Inquiry in the Middle School: Content Learning

by Julia Marrero

When I began teaching ten years ago, my goal was for my students to love science. My own experience had taught me that science is not about memorizing facts, but about doing. As a new teacher, I made the common error of stringing together interesting science activities, most of which were teacher-directed. My students were enjoying science, but without a great deal of critical thought. It was my work with the Institute for Inquiry at the Exploratorium which moved my teaching from being merely engaging to truly inspired.

My collaboration with the Exploratorium began after my first year of teaching, when I signed up for a three-week workshop on light and color. Rather than being taught how to teach light and color, the participants of the class were engaged fully in the learning process. We didn't just study light and color, we participated in an in-depth investigation of the intricate phenomena involved in the subject. More fascinating than the content was the notion that by taking part in an investigation, the way I looked at the world could change. Through such immersion, I began to notice phenomena which had previously escaped my eye. Shadows and reflections held new meaning for me. I was determined to excite my students in the same way. Later I joined the Teacher Learning Group and through interaction with the other teachers in the group, expanded my ideas about inquiry.

I now guide my sixth graders through three to five scientific inquiries a year.

I measure my success by the level of enthusiasm in the classroom, as well as the level of thinking that goes on there. My students look forward to science and feel confident about their capacity for conducting scientific investigations. Their questions are realistic and grow in sophistication. They can determine which experiments are "fair" or "unfair," and they readily identify controls and variables in an experiment. Just as we want our developing writers to view themselves as authors, we hope that our budding investigators will view themselves as scientists. My classroom is full of scientists: students who think critically about, care about and reflect on what they are learning. The biggest jump in my teaching occurred when I began to see how almost any unit could be opened up into a scientific inquiry.

The four stages of inquiry

There are essentially four stages my students move through in an inquiry: concept development, planning and prediction, investigation, and summary of findings.

In the first stage, students are given multiple experiences with a single phenomenon. Through this interaction, students develop a variety of concepts and questions. It is ineffective to ask students to come up with questions on a topic before they have concrete experiences with that topic.

As an example, I teach a unit on the physical states of matter. I begin the unit by having students complete a set of stations on physical states; this takes about a week. Their questions often arise directly from their participation at one of the stations. For example, one of the stations the students engage in is designed to show the concept of diffusion. The students simply put a drop of food coloring into a beaker of water and observe what happens over time. Many are surprised to find that the food coloring mixes on its own, thus explaining one of the properties of liquids: molecules in a liquid are constantly moving. This experiment can lead to multiple investigations. Does the temperature of the water change the rate of diffusion? Do all liquids diffuse at the same rate? Does the color of the food coloring affect the rate of diffusion? These questions come from the students. In formulating their questions they are already beginning to un-

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derstand some of the rules of science: for example, only change one thing at a time.

After students have had multiple experiences investigating phenomena, we come to the second stage of the inquiry: planning and predictions. In this stage students formulate a question, create a plan for investigating their question and predict what they think their results will be. It is extremely important for students to be given feedback on their plan before they begin their investigation. I like to conference with each student or group of students (if they are working together) before they begin their plan. If the question is not clear, the investigation will not work. I point out any difficulties that I see in a particular question though I will allow students to keep a problematic question if they are really wed to it. (Often some of the best learning takes place under these circumstances.)

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When students feel confident that they have a solid question, they work on writing their plan. They then share their plans with their classmates, either in groups or as a whole class, for feedback. I also participate in giving feedback to students. I make sure that all students know what they need to bring in for their investigation and what their first step will be.

The third stage is the investigation itself. Here the students are pretty much on their own. I am always amazed at how little they need or want my guidance.

Beginning and *completing* the investigation

Watching how involved students become in their inquiries is for me the greatest evidence of the value of scientific inquiry in the classroom. Classroom management is handled because students are interested in what they are doing. They feel empowered at being allowed to make their own choices. I do circulate amongst them as they work but mostly to ask them questions about what they are noticing and to take part in their discoveries.

