thermal Energy

1. Water or Air
2. Differences in design
3. Storage of excess energy
4. Hydronic
5. Radiant heating
6. Heat pumps (include geothermal)
7. Sizing for efficiency
8. Control equipment

Other Topics for Research and Inclusion

1. NREL: Golden Colorado
2. Grants: Federal, State, Local (who is your energy provider? There are likely at least two energy suppliers that may provide a grant. A popular reference organization is DSIRE.)
3. Federal Department of Energy; Colorado Dept. of Energy
4. Building codes: local and national

   Roof loads, unacceptable heat exchanger, improper wiring, unlawful tampering of potable water supplies, obstructing side yards, erecting unlawful protrusions on roofs, siting too close to public property (streets, sidewalks) or neighboring properties and easements, covenants including HOA's.

5. Solar pools
6. Parabolic collectors (high versus low temperature thermals)
7. What other questions are generated while researching all of the above topics? You must include several paragraphs of questions that you have while you researched, and reflections of those questions. What do you think, why, and what research could you do to answer your questions? Are your hypothesis' testable? How would you do such?

Sources to try: US Department of Energy; American Solar Energy Society (www.ases.org) Solar Energy Industries Association http://www.seia.org; Colorado Governors Energy Office http://rechargecolorado.com/

Select the method or product desired to share learning for a Wind Energy presentation in class.

Appendix C Samples – Rubric for a notebook (STEP-uP, 2007), Probes (Keeley, 2007).

What's In My Science Notebook?

	Category	Good	Best
1	My Science Notebook Format	I used 4 of these: • *Table of Contents* • *Page numbers* • *Dates* • *Activity titles* • *Scientific Words*	I organized my notebook with: • *Table of contents with activity titles and page numbers* • *Page numbers* • *Dates for each activity* • *Title for each activity* • *Scientific words noted*
2	Is m notebook complete?	I am missing entries for 1-2 activities.	I have an entry for each activity.
3	How I showed my work.	I used 3-4 ways to show my work.	I showed my work 5 or more ways, such as: • *Written notes* • *Diagrams, sketches with labels* • *Graphs, plots* • *Tables, T-charts* • *Physical samples in notebook* • *Comparisons (Venn)*
4	What I observed	I wrote what I saw and did in the lesson activity. My drawings are labeled and fairly accurate.	I wrote carefully what I saw and did in the lesson activity. My drawings are labeled, interesting, and accurate.
5	Did I think and wonder about science?	I wrote some thoughts and ideas about the activities I was doing. I wrote a question I had, and had an idea to answer it.	I wrote many thoughts and ideas about the activities. I wrote questions and ideas to answer them.
6	I tested and concluded.	My conclusion is basic but only uses one example to support it.	I wrote a good conclusion and used more than one example. I had conclusion statements for many activities.
7	How I showed "Big Ideas"	I wrote a few times about the "Big Idea" of this kit. I did not mention activities.	I wrote about the "Big Idea" often. I connected the "Big Idea" to lesson activities.

STEP-uP, 2007(Getty and Others)

Doing Science

Four students were having a discussion about how scientists do their work. This is what they said:

Antoine: "I think scientists just try out different things until something works."

Tamara: "I think there is a definite set of steps all scientists follow called the scientific method."

Marcos: "I think scientists use different methods depending on their question."

Avery: "I think scientists use different methods but they all involve doing experiments."

Which student do you most agree with? ________________________

Explain why you agree with that student and include why you disagree with the other students.

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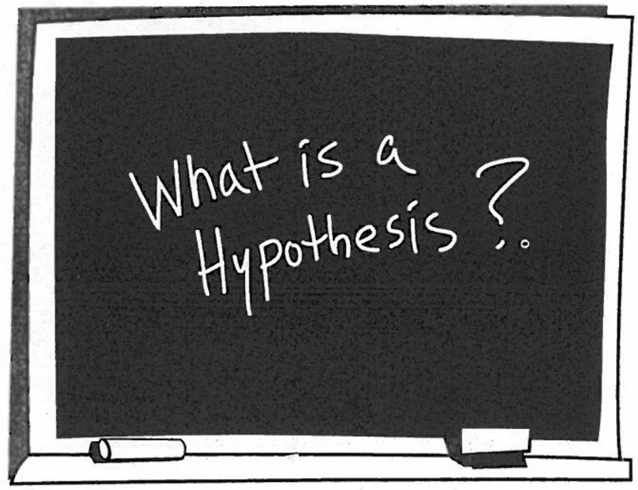
What Is a Hypothesis?

Hypotheses are used widely in science. Put an X next to the statements that describe a hypothesis.



_____ **A** A tentative explanation

_____ **B** A statement that can be tested

_____ **C** An educated guess

_____ **D** An investigative question

_____ **E** A prediction about the outcome of an investigation

_____ **F** A question asked at the beginning of an investigation

_____ **G** A statement that may lead to a prediction

_____ **H** Included as a part of all scientific investigations

_____ **I** Used to prove whether something is true

_____ **J** Eventually becomes a theory, then a law

_____ **K** May guide an investigation

_____ **L** Used to decide what data to pay attention to and seek

_____ **M** Developed from imagination and creativity

_____ **N** Must be in the form of "if…then…"

Describe what a hypothesis is in science. Include your own definition of the word *hypothesis* and explain how you learned what it is.

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