

The Fulcrum Flash

Fulcrum Summer Institute 2007



Teachers Nancy Wile (Pentucket Regional) and Varsha Desai (Shrewsbury) investigate the mass of air during the summer institute.

Fulcrum Institute participants, K-8 inservice teachers from the Greater Boston area, spent a week this past summer on the Tufts University Medford campus. They worked with Tufts scientists and TERC curriculum developers to explore their own beliefs about science, as well as that of their students. The Fulcrum teachers thought long and hard about how their classrooms take advantage of how children experience their world and how they might enhance their own teaching by linking that experience to the big ideas of science.

Each day's session began with a hands-on investigation. The sequence of investigations was designed to provide evidence for what we all profess to believe –

i.e., that all matter in the universe is composed of microscopic particles that are in constant motion. For example, if matter is composed of particles, is the space between the particles filled with anything? If it is, is that stuff made of particles too? If it isn't filled with anything, then how much of the stuff around us is empty space? Why can some stuff be squeezed and other stuff can not? And if these particles are all moving, how fast are they moving? What happens when they slow down? Suppose they stop moving?

Something to Think About

Fresh cucumbers contain 99% water by weight. Three hundred pounds of cucumbers are placed in storage but, by the time they are brought to market, it is found that they contain only 98% water by weight. How much do the cucumbers now weigh?

[from the new Mass DOE "Guidelines for the Mathematical Preparation of Elementary Teachers]

Insights to these questions emerged as the Fulcrum teachers pursued their investigations and discussed their observations during the week. In addition, there were presentations by physicists and cognitive scientists, and round table discussions to deepen these discussions.

The Fulcrum participants used the Tufts library and its collection of research texts to follow their particular interests in understanding different aspects of children's ideas about phenomena such as forces, motion, electricity, sound, and light. They also used the two volume [Atlas of Science Literacy](#) and the [Benchmarks for Science Literacy](#), publications of the American Association for the Advancement of Science, to guide them in their curriculum projects.

-Judah Schwartz

Focused Group Discussions: Constructing Meaning with Models

Two of the Guiding Principles in the Massachusetts Science And Technology/Engineering Curriculum Framework state the need for students to be given the opportunities to both “examine their ideas as they apply them in explaining a natural phenomenon” and “to talk about their work in focused discussions with peers and with those who have more experience and expertise.” By 6th grade, students in Massachusetts public schools are expected to “present and explain data and findings using multiple representations, including tables, graphs, mathematical and physical models, and demonstrations.” To improve the scientific literacy of K-8 teachers, the Fulcrum Institute models these same effective strategies using an inquiry-based approach to the teaching and learning of science.

Maintaining the perspective that learning is a collaborative effort, the Fulcrum Institute creates opportunities for K-8 teachers to engage in inquiry and discussion with one another to construct their understanding of science content. In the Fulcrum online courses as well as the face-to-face sessions, teachers are given opportunities to investigate natural phenomena in small teams and to analyze and discuss their findings with their peers for the purpose of deepening their own conceptual understanding.

The science learning goals for the Fulcrum Summer Institute held in July at Tufts University were intended to have teachers develop evidence for the particulate model of matter. Teachers were asked to rely not upon the fact that they had “heard” there are atoms, but rather to investigate some phenomena and then describe and explain the physical phenomena at both the macroscopic and microscopic levels.

On the second day of the Institute, teams of teachers used graduated cylinders to measure 25 ml of isopropyl alcohol and then found the mass of this quantity. They did the same with 25 ml of water. After pouring the two liquids together in a cup, they were asked to pour the alcohol and water mixture back into the graduated cylinder to measure and weigh the combined solution. The teams of teachers were also asked to view four possible molecular models that would explain their findings:

- **Model 1:** Continuous liquids. This model proposes that matter is non-particulate or continuous. The implication of this model is that

the product will result in the same mass and the same volume as the parts.

- **Model 2:** Tightly packed particles. The implication of this model is that the particles are of the same size, with no spaces between them, and the product of the particles will result in the same mass and the same volume.
- **Model 3:** Loosely packed particles of different sizes. The implication of this model is that the particles have spaces between them and the smaller particles fit between the spaces of the larger particles. The mass would stay the same while the volume decreased.
- **Model 4:** Tightly packed particles with evaporation. The implication of this model is that the particles are of the same size, with no spaces between them, but there is evaporation from the surface. The volume would decrease as well as the mass.

