Teaching Sensible Science

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with contributions from Michael D'Aleo, Lilli Anthon, and Barbara Richardson

What is the nature of sensory impressions, and what are the resulting relationships by which we develop an understanding of the world and of ourselves? These questions lie at the heart of comprehending a phenomenological approach to science, which we are exploring in depth in a new course for elementary school teachers of grades 5–8 in Waldorf schools.

The course was envisaged two years ago by Michael D'Aleo, high school science teacher at the Waldorf School of Saratoga Springs, researcher with the Saratoga Experiential Natural Science Research Institute (SENSRI), and co-author of *Sensible Physics Teaching*. The course arose from a conversation between Michael and Douglas Gerwin, Director of the Center for Anthroposophy. The Research Institute for Waldorf Education, SENSRI, and the Waldorf School of Saratoga Springs sponsored the first cycle of course during.

Michael's experience showed the need for a three-week course in order to allow enough time for class teachers to be confident with the methodology underlying a sense-based approach to science teaching and to explore the breadth and depth of the physical science curriculum. Each week was devoted to experimental topics for each of the three upper elementary school grades. The first week took place in March 2005, the second at the end of June, and the third over a long weekend in October. A format of this length also allowed teachers to try out the approach in their classrooms and return with fresh ideas and questions.

Gary Banks and Lylli Anthon were chosen to present experiments and lead discussions about practical aspects of the method. Lylli was also asked to lead the group in exploring ways to render experiments artistically through writing and drawing. Gary has a background in aerospace engineering sciences. He taught a class from first through eighth grade, taught high school science, and began a new first grade in 2004. In her 25-year teaching career, Lylli began by leading a class through eight grades and has taught middle school for many years. Barbara Richardson was selected to lead eurythmy because of her background in Eurythmy in the Workplace and as a class teacher. Eurythmy was added to the course as a way to further explore the nature of experience and working together and to enliven our full days of discussion and experiments.

The fifteen teachers who signed up for the course were all actively teaching in Waldorf schools in every grade from third to eighth. Many were from New York and New England, while some came from as far away as Washington, D.C., Minnesota, California, and Canada. A few already had a bent toward science, while others came more from an artistic background.

As a beginning, participants described their own relationships to science. Some recounted how they had loved science as students, often through the inspiration of an interesting teacher. Others related that they had horrible experiences of science as students, and these negative experiences left them feeling unprepared and apprehensive about teaching science. Several teachers had already taught science, and each one of these was enjoying the experiential approach to the curriculum.

Our mornings were filled with discussions of epistemological questions led by Michael D'Aleo. These sessions covered a range of topics, from the nature of sense experience and how we form concepts of our experiences to the roots of materialism in our age.

Michael's talks were punctuated by interesting examples taken from his experience as a mechanical engineer in the electronics industry. In his first presentation he told a story about an engineering graduate he had interviewed for his engineering group. Fresh out of college, the young man had performed brilliantly whenever he was asked to make a calculation. But when asked to identify the metal out of which pennies are made, he could not. When asked to identify a resistor, one of the most basic components of an electronics device, he was befuddled. After four years at one of the best engineering schools in the country, he had no connection to common elements and components of modern technology. For Michael, this illustrated a common shortcoming in science and engineering education, which tends to emphasize theoretical and mathematical models rather than actual experience.

The intention of the morning sessions was to ensure that the course participants developed a clear understanding of the distinction and rightful role of sensory impressions—observations—and conceptual relationships as the foundation for understanding any scientific experiment or even mundane experience. Our present times are filled with concepts that are presumed to have phenomenal qualities that are not, in fact, sensory based. An example of this is the common understanding that heat is an object-like entity that can be transferred between objects. Nothing is actually transferred, but we experience that when a warm object and a cool object are brought into proximity, the warm object cools and the cool object warms.

