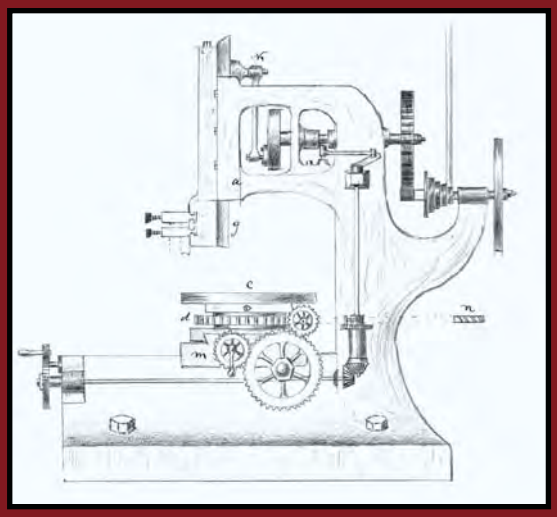
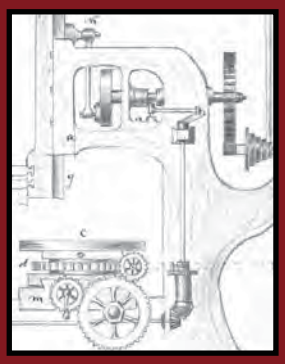
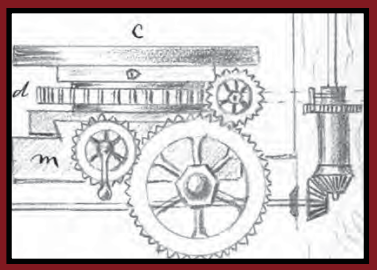
Colloquium on Physics







AWSNA
Research Institute for Waldorf Education
March 2009

Work in Progress

Research Project #11

Proceedings

Colloquium on Physics

Sponsored by

Rudolf Steiner College

Research Institute for Waldorf Education

and

The Waldorf High School Research Group

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Research Project #5: Proceedings of the Colloquium on Life Sciences and Environmental Studies
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Research Project #8: Proceedings of the Colloquium on United States History
Research Project #9: Proceedings of the English Colloquium
Research Project #10: The Power of Grammar
Research Project #11: Proceedings of the Physics Colloquium

Title: *Proceedings of the Colloquium on Physics*

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Research Institute for Waldorf Education

The Research Institute for Waldorf Education is an initiative working on behalf of the Waldorf school movement. It receives support and guidance from the Pedagogical Section of the School of Spiritual Science and financial support through the Association of Waldorf Schools of North America (AWSNA), the Midwest Shared Gifting Group, the Waldorf Schools Fund, the Waldorf Curriculum Fund, and private donors through the Rudolf Steiner Foundation.

The Research Institute was founded in 1996 in order to deepen and enhance the quality of Waldorf education, to engage in serious and sustained dialogue with the wider educational-cultural community, and to support research that would serve educators in all types of schools in their work with children and adolescents. The Research Institute has responded to the call for research as a top priority of the Waldorf school movement by becoming a supporting organization of AWSNA and by co-sponsoring research projects with the Association and with the Pedagogical Section.

The Research Institute supports research projects that deal with essential contemporary educational issues such as the role of play in early childhood, attention-related disorders, trends in adolescent development and innovations in the high school curriculum, learning expectations and assessment, computers in education, the role of art in education, and new ways to identify and address different learning styles. The Research Institute has sponsored colloquia and conferences that have brought together educators, psychologists, doctors, and social scientists. The Research Institute has published the *Research Bulletin* twice a year for the last decade, and we are developing and distributing educational resources to help teachers in all aspects of their work. We sponsor the Online Waldorf Library: www.waldorflibrary.org, whose mission is to make available contemporary writings on Waldorf education, and we host our own site: www.waldorfresearchinstitute.org, where up-to-date research is posted.

The Waldorf High School Research Project is under the auspices of the Research Institute, which is a 501(c)(3) tax-exempt organization and gratefully accepts donations.

WHSRP Mission Statement

Formed in August 1998, the Waldorf High School Research Project is charged with strengthening the Waldorf high school movement by creating an updated picture of adolescents today and stimulating curriculum development within the Waldorf high schools.