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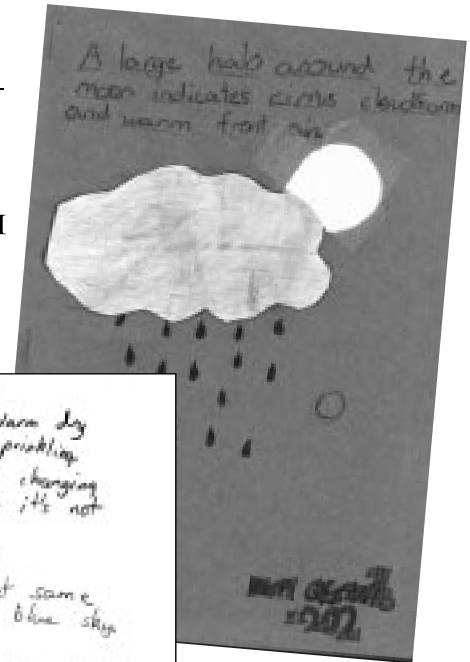
It is very important to allow students as much time as they need to complete their inquiries. I always make sure I have something for them to do if they finish early. More often than not they begin working on analyzing their results. I require students to keep accurate records of their findings as they work, and many students create tables to organize their data. Students invariably want to see what their classmates are doing and I allow them to move about the room to do so. I am often pleased with the level of critical thought that is apparent as students give what is truly authentic feedback to one another.

The final stage

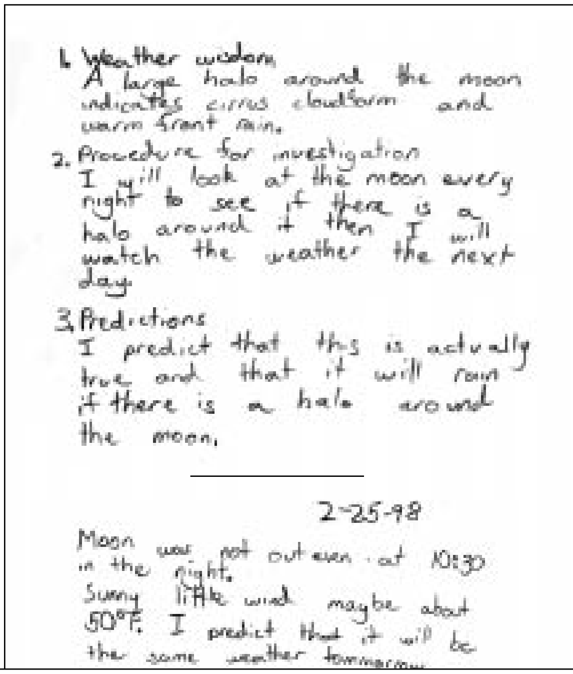
The final stage of the inquiry is the summary of findings. I like to tell my students that all scientists report their findings. Often we turn the classroom into a mock conference. I have learned to vary the way in which students report their findings. The first inquiry of the year usually requires a written report as well as an oral one but as the year progresses I sometimes make this stage entirely oral. I made this change after realizing that some students were beginning to associate inquiries, not with the process of investigation, but with the paper they were required to write. The summary itself has three components: restate the question and predictions, describe the investigation, and interpret the results. Students are assessed with a rubric which details each of these components. Towards the end of the year I have students create their own rubric and assess one another.

Last year the students completed the inquiry on physical states, where they learned about the water cycle. While most students investigated questions that arose directly from the preliminary stations, some ventured further. One group decided that they wanted to see if they could make a thermos that would work better than the ones that they used at school. Their goal was to try to keep ice water cold for as long as possible. In their enthusiasm they brought in a bevy of materials: Styrofoam (popcorn, fabric, tape, Play-Doh, and more.) During the process of investigation they researched thermoses on the Internet, adding to their own knowledge of what helps keep things cold. In the end, their thermos didn't function as well as the commercial ones they had brought in, but this was by no means a measure of their success.