Such sensitivity to language may at first seem unnecessary. Reliance upon non-sensory, hypothesized objects as causal entities for all phenomena, however, limits students to a 19th Century view of physics and the world. Such a view can also give student and teacher the impression that the world is "not as it appears" and that they can no longer rely upon their sensory impressions and the concepts they develop. Such a view encourages alienation from a world that can never be "truly" known.

By using language that focuses on relationships between sensory impressions, students have the foundation for understanding modern field theory, which is more relationally based and no longer relies on the object-like entities of older models. Additionally, teachers and students practicing this approach build a deeper connection to the world and to other human beings by developing a more subtle sensitivity to their own sense impressions and to the activity of finding relationships.

Participants in the course remarked that, although they had received an overview of the content of the science curriculum in their Waldorf teacher training and in summer courses, they were unfamiliar with the nuances of the phenomenological approach and the use of language in forming concepts. There was a universal sense that the morning sessions led by Michael prepared the way for a deeper understanding, and it was clear that practical experience with the approach would be key to intensifying our preparation.

Unexpectedly for some, eurythmy provided a first means of deepening our method. The eurythmy sessions, occurring twice each morning, were integrated into the themes from other sessions. Doing eurythmy helped us get to know each other, brought us life forces, helped us be alert, centered us in ourselves, and helped us to find ourselves in the group. Eurythmy also prepared us to perceive and observe in a new way. One of the poems we worked with during the second week spoke to the mobility of perception we found ourselves developing.

The hand moves
And the fire's whirling
Makes different shapes.
All things change when we do.
The first word, "Ah!"
Blossoms into all words.
Each of them is true.

– From "Singing Images of Fire,"
Kukei, 8th c. Zen Master

Throughout the course, all of us, participants and presenters, were grateful for the expertise and skillful weaving of themes Barbara provided and for the true refreshment and rejuvenation we experienced through eurythmy.

The afternoon sessions were spent exploring the experiments that form the heart of the elementary school science curriculum. Each week was formed around the physics curriculum of a particular grade, starting with grade six. Gary and Lylli performed new experiments each day but waited for discussion of them until the following day, as practiced with our students. The second week also saw the addition of the chemistry curriculum of grade seven, led by Gary in evening sessions.

Many teachers face an intimidating obstacle in setting up experiments, especially in developing schools where materials may be scarce. Experiments in physics and chemistry involve unfamiliar equipment, and more complicated experiments often require special conditions and careful preparation. Safety is also a genuine concern that American schools cannot ignore. Long experiment sessions and the hands-on approach allowed participants to become more confident with this practical aspect of teaching science phenomenologically.

As we discovered in our first meetings, however, setting up and conducting experiments is not the only obstacle to teaching well. The way we form concepts with students about experiments before and during our classes ultimately determines whether or not our teaching is healthy. We are faced with the challenge of recognizing and often overcoming our habituated patterns of thinking.

A first experiment was a testimony to this. In this experience, appropriate for a grade six introduction to thermal physics, participants felt five different objects in the room and noted their thermal characteristics. The objects were a blackboard, a metal music stand, a piece of glass, a wooden desk, and a piece of carpet. We ranked them according to how hot or cold they felt, noting at the same time how some of them warmed over the course of the experiment.

After sleeping on the experience we returned for a discussion the next afternoon. We noted how we had conducted the experiment and then characterized the results. Everyone agreed that some objects felt warmer and some cooler. There was some variation in the way we ranked the order from warm to cool, but all agreed that the carpet and wooden desk felt warm and that the blackboard and piece of glass felt colder.

Difficulties arose when we tried to understand why these objects did not all feel the same. One would hardly think that so simple an experience would warrant much discussion, yet an hour and a half later we were still discussing the experiment passionately. Preconceived notions kept creeping in. One participant was finally able to articulate the problem: she believed that the objects were all at different temperatures. We pointed out that, even though it was late winter in upstate New York, all objects were in the room and therefore must have been at the same temperature. We even measured the temperature of each object with a thermometer to demonstrate this. It was shocking for her to realize that she had already superimposed a concept on the experience. Further, until she could escape the trap of her concept, she could not explore the actual experience any farther.