As a designated committee of the Association of Waldorf Schools of North America (AWSNA), the Planning Group of this project is specifically responsible for

- identifying and articulating changes in the needs of North American teenagers
- formulating research questions concerning adolescence; commissioning qualified educators and other professionals to undertake research into these questions
- sponsoring subject colloquia as well as conferences on adolescent development and needs for those working in Waldorf high schools
- preparing North American conferences for those working in Waldorf high schools – to share and deepen research; to stimulate dialogue; to activate meaningful change for youth in the twenty-first century
- developing publications and other media resources to assist those working in Waldorf high schools
- stimulating Waldorf high school educators to examine and strengthen their programs
- seeking funds to support the commissioned research, colloquia, publications, conferences, and follow-up initiatives in the Waldorf high schools in coordination with AWSNA Development in line with the overall AWSNA priorities.

Schedule

Colloquium on Physics

Rudolf Steiner College, Fair Oaks, CA
16–19 October 2008

THURSDAY 16 OCTOBER

6:00 P.M.	Dinner
7:00 – 7:30	Introductory remarks and announcements
7:30 – 9:00	"*Where Are We Coming From?*" (Michael D'Aleo)

FRIDAY 17 OCTOBER

8:00 A.M.	- - - Breakfast - - -
8:45 – 9:30	Eurythmy (with Ruth Bucklin)
9:30 – 10:30	*"The Visible and Invisible: Electricity and Magnetism as the Interaction of Qualities Rather than the Creation of Pseudo-Phenomenal Entities"* (Michael D'Aleo)
10:30 – 11:00	- - - Break - - -
	Eurythmy (with Ruth Bucklin)
11:00 – 12:30 P.M.	Discussion
12:30 – 2:00	- - - Lunch - - -
2:00 – 2:45	Eurythmy (with Ruth Bucklin)
2:45 – 3:45	*"Building Machines: Putting into Practice What Students Have Learned"* (Paolo Carini)
3:45 – 4:00	- - - Short Break - - -
4:00 – 4:30	Eurythmy (with Ruth Bucklin)
4:30 – 6:00	Discussion
6:00 – 7:30	- - - Dinner - - -
8:00	Round Table Discussion: "*Why Do Young Waldorf Teachers Burn Out?*"

SATURDAY 18 OCTOBER

8:00 A.M.	- - - Breakfast - - -
8:45 – 9:30	Eurythmy (with Ruth Bucklin)
9:30 – 10:30	*"Successes and Challenges in Teaching Phenomenological Physics"* (Geoff Robb)
10:30 – 11:00	- - - Break - - -
11:00 – 12:30 P.M.	Discussion
12:30 – 2:00	- - - Lunch - - -

2:00 – 3:00	Robotics (James Madsen)
3:00 – 3:45	*"Sustainabilty and the Applications of Simple Technologies in Our Everyday Lives"* (Brian Gleichauf)
3:45 – 4:00	- - - Short Break - - -
4:00 – 4:30	Practical work with a Hydraulic Ram
4:30 – 5:00	- - - Break - - -
5:00 – 6:00	Eurythmy (with Ruth Bucklin)
6:00 – 7:30	- - - Dinner - - -
8:00	Round Table Discussion "*Preparing Our Students for College*"

SUNDAY 19 OCTOBER

8:00 A.M.	- - - Breakfast - - -
8:45 – 9:30	Eurythmy (with Ruth Bucklin)
9:30 – 10:30	*"How Do We Carry Forward?"*
10:30 – 11:00	- - - Break - - -
11:00 – 12:00	Wrap-up discussion, appreciations, and reflections
12:00 noon	- - - Lunch - - -

Colloquium Participants

Front from left: Beth Wiseburn, Fred Bassett, John Petering, and Hezi Haut.
Second Row: Jeff O'Brien, Ruth Bucklin, Brian Gleichauf, Rick Malone, Paolo Carini, Geoff Robb, Michael D'Aleo, Tara Wyman, Amber Proaps
Back Row: James Madsen, Bob Pickering

Introduction

by

Michael D'Aleo

First of all, it's great that there are so many people here. I know there was significant travel involved in getting here. I must say that when I spoke with people about attending this conference, many of you asked, "What is this colloquium going to be about?" I wrestled a lot with what this colloquium could be and also listened to the input of many other people. My sense is that this physics colloquium has a strong relationship to the chemistry colloquium that took place in March of 2008 at Lexington, Massachusetts. I would like to open this colloquium with the suggestion that we consider three important intentions in our working together.