These students clearly felt proud of their accomplishment and made it known to me that they could have spent an additional week investigating their question. One of them said they would never look at a thermos in the same way again. Then I knew I had been successful. ✎

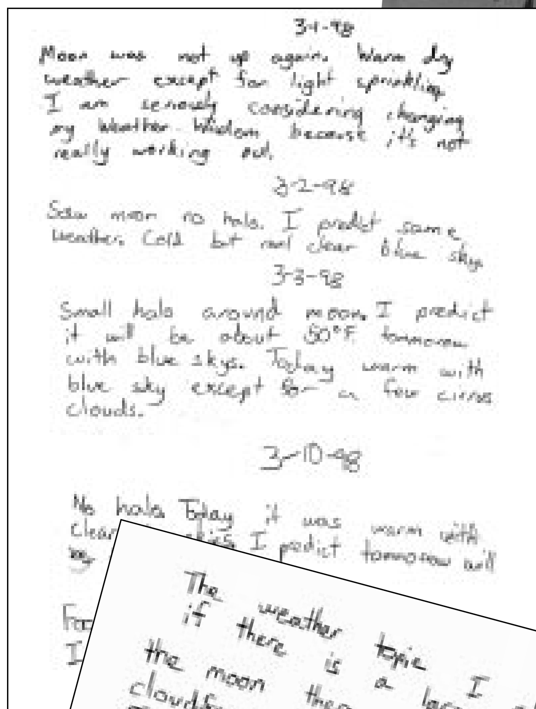


Selected entries from one student's notebook:



1. Weather wisdom
A large halo around the moon indicates cirrus cloudform and warm front rain.
2. Procedure for investigation
I will look at the moon every night to see if there is a halo around it then I will watch the weather the next day.
3. Predictions
I predict that this is actually true and that it will rain if there is a halo around the moon.

2-25-98
Moon was not out even at 10:30 in the night. Sunny little wind maybe about 50°F. I predict that it will be the same weather tommorow

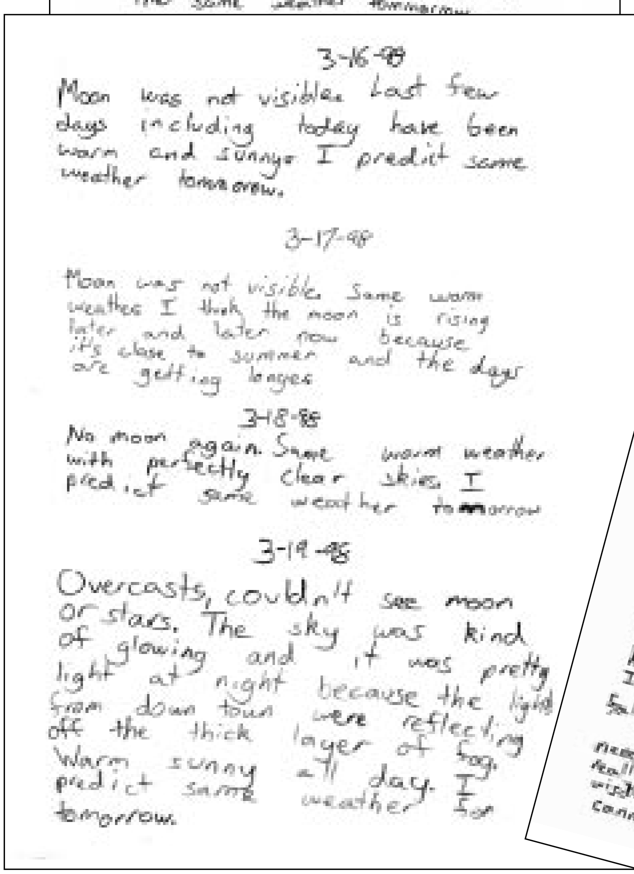


3-1-98
Moon was not up again. Warm dry weather except for light sprinkling. I am seriously considering changing my Weather Wisdom because it's not really working out.

3-2-98
Saw moon no halo. I predict same weather. Cold but real clear blue sky.

3-3-98
Small halo around moon. I predict it will be about 80°F tommorow with blue skys. Today warm with blue sky except for a few cirrus clouds.