The Fulcrum teachers were surprised at what they found. They all discovered that the combined volume was less than 50 ml, but the mass had essentially stayed the same. Listening to the different groups discuss their results and the reasons they chose a particular model provided insight into how the learners thought about the evidence; the same observed phenomenon did not lead the learners to the same molecular model. Each team interpreted the results differently.

Lisa, a teacher in Wareham explained her group’s conundrum, “We didn’t feel that there was a model that perfectly fit [our experience]. The closest one that fit evaporation, of the models that were there, was the loosely-packed [Model 3]-with-evaporation-model [Model 4] because of the bubbles that were released. The bubbles inside the graduated cylinder seemed to be uniformly distributed, which seemed more loose than compact. Compact bubbles would be all at the top or at the bottom, not evenly spread out.”

Renee, a teacher from Methuen and Lisa’s teammate added, “We ended up at about 48 ml. We could see condensation at that top [of the graduated cylinder]. We could see something had evaporated. If we had let it sit longer we would have seen more evaporation in the cylinder.” Other teams reported that they too had seen bubbles and what appeared to be condensation. All five teams in the room had witnessed a loss of 2-3 ml of volume, once the 25 ml of alcohol and the 25 ml of water were combined.



Explanatory disparity arose among the groups as they discussed their findings. In explaining the reason for the bubbles, one group saw them as red her-rings—just the result of trapped air caused by the mixing of the alcohol and water. Lisa’s group believed that the bubbles were the result of a chemical reaction and key in understanding why there was a slight loss in volume. If meaning is to be constructed by the learners, then it is important that all ideas are heard and discrepancies are addressed.

Peader, a teacher in Somerville, thought carefully before saying, “I am not sure that bubbles are indicative of evaporation. I think if you had seen evaporation, you would have seen a decrease in the mass. It’s hard to know exactly how accurate the instruments are, but there wasn’t a decrease in the mass when we combined the water and alcohol. We actually had a minor increase in the mass which I think is a reflection of the sensitivity of the instruments and our techniques, but I think if there had been evaporation you would have seen a decrease in the mass of the combined liquids. I know I saw the bubbles as well but I don’t know necessarily if the bubbles indicate evaporation.”

Peader brought attention to the difficulty of obtaining accurate results through experimentation. Science can be a messy process and one needs to be guided by clear models and relevant variables.

The role of the facilitator in the discussion is to ask a central question, redirect the discussion if needed, and encourage full participation. At this point, the facilitator steered the discussion away from the focus on the bubbles, “It seemed like there’s one group that’s committing to an evaporation model. Are there others who chose a different model to explain all of the things you saw today? You saw several things today. You saw you were able to compress the gas but not the liquid. Then you saw that when you mixed two different liquids you got a slight reduction in volume. Is there a model that can explain that in terms of the particulate model or



Peader Dooley mixes alcohol and water.

can help you make sense of that? Of the models we looked at?”

Mike responded, “We’re quite happy with saying that we had particles of different sizes. The smaller particles fit into the empty spaces between larger particles. And in working with the alcohol and water, we don’t know which one has the larger particles but one has bigger gaps in between so they can’t pack totally solidly.”

Ruth agreed, “That was Model 3.”

Cynthia hesitated, “We said Model 3 with a combination of Model 4 [because we wanted evaporation to be shown.]”

Shirley, a teacher in Shrewsbury, jumped into the conversation, “Not having lost the mass, we were thinking that the pieces were fitting together. (She interlocked her fingers of both hands before continuing.) We compared it to if we were using water and oil that wouldn’t blend, then we would have kept the same volume. We thought where these liquids did mix and we have the small particles fit in between the other ones, that would drop the volume down without losing the mass. We thought what would be a nice model would be just the blue pieces and just the red pieces sitting on top of one other not mixed together which would show liquids that wouldn’t mix like oil and water.”

“But that’s not what our water and alcohol did!” challenged Cynthia.

“Right, we had just the opposite,” Shirley continued, “but that’s where we had our loss [in volume] because they were able to meld together [the water and alcohol particles.] *What if* we did a different combination and they weren’t able to blend, then would it then keep it at 50 [ml] instead of going down to 49 [ml] or 48?”

Ellen came to understand Shirley’s reasoning, “Oh I see what you’re saying.”

