LET'S OBSERVE!

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"*What we have to learn to do, we learn by doing.*"
--Aristotle, Greek philosopher

Abstract

Teaching the non-science major how to teach science is a challenge! No matter what science course is being taught, professors must model good teaching strategies that promote an inquiry approach that incorporates prior knowledge, connections, a social environment, relevance, and time to actively construct new understandings of scientific concepts.

Introduction

As twenty-five undergraduate early childhood education majors cross the threshold of our classroom each semester, I see their eyes going back and forth as if they are searching for something familiar to survive. They are starting their semester courses of *Elementary Science* or *Early Childhood Mathematics and Science* and are frightened. Inside, they are thinking, "I can't do science or math!"; "I must endure this course, though, in order to teach!"; and, "What am I going to do?" Knowing that 90% of these junior and senior students do not have any confidence in these two subjects, I feel that it is my job to open their world to include science and mathematics education. They must be at ease with both before there is any hope that they will be at ease in front of twenty elementary students!

As we as a class progress through the semester, fear evaporates like a puddle of water because, as Ralph Waldo Emerson said, "Knowledge is the antidote to fear." By helping the pre-service teachers confront their fears and learn how easily math and science can be included in a curriculum, they are empowered to begin their student teaching experience and eventually start their first year of teaching. Using the topic of observation, I will demonstrate how engaged the early childhood/elementary educators become and how easily they are immersed in science without fear. Using this lesson, the pre-service teachers see how easily science continues a child's natural curiosity. By providing an inquiry-based approach to science that reflects the *National Science Education Standards*, the early childhood/elementary educator will learn how to

The Journal of Mathematics and Science: Collaborative Explorations Volume 11 (2009) 245 - 256

help channel the elementary students' energy, curiosity, and interest into a lifelong interest in the world of science [1-3].

Educational Theory

Even in the early grades, schools were traditionally considered to be warehouses of knowledge: students filed into them, systematically going down one row (one grade), receiving pieces of equipment (facts, school experiences) from the warehouse shelves and from the warehouse supervisor (the teacher), putting them into their baskets (brains) and magically putting all of the pieces together to know something in order to be promoted to the next row of the warehouse with new equipment and a new supervisor. Ira Shor states, "Classrooms die as intellectual centers when they become delivery systems for lifeless bodies of knowledge" [4]. There were no connections, discussions, or interactions between students. It was a sad and lonely way to learn. This has happened and is happening in many classrooms across the nation, from the elementary to the college level.

One way to change these classrooms would be to teach all students from a "learner-centered" perspective that would enable the transformation of these sad and lonely classrooms to dynamic, interactive classes that could help students become more comfortable with science [2,3,5]. Chickering and Gamson has a list of seven recommendations that should be the foundation for instruction for all teachers and professors in all "learner-centered" classes:

1) Frequent student-faculty interaction should occur;
2) Cooperative learning activities should be interspersed among other engaging instruction formats;
3) Students should be actively involved with learning;
4) Instructors should provide prompt, constructive feedback on student performance;
5) Instructors must keep students focused on learning, not on the fear of embarrassment or other distractions;
6) Teachers should communicate high expectations; and,
7) Finally, teachers must respect diverse talents and ways of learning [6].

Results from a survey sent out to professors within the state of Louisiana documented the fact that few professors are teaching with these recommendations in mind [7]. The lecture mode is still alive and well.

Looking at these recommendations, connections are important for students of all ages, and these connections promote active learning. Without being able to search the archives of the brain in order to pull out the file drawer containing some prior fact or experience that would connect to a new experience, long-term understanding and learning ceases [3, 8-12]. This is just as important for the twenty-year-old college student as for the six-year-old first grader. The student must be engaged in learning by being an active participant, not a passive one. Learning science is a process of knowledge construction (active), not of knowledge absorption (passive). Through active participation, the learners are able to internalize, reshape, or transform new information. This transformation only occurs through the creation of new understandings because the teacher has designed a learning environment that includes a curriculum that meets the interests, knowledge, ability, and background of the students [2, 13-16].

Learning is a social experience, not the stereotypically portrayed scientist in a white lab coat in the corner of the lab working alone. Students must be allowed to discuss, explore, investigate, and discover in order to actively construct new understandings. This constructivist approach to learning aligns itself well with the brain-based research that has developed over the past three decades [17-19]. Talking and doing is the vehicle for learning and, as Deborah Meier stated in 1995, "Teaching is mostly listening and learning is mostly telling" [20].