A great deal of frustration also arose out of this discussion—"Why don't you just tell

us the answer?" Through this we learned that the discovery of our own answer has more meaning than any answer given by an outside authority. The presenters fell into the role of being identifiers of preconceived notions—concepts—that did not connect with the experiences—percepts. The medium for this discovery was language, and in each experiment we carefully crafted the language that would help us form living, meaningful concepts. We carefully avoided model-based explanations that were not verifiable through the experiment itself. The goal of each dialogue was to reunite concepts with percepts. This took time, and the first half of our afternoons was filled with discussions of the previous day's experiences and presentation of new experiments.

Later in the first week we did a classical physics demonstration in which a thin steel wire, hung with weights at either end, passes through a solid block of ice over a period of several hours, leaving the ice in a single piece at the end. During the recapitulation of this experiment, the frustration that teachers feel at leading a dialogue with students became apparent. "How do we conduct a presentation and come to meaningful conclusions without forcing them upon our students?" One teacher bravely noted that he did this experiment during his internship when he was in training. The discussion started going awry, and the students just weren't getting it. In a moment of near panic, he blurted out, "I'll tell you what it is. It is PSI, pounds per square inch!" The mentoring teacher at the back of the room shook his head vigorously from side to side and buried his face in his hands. In retrospect, he could find humor in this situation, but at the time, it represented a crisis of soul for the presenting teacher.

Many new and even experienced teachers feel such a moment of panic and all too easily fall back on the security of the concepts they learned in school or read about in preparation for teaching a course. Science teachers in particular are expected to have a level of expertise for which many are unprepared. To live into the phenomena and to form vibrant concepts directly out of those experiences, this creates the antidote to teacher panic.

Sometimes, waking up to our habitual concepts takes a bit of a shock. At several key moments in our discussions participants kept repeating what they thought should have happened. In leading the discussion, Gary repeated dramatically, "It does not matter what you think happened or what you think should have happened. What was your experience?" A class teacher who does not have a formal scientific training but who can penetrate the phenomenological approach has the tools to provide an excellent science education in elementary school. In fact, through disciplining oneself in this practice, new discoveries can be made. There were many such moments in the training when, through our openness to the experiences, we uncovered new and unexpected aspects of the phenomena.

To stimulate greater confidence in living into the phenomenological approach, participants were invited to prepare experiments and present them, and also to lead discussions. In teacher training and in our faculties we often don't take the time to do such model teaching, and we can feel intimidated by the prospect of making a mistake or being unclear in front of our peers. Michael put us at ease by reminding us, "This is the cheapest opportunity in which to make a mistake."

Over the three week-long sessions we came to realize what is required to help a discussion about an experience proceed without being too leading or "teacherly" about it. When we have conclusions fixed too rigidly in our own presentation style, we rob students of the essential activity of their own discovery of the concept. In this context science education can either take on a deeper meaning and connect the students to their experience or become a means of merely imposing concepts without actual experience. We came to realize that how we as teachers lead a discussion

about an experiment determines whether the individuality of the child can begin to unfold. In retrospect, many participants expressed gratitude at the wisdom of carrying the "Teaching Sensible Science" course through three weeks, time sufficient for us to begin to transform our habitual ways of expressing ourselves to our students.

During the second week, we recreated and discussed many of the most challenging experiments of grade seven physics and chemistry curricula, including a lime kiln, a camera obscura, and a Voltaic pile. Throughout this week we noted how the discussions flowed more easily and how all participants became more versed in avoiding misleading language and conceptual traps.

The course presenters recommended working with some experiments between the sessions to become more proficient in this approach. Two of the course participants who teach at the same school took up this suggestion by starting a weekly half-hour study, open to the whole faculty. In these sessions, they focused on observing a particular experiment and forming meaningful concepts about it. We found this to be an inspirational example of how we can expand our work with the phenomenological method in our schools.