Shirley presented a new pathway to Model 3. The importance of discussing ideas with peers is to provide new insights and explanations. Shirley’s mental imagery of how different liquids might behave and her gesturing with interlocking fingers are difficult to forget and help the science learners consider another perspective.

Judah Schwartz, the Principal Investigator of the Fulcrum Institute and visiting Professor at Tufts University continued to challenge the group, “In the spirit of *what if*, here’s a question you may want to think about. Do you think it’s conceivable to have 25 cubic centimeters of some liquid and 25 cubic centimeters of a different liquid and when added together would give you more than 50 cubic centimeters?”

Professor Schwartz's question caused a brief moment of silence and then a flurry of shared ideas. As one of the science experts in the room, he had listened to the discussion, imagined the mental models the learners had constructed, and then provided a challenging question. The discussion continued for another 20 minutes as the teachers shared their ideas in response to his intriguing question.

As Fulcrum Institute teachers experience firsthand, the value of classroom discussions and the use of models in making sense out of science investigations, they are encouraged to align their science teaching to an inquiry-based approach. The Fulcrum Institute encourages students to reason, question, and develop skills of scientific discourse. Using this framework, this "focused discussion with peers," students improve their own understanding as they share ideas and knowledge that benefits the entire learning community.

-Roxane Johnson-

Fulcrum Teachers: Invaluable Resources for Science Leadership

...I believe more strongly than ever in the power of teachers. This is because I have seen breathtaking teachers in action, and I have witnessed firsthand what they can achieve. I have also come to understand that teachers are not mere sponges, absorbing the dominant ideologies and expectations floating around in the atmosphere. They are also active agents whose words and deeds change lives and mold futures... Teachers *can* and *do* exert a great deal of power and influence in the lives of their students.

Sonia Nieto, p19
What Keeps Teachers Going? 2003

Sonia Nieto wrote *What Keeps Teachers Going?* to give public voice to the work and writings of several veteran teachers she had the opportunity to mentor in a study group supported by the Annenberg Institute. The book is dedicated to "all those teachers who keep going" and who demonstrate their commitment to young people and their school community each and every day. Reading the stories and writings of these talented teachers always helps me think about

what it means to teach, what it means to "lead" from the classroom. Reading the stories after working with the teachers in the Fulcrum Summer Institute in July, I find I can apply Dr. Nieto's words to the "breathtaking" teachers who participated in the Institute and who continue to hone their science learning, teaching, and leadership skills in their classrooms.

One of the goals of the Fulcrum Institute is "leveraging leadership in science education." If science teaching and learning are to improve in any authentic and lasting way, then the improvements have to come from the classroom teachers who endeavor to improve their own science content knowledge and develop lessons for their students which are centered around investigating ideas and phenomena that intrigue "real scientists." Each component of the Fulcrum Institute experience...the on-line courses, the summer labs and curriculum analysis, the opportunities to discuss questions with scientists...is designed to empower teachers to be effective science teachers and therefore, an invaluable resource for science leadership in their school.

In their final evaluations of the Summer Institute, teachers commented on how much they had learned and how enthusiastic they were about the work they had done together.

"The inquiry model of teaching is so effective. I now feel I am able to learn science confidently and with understanding."

"I feel much more confident in my ability to analyze curriculum and make adaptations for my students."

"Discussion is so important in clarifying one's own ideas and getting feedback to refine those ideas."

Whereas all the participants felt as though they were gaining confidence in their ability to learn and teach science effectively, several expressed being anxious about the idea of taking a leadership role in science in their school.

"Leadership is my least confident area; there are so many changes occurring in my school."

"I would like support in the leadership area. I'd like advice and ideas from other teachers who have more experience with this."

"I feel less confident in leadership because I really want to make a difference in my school and there are so many factors involved."

And then, there is this comment:

"As I sit here [completing this evaluation] I realize I can show leadership in my classroom with

my students. To give them courage to take a risk without fear of failure... [they will learn] that sometimes there are [different ways to understand phenomena] in science.”