Another very important component of any educational theory or philosophy is that the experiences in the classroom should be relevant. Defining words at the end of the chapter in the science textbook has no relevance. By discussing the vocabulary and using it in a hands-on experiment, the scientific jargon will have meaning for the student. Science must not be taught as a laundry list of terms and procedures. Science is a dynamic field that surrounds every person and should be one of the easiest and most exciting subjects to teach if good, sound teaching strategies are implemented. As pre-service teachers in a methods class, they must experience this inquiry method of learning in order to teach science this way in their future classrooms [21, 22].

The Science Standards

It is imperative that pre-service teachers are acquainted with the *National Science Education Standards* because wherever they teach, they are accountable for meeting these standards as prescribed for each grade level [1]. Each lesson, as this simple observation lesson developed in the methods classroom, must refer to these *Standards*. In the *National Science Education*

Standards, Content Standard A for kindergarten through twelfth grade addresses the issue of observation:

> [The] students can investigate earth materials, organisms, and properties of common objects. Although children develop concepts and vocabulary from such experiences, they also should develop inquiry skills. As students focus on the processes of doing investigations, they develop the ability to ask scientific questions, investigate aspects of the world around them and use their observations to construct reasonable explanations for questions posed [1].

These *Standards* provide the framework for all science lessons across our nation. For example, the New Mexico State Science Standards were drafted using the *National Standards* as the primary resource [23]. It is the same for many states; therefore, our pre-service teachers must know how to meet these *Standards* because they will be responsible for using them in their classrooms in different school districts.

There are other standards, such as the *Benchmarks for Scientific Literacy*, that also encourage the active participation of all students in making observations as a springboard to completing inquiry-based investigations [24].

One Science Lesson

If I had stood in front of the class of twenty-five pre-service teachers and lectured for two hours, as so many of their previous mathematics and science professors have done, I would have lost them on the first day. From the very beginning of the semester, I model how they should teach in their future classrooms. Keeping in mind that my educational philosophy mirrors what was discussed in the preceding section, I will demonstrate in the following paragraphs a typical lesson on a very fundamental scientific subject: observation.

Engagement Hook—What Happened to the Water?

With three styrofoam cups—one empty, one filled with confetti, and another with a little sodium polyacrylate—I ask the class to test their observation skills. I have a beaker with water and ask a student near me to tell the class how much I have in the beaker. Then I pour the water into the cup with the sodium polyacrylate. Of course, the water is absorbed immediately, but the class does not know what is in the cups. Now, I move the cups about while humming, of course! The students' mission is to tell me where the cup with the water is located. Every pair of eyes is watching carefully. Of course they choose the correct one, so I toss the "water" at the students, and nothing happens. Next, we try a cup they choose (one has confetti and the other is empty) and each are tossed at the class. This is a wonderful way to begin discussions! Each group discusses and writes at least one hypothesis of what happened to the water. Eventually, one group will say that something in the cup, like a sponge, absorbed the water. As words are thrown out, a list of terminology is kept on the board by a student, such as "absorption," "evaporation," "liquid," "solid," "gas," and others as the class talks.

The secret is out, it was the sodium polyacrylate. Then, we talk about Pampers® and how disposable diapers work. Each group tears apart a diaper and sees the white powder. They talk about how this substance could be used in the classrooms in different experiments that their students would like to try—just as they would like to try.

There is usually a discussion about how science is never "magic." There are always explanations, but sometimes it takes years for scientists to explain phenomena. At this point, I bring in newspaper articles about something discovered and solved scientifically in New Mexico [25]. For example, this year the mystery of the formation of our famous Carlsbad Caverns was solved through scientific observations and experiments. The old trickle-down theory of carbonic acid seeping down to the limestone from rain runoff and slowly eating away six football fields' worth of rock just did not provide an answer since there was no way to get rid of so much limestone (no streams or rivers). Our University of New Mexico biologist, Diana Northup, and geologist, Carol Hill, are proposing the theory that carbon compounds available in oil (pools of petroleum exist under the Carlsbad region) are eaten by microorganisms. The product they produce is hydrogen sulfide that rises through fissures and reacts with oxygen to produce sulfuric acid which certainly dissolve entire stadiums of limestone. The clues, such as blocks of gypsum, were there all along to be observed by the scientists. It just took time to put all of the observations together.

It is hoped that the students will also observe that two *women* scientists were responsible for this discovery. I talk about the stereotyping of scientists and how students of all ages still think of a scientist as a white male with glasses, a lab coat, wild hair, and holding beakers of bubbling liquid [26, 27].

Engaging Observation Activities—Where is My Pecan?