3-10-98
No halo Today it was warm with clear … skies I predict tommorow will …

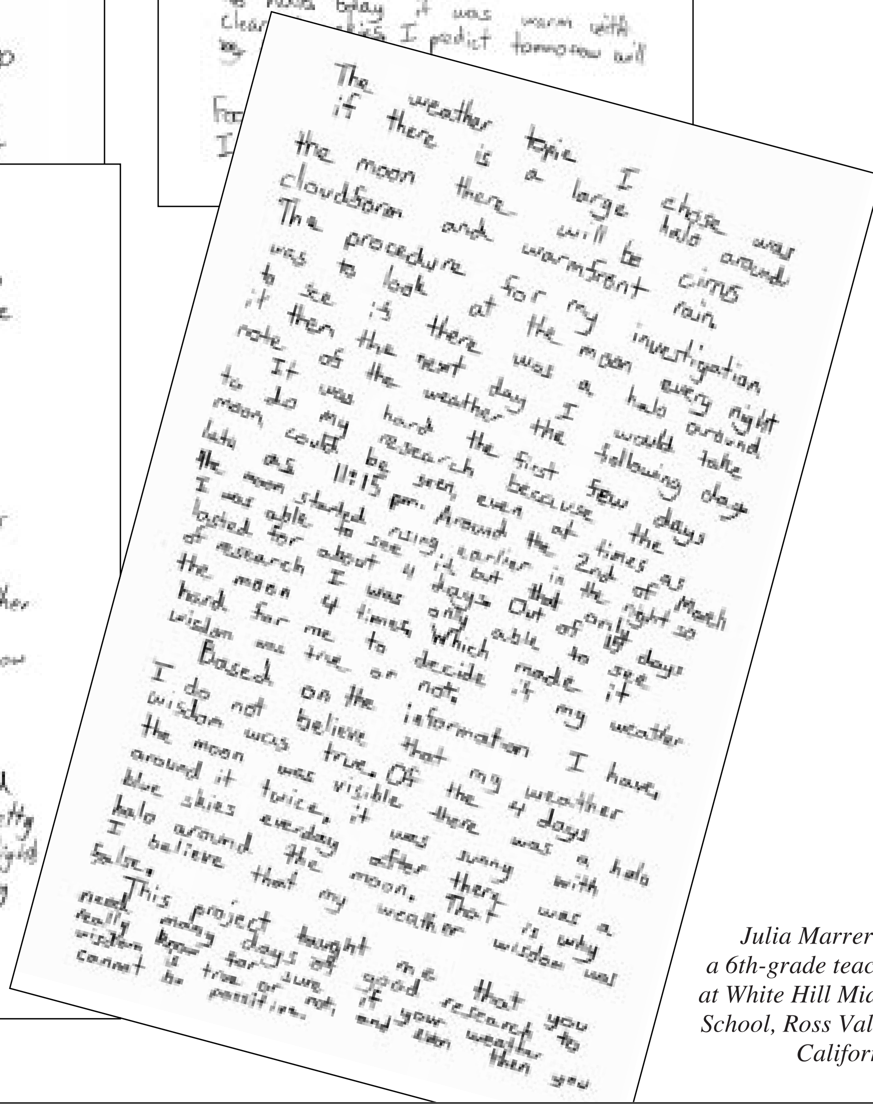


3-16-98
Moon was not visible. Last few days including today have been warm and sunny. I predict same weather tomorrow.

3-17-98
Moon was not visible. Same warm weather I think the moon is rising later and later now because it's close to summer and the days are getting longer.

3-18-98
No moon again. Same warm weather with perfectly clear skies. I predict same weather tomorrow

3-19-98
Overcasts, couldn't see moon or stars. The sky was kind of glowing and it was pretty light at night because the lights from down town were reflecting off the thick layer of fog. Warm sunny all day. I predict same weather for tomorrow.



The weather topic I chose was if there is a large halo around the moon there will be cirrus cloudform and warmfront rain.
The procedure for my investigation was to look at the moon every night to see if there was a halo around it then the next day I would take note of the weather the following day.
It was hard the first few days to do my research because the moon could be seen, even at times as late as 11:15 pm. Around the 2nd of March the moon started rising earlier in the night so I was able to see it but that only lasted for about 4 days. Out of 18 days of research I was only able to see the moon 4 times. Which made it hard for me to decide if my weather wisdom was true or not.
Based on the information I have, I do not believe that my weather wisdom was true. Of the 4 days the moon was visible there was a halo around it twice, it was sunny with blue skies everday after there was a halo around the moon. That is why I believe that my weather wisdom was false.
This project taught me that you need really many days of good research to really know for sure if your weather wisdom is true or not, and even then you cannot be positive.

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