Lylli provided a unique presence in the course, namely as a model of what a class teacher without a formal scientific training can accomplish by using this method. Lylli conducted experiments, led discussions, and led sessions in the later part of the afternoons that resulted in a record of the experiments we had performed. Her gift was to help us understand how a teacher can develop the ability to capture the essence of the experiences.

Further, Gary Banks' contribution to the course was considerable. One participant wrote, "During our afternoon sessions and experiments, Gary was able to validate our sense experiences by guiding us with carefully formulated questions. This facilitated our grasp of appropriate thought processes. All our experiences during the experiments captured his interest, and no question was too simple or too basic. This gave us a profound sense of the key elements that have been brought forward for teaching the sciences in the sensible way—phenomenologically. His encouragement and patient guidance are models to us all, as we stand before our students each day." [1]

On Wednesday afternoon of the second week our topic was water. For this study, Michael took us to the Adirondacks. We gathered for informal conversations on the porch of his recently constructed log cabin while waiting for a soft and peaceful rainstorm to pass. Besides giving us some much-welcomed relief from the oppressive heat earlier in the week, we enjoyed forming closer connections with each other.

Following the rain, we hiked to the base of a waterfall on a clear mountain stream where we observed the patterns and currents in the water, an activity we repeated on Thursday at Saratoga State Park. On reviewing these and other observations of water, we came to see that observing water could become a metaphor for moving into the middle school, where mobility and change are constant themes. One participant's response, written after the next eurythmy session, was a short poem:

A pool in sight
Just water and light,
Swirling, whirling,
The present unfurling.

Michael left us with a wonderful question to ponder as teachers: Like water, do you have the mobility to go anywhere without being pushed anywhere?

In the third session in October, the group gathered for five days to focus on grade eight physics and chemistry. We followed a similar format to the other sessions with epistemological discussions and eurythmy in the mornings and experiment sessions in the afternoons and evenings. We sensed what a deep-

ening had occurred in the ability for the participants to suspend judgment, observe deeply, and think imaginatively about the phenomena we were exploring. The experiments involved refraction, prisms, electromagnetism, and the electromagnetic motor.

The eurythmy sessions worked with verses by Romantic poets such as Wordsworth, Shelley, and Blake, who had the remarkable ability to live deeply into an experience of nature and relate it to human soul experiences. Over two days, we created eurythmy forms in groups to lines of Shelley's *Ode to the West Wind*:

> Make me thy lyre, even as the forest is:
> What if my leaves are falling like its own?
> The tumult of thy mighty harmonies
> Will take from both a deep autumnal tone,
> Sweet though in sadness. Be thou, Spirit fierce,
> My spirit! Be thou me, impetuous one!

These final two lines speak to the solitary experience of the Consciousness Soul, that aspect of our souls that we must call on as we approach phenomena in a living, meaningful way and seek to present them to our students.

Our final activity together was to revisit a pond we had observed during the first week. In silence and alone, yet with a united intention, we stilled our thoughts and observations as we entered into this activity. With a new consciousness, we could observe the buoyancy of the ducks as they bobbed with their heads down in search of food, the apparent lifting of the pond bottom through refraction of the water, and the lively impressions of reflected images in the gently rippling water of the pond.

In this way, we came away from our three weeks of "Teaching Sensible Science" with new confidence in the phenomenological approach to teaching science in the Waldorf elementary school grades, a confidence we hope to spread to the remainder of the faculty in our schools. We left after the final week hopeful that the phenomenological approach can extend far beyond the classroom to inspire an attitude toward life based on sensory experience linked with thoughtful insight.

"Teaching Sensible Science" was conceived following discussions among the circle of AWSNA delegates in which was recognized the need to strengthen science teaching in the Waldorf school movement. A second session of the course will be presented in 2006, again in Saratoga Springs. The dates of the course are February 25–March 3, June 24–30, and October 4–9. Further inquiries about the course may be directed to one of the course presenters or to the Research Institute (researchinstitute@earthlink.net).

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