Each table gets a bag of pecans which are grown right here in the valley by Las Cruces. This is an example of making connections within a lesson to the environment of the student. From this bag of pecans, each student chooses a pecan, studies it, and returns it to the original bag. The pecans are mixed up and then each student finds their new "friend/pecan" again. They have the task of describing to the group how they found their own pecan in the big pile of pecans. This encourages communication, builds vocabulary, and increases observation skills. To make it more difficult, two tables combine all of their pecans and again, only through observation, the students find their "special pecan."

We then talk about the power of observation and extensions of this activity. For example, elementary students can make a center by writing descriptions of their pecan with a picture. Then, the pecans can be placed in a basket together and the student would need to match the descriptions and pictures with the correct pecan. Combining art and language arts, the students can make posters advertising their "lost pecan." The ideas are only limited by the imagination of the students and their teacher.

Liquids, Liquids, and More Liquids

The student in the group wearing the most green is asked to come up to the lab table and take a tray back to their table. On this tray are six different liquids (labeled A-F), along with food coloring, paper clips, ice cubes, and small fishing weights. The six liquids are: water, 7UP®, vinegar, alcohol, seltzer water, and Karo® syrup. The liquids are clear, and the same amount of each liquid is in each cup. The instructions are simple: using the materials given and through observation, determine if these liquids the same. Each group's representative must be able to justify the group's decision and illustrate the results to the other groups. At this point, conversation and activity fills the room. I supply graph paper, big sheets of paper, markers, and meter sticks.

Of course, each group comes to the conclusion that the liquids are not the same. Just through observation, the 7UP® has more bubbles than the seltzer water; the Karo® syrup is thicker when you tilt the cup; and, the clearness is different when the liquids are compared. They smell differently (I teach them how to safely smell substances). The food coloring drop diffuses differently in each liquid (many groups made pictures of this phenomenon). The ice cube sinks in the alcohol, but not in the others. Like the food coloring, the fishing weight migrates down the different liquids at different speeds. Normally, their conclusions are well thought out and their documented presentations very scientific.

Worms, Worms, and More Worms

Each group receives two styrofoam cups covered with foil, one marked ***A*** and the other ***B***. The instructions are simple: observe what is in the cups, write down observations, beginning with cup ***A***, and then compare the contents of cup ***A*** and ***B***. Cup ***A*** has "soil" made from Oreo® cookies ground up in a food processor, along with five or six Gummy Worms. Cup ***B*** has live earthworms in real soil. I have rulers and scales available for use.

The students always have a great time as they measure, weigh, count, describe, and discuss the worms. The discussions include the ecology of the worm and the characteristics of living versus non-living. This is an intriguing observation activity that engages all of the pre-service teachers in using scientific terminology and process skills. It also emphasizes that there is so much data that can be gathered by simply observing.

NASA Needs Your Help

I introduce this lesson to the pre-service teachers as though they are in a third through seventh grade science class. I propose that NASA has sent us two samples, one from a space object NASA is called "Zercon," and one from another space object, "Xelicious." Their mission is to design a spacecraft that could land on both objects in order to study them. They are then to identify what they are and discover how to mine the resources on these objects for use on Earth.

The class brainstorms a list of possible things these space objects might be. A list is compiled on the board and different groups volunteer to find out information about that "space object" and report to the rest of the class. Wireless laptops with an Internet connection and an entire wall of resource science and mathematics books are available for their research.

One sample is "gluep," made from combining a 4% borax solution (dissolve 112 grams of borax in one quart of tap water) and Elmer's® Glue mixture (mix equal volumes of water and Elmer's® white glue). The formula for this "gluep": 25ml of the glue mixture, a drop of food coloring, and 19ml of the borax solution. These ingredients are combined inside an ordinary Ziploc® bag. After the bag has been securely sealed, the mixture is then gently kneaded.

The other sample is "oobleck" (four boxes of cornstarch, 1600ml of water, and several drops of food coloring) that has been divided into small plastic bags for distribution to the small groups of pre-service teachers.

Each group obtains a sample from each space object. Time is spent simply observing, exploring, and comparing the two samples. We discuss and design class definitions of the three states of matter, and then each group tries to classify/label the two samples of matter. A lively discussion about the sample from Xelicious evolves because the sample does not exactly "fit" the definitions that the group had constructed of a liquid, solid, or gas.

After the class and group discussions about matter, each group makes a chart with descriptions of the characteristics of each sample. These charts are placed around the room to be shared with the other groups. At least twenty minutes is used simply to discover the properties of the samples. It is important to give students of all ages time to explore. We have a tendency to rush through activities, and this does not engage the students in the critical thinking process.