All of us are scientists—physicists, physical science teachers and a few of you have biochemistry degrees. It would be very easy to jump into the nuts and bolts of what we do, which could be of great interest. But I'd like to suggest to you that there are larger opportunities. One opportunity is to make sure that we are seeing what we are teaching our students within a larger context, so that it will lay the groundwork for a deeper understanding in the future. We can ask the question, why in Waldorf education aren't the sciences taken seriously, and understood? In Steiner's autobiography, he described what had a lasting impression on him in his early education. It was geometry and life sciences that made a lasting impression on him, not the arts or the subtle understanding of the human being. The sciences were the most inspiring elements of his classical educational life. It is important to put that out front and center—Steiner was a scientist. We might come to a larger picture of this later.

In Steiner's lecture cycle entitled in English, *Education as a Force for Social Change*, we come to chapter 6, a lecture he gave just before leaving for Stuttgart, Germany, to begin the teacher training with the teachers at the soon-to-be founded Waldorf School. It was the last lecture he gave before he gave the lectures cycles we know as *The Study of Man*, *Practical Advice to Teachers*, and *Discussions with Teachers*. Two key points that Steiner gave in this lecture: First, intellectualism is present in science today. He uses the word intelligence to describe that type of knowing most often focused on in science, not wisdom. He is making a distinction between what was translated as intelligence in the English language and a higher knowing. His second key point is that if the individual human being isn't successful in expressing his or her individuality, his or her own unique means of knowing and creating a relationship with the earth and cosmos, then humanity has missed one of the main intentions of earthly evolution.

Key intentions

1st I am hoping that this colloquium will allow us to look at a variety of expressions of being human through the experience of physics.

2nd Each of us should hear the approaches presented by individuals and decide for ourselves the appropriateness of that approach. We should not leave here with a standard physics curriculum (Waldorf or otherwise). I think there can be a variety of approaches that can be successful, but I think we can leave it to each individual teacher to decide what is appropriate. There may be more than one truthful expression of a concept, but not all expressions of a concept are necessarily truthful. We can discuss and really work through some of these things, but I don't think we need to come to an agreed upon goal for each specific experiment or concept.

3rd Listen to each other, be willing to hear and receive comments and suggestions, and each person will experience that there will be time to respond and be understood. Have that sense even if someone is bringing an oppositional view that we don't need to hurry through it, but be open to it so we can weigh and discuss it.

Perhaps we could describe the overall goal of this colloquium as being one in which we understand the world of physics and see how it applies to our students in their everyday experience of their lives. To be successful as a teacher, I must have a sense for why the students in my class should want to be there participating in experiments, demonstrations and listening to each other speak about principles of the world that we term as physics. Unless it bears some relation to their existence as human beings, all of our lessons are for nothing.

The intention for eurythmy—finding a way to harmonize our individualities, and harmonize with other styles. At the school where I teach, the Waldorf School of Saratoga Springs, I choose a theme for the year that I am individually working with, which also rose out of preparation for this conference—how can we work as free human beings and not let our work prevent other human beings from doing their work? Can we work out of our own initiative and be worked with in a way that won't prevent another from taking initiative? In thinking about that more, we do have different levels of experience as teachers. We all start where we are. It's not about how many years we've taught. But in the end we all have to assess what we will teach, why we are teaching it and how to bring it to the students in such a way that it becomes part of a student's own experience of the world.