Thinking about what it means to be teacher leader in science should lead one to reflect on Sonia Nieto’s description of teachers who truly make a difference in the lives of their students and colleagues. “They are also active agents whose words and deeds change lives and mold futures.” Teacher leadership in science begins in the classroom by modeling effective inquiry, sharing ideas for engaging investigations, and talking with colleagues about science. Teacher leadership in science begins in the classroom by informing parents and caregivers about the investigations going on in the classroom and the ideas that children have about air, molecules, habitats, electricity, energy and the sun. Teacher leadership in science begins by sharing student work in science and developing a way for teachers to talk together about the development of students’ ideas in science and the different ways they can demonstrate their understanding and learning.

The teachers in the Fulcrum Institute also model a very important leadership quality that is often overlooked in trying to define the role of the teacher leader. The participants are continuing to challenge themselves to learn more science content. They challenge themselves to “give a think” about complex ideas like “matter is constantly in motion” and what implications this has for understanding our world. As these teachers continue to grow and nurture their own intellect and interests, they model for their students and their colleagues what Nieto means by the “power of teachers.” Their willingness to learn as they teach, to guide as they discover, inspires us all to consider the energy, potential, and promise of teachers to truly improve the ways science is presented, understood, and appreciated, in our public schools.

-Linda Beardley

Principal Joins Teacher During the Fulcrum Summer Institute

The day I spent at the Fulcrum summer institute challenged me in many ways. Arriving that morning, I met Ruth, the Fulcrum teacher from my school and her enthusiastic peers. Meeting all the teachers eager to investigate complex scientific questions intimidated me as an English/social studies educator. Would I be able to offer anything to the group? How



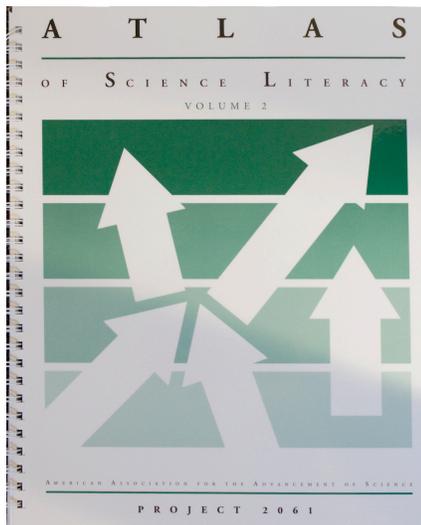
Overlook teacher, Ruth Crowley (center) works with colleagues Jason St. Clair (l) and Varsha Desai (r) while investigating the concept of equilibrium.

would my participation as an administrator benefit this assembly? It didn’t take more than a few minutes to become part of the group and to see scientific inquiry at its highest level. Everyone offered insights into the experiment. After the experiment, the teachers met with the professors and the conversations around what they had observed and the conclusions they came to illustrated, again, more inquiry. People had time to think and the wait-time was wonderful allowing deeper thoughts and ideas. I was impressed. This is how teaching/learning should happen. At lunch I sat with a middle school teacher, an elementary teacher and a high school teacher. All of them contributed to the discussions.

In our meeting with the other principals and administrators, we discussed how we could use these teachers in leadership positions in our schools. How could we envision them leading other teachers in this type of inquiry? Science and scientific method are all about hypothesis and inquiry as is authentic learning of any kind. In the days ahead, as we meet in content areas to examine programs and best practice, begin data analysis of our MCAS tests, and disaggregate MCAS scores, I hope that Ruth will take a leadership role in those activities. Another goal would be to encourage other science teachers in my school to take advantage of this wonderful opportunity. I will encourage other administrators, as the instructional leaders in their buildings, to participate in the Fulcrum initiative because it is a truly enlightening experience for teachers that will benefit all students.

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A Gift to Fulcrum Schools



In order to help Fulcrum Institute teachers plan and map their science curriculum during the Summer Institute, The Fulcrum Institute for Leadership in Science Education

gave each team of teachers Volume 1 & 2 of the Atlas of Science Literacy to take back to their schools and share with their colleagues. The Atlases were developed by Project 2061, a

long-term AAAS initiative to advance literacy in Science, Mathematics, and Technology. The Atlases are designed to help educators use the learning goals set out in Benchmarks for Science Literacy by providing conceptual strand maps that show how scientific understanding develops from Kindergarten to 12th grade. During the Summer Institute, teachers used these guides when analyzing the science curriculum they teach. The guides help teachers make decisions about effective ways to teach scientific “big ideas” across the grades in their school. Please share them!

To learn more about Project 2061 and the Atlases for Science Literacy please visit:

<http://www.project2061.org/publications/atlas/default.htm>