Next, each group starts designing a spacecraft to land on both space objects. You may see students using pennies and other objects to determine if they sink down into the sample. Weight is a tested element; water resistance is a factor—the list keeps emerging and changing as groups design experiments in order to understand the characteristics of the "landing strips."

The discussions are fantastic with very rich scientific vocabulary being used. The ideas are interesting, and students with prior knowledge are able to contribute this information to the group. The groups design spacecraft, draw designs of the spacecraft, and as visiting engineers from different states, they present the plans to a "NASA Board" at the next class meeting. This "NASA Board" consists of engineers and professors from the Colleges of Education, Physics, and Engineering. Members of the Board observe both samples before and are able to ask questions about the design of each group.

These pre-service teachers start by simply observing and then conclude the activity through presentations before a "Board." Over the course of this activity, these teachers learn how to do the following: experience the dynamics of group work, experience the power of simply observing, build class definitions, use these definitions, research information, integrate art and language arts, communicate, and prepare a presentation for a group of "distinguished guests." For students of all ages, this makes the classwork have relevance—they are not just doing the activity.

Ongoing Observation Activity

What happens when an egg is put in vinegar? The groups hypothesize, agree on one hypothesis, and put an egg in vinegar to be observed. Each group decides on an observation schedule and reports during the next class period within the next week (the class meets once a week for three hours).

When they return the next week, we discuss how the egg became rubbery, bouncy, and bigger. The words osmosis, diffusion, and other terminology are added to the students’ scientific vocabulary. Through observation, the students can understand the definitions of these scientific words. Talking about their future classrooms, I discuss the advantages of using scientific jargon in early grade levels because the students can use it and they love it! These early elementary grades are building the foundation for future science classes. To extend this activity, you can put an egg in Karo® syrup and observe the shrinking egg as compared with the growing egg in the vinegar.

It is interesting to note that, in my many years of teaching this methods class, only one or two students have ever seen an egg in vinegar. Although this is an experiment that has been in many books for a long time, it is important to realize that many of the early childhood elementary education majors have had very little science; some of these “old” experiments are wonderful to use to discuss fundamental scientific concepts. Don’t be afraid to use them!

Ongoing Research

Teaching the *Early Childhood Mathematics and Science* methods classes by using an inquiry approach gives the pre-service teachers opportunities to understand the scientific concepts as their students would. In order to verify that this type of college teaching makes a difference, it is imperative that observations are continued of the pre-service teachers in their classes as they begin their teaching careers. Using the “Collaborative for Excellence in Teacher Preparation Classroom Observation Protocol,” pre-service teachers who have taken this methods class are observed in order to document the transfer of inquiry-based teaching of mathematics and science from their college classes into their classrooms [28].

Observing only teachers within our immediate geographic area excludes those pre-service teachers who have begun their careers elsewhere. To obtain data from a larger audience, a survey is being written to be sent to these teachers so that we can document their use of inquiry-based science in their elementary classrooms. To add to this data, the standardized scores of the students who are in these classrooms will be collected and compared to the population of students in the classrooms of teachers who did take the inquiry-based mathematics and science methods course.

Through the triangulation of the observations, the surveys, and the comparison of standardized scores, the impact of this type of instruction in the college classroom will be documented. More importantly, we will be investigating the impact on learning for the students in those classrooms.

Conclusion

Observation is a very fundamental tool of all scientists, and we need to encourage students to develop this skill. We need children to be able to observe first and then make decisions based on these observations. In order to do this, they need practice, and kindergarten is a good place to begin. This will not happen unless pre-service teachers have experienced this inquiry-based approach to investigating the world around them in their own science classes. Professors must take the time to model this approach that reflects the national science standards. With the NASA activity, the pre-service teachers develop concepts through observations (states of matter), ask scientific questions, investigate aspects of the world around them (identifying possible space objects), and construct reasonable explanations for the question posed (developed spacecraft to land). These pre-service teachers are allowed to use prior knowledge, make connections, and complete the findings in a presentation to a “NASA Board” to add relevance to the lesson.

Since all of the activities could be used easily in the elementary classroom, the pre-service teachers are adding to their knowledge base of teaching science in this setting. As higher education educators, we must realize that the majority of pre-service teachers are afraid of science and resist it because of the way they were taught. By modeling good science teaching strategies in all the science classes, slowly but surely, science education will be transformed in future elementary classrooms. As Aristotle advised, the undergraduate pre-service teachers must learn by doing just as the future students who will fill their classrooms. There is no such thing as simply observing! By offering opportunities for pre-service teachers to engage in inquiry-based, constructivist science experiences, they will realize that observation is a fundamental scientific skill that opens the doors and allows the students to investigate the world around them in an exciting way.

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