The poet David Wagoner interviewed many Native American elders, primarily of the Pacific Northwest. He took their stories, worked with them, and tried to turn them into verse form that would be meaningful to people in our Western culture today. Having read his work and worked with it for a bit, I have to say, I haven't been disappointed. I was reading one of the poems on the flight here and my understanding shifted a bit in working with one specific poem. About two to three weeks ago, I gave a lecture at the Halton Waldorf School in Ontario Canada on the phenomena-based approach to science. At the end of the lecture, I asked if there

were any other questions. A woman spoke up and by the nature of her question, I immediately recognized that she had understood how this approach to science meets the Native American approach to the world – she was member of the Iroquois and specifically the Mohawk Native American tribe which originally lived in the area surrounding the city I live in at Saratoga Springs, New York. There was an immediate recognition in what this women said that what is in Waldorf education was harmonic with traditional native cultures. Also present at this lecture was a self-proclaimed skeptical father, a businessman in the engineering field, with whom the lecture also resonated. I spoke with each of these people individually after the lecture. Note: There were two different conversations with two different people, but one central approach to the world met them both. One of the keys to understanding many of the Native America languages is to experience that many of what we call nouns are experienced by them as verbs or adjectives. Everything is much more relational in these languages. When I asked this Native American woman about this quality of their language, she replied, "Yes, that is true." She then responded with a question herself. "What is in Waldorf education that is so healing and still so contemporary?" It is the synthesis of these approaches, through the experience of physics and the physical sciences, that we are here to work on during these few days.

A poem was read from David Wagoner's book, *Who Shall Be the Sun?* (Indiana University Press, Bloomington, Indiana, 1978).

Old Man, Old Man

Young men, not knowing what to remember,
Come to this hiding place of the moons and the years.
To this Old Man, Old Man, they say, Where should we go?
Where did you find what you remember? Was it perched in a tree?
Did it hover deep in the white water? Was it covered over
With dead stalks in the grass? Will we taste it
If our mouths have long lain empty?
Will we feel it between our eyes if we face the wind
All night, and turn the color of earth?
If we lie down in the rain, can we remember sunlight?

He answered, I have become the best and worst I have dreamed.
When I move my feet, the ground moves under them.
When I lie down, I fit the earth too well.
Stones long under water will burst in the fire, but stones
Long in the sun and under the dry night
Will ring when you strike them. Or break in two.
There were always many places to beg for answers:
Now the places themselves have come close to be told.
I have called even my voice in close to whisper with it:
Every secret is as near as your fingers.
If your heart stutters with pain and hope,
Bend forward over it like a man at a small campfire.

Stephen Edelglass, Ron Brady, Georg Maier and Hans Gebert were people who have inspired many of us, perhaps we can hear their voices in the second half of this poem.

So my hope is that, over the course of these three to four days, over a campfire of rich sharing, we can take with us elements that can help/inform the larger group. If we are all striving toward higher consciousness of understanding, if the dream I have that perhaps some day in the future, when our students from different schools will work together, because they had different teachers who brought them different experiences in different ways, they will find they benefit from sharing with each other. The contrary would be that they, all having had the same common background, find they have nothing to learn.

Michael D'Aleo

Ruth Bucklin and Amber Proaps

Discussion #1:
Where Are We Coming From?

Michael:

I am imagining that the presentations won't take the whole time. My sense is to have the presenters put some things out there, then have a real discussion and really try various approaches. I think the discussion is as important as the presentation. When I planned the first one-hour presentation, in the second hour I imagined this was a time for everyone to speak. I have tried to put very different topics together, building on Stephen Edelglass' approach to phenomenology … another is building machines, and being very hands on. Jeff wants to put some thoughts out there such as: What are the struggles of a phenomenological approach to physics? When we get to the presentation, my hope is that the conversation will start from the presented content and then expand out. Especially in the evening, we can take the conversation even further as people feel the interest and the need. If we want spontaneous conversation, that's what the evenings are for.

Paolo:

My basic concern is that we don't get side-tracked much on content. More than the content, the pedagogical question is crucial: WHY do we do this. It is not what we're doing that matters, but it is the WHY that matters. Are we agreeing that anyone can play that card at any time?

If we're going to bring up content, bring up what the pedagogical value will be. What I am eager for is not new ideas, but why we are doing what we are doing.

Is there any value in sharing any of the failures? Rhetorical questions? Things that blew up in your face and why? I don't know, I'm asking. We have a total of 812 years of teaching experience in this room.

A pedagogical concern is as important as a practical one. Practically it might be okay, but pedagogically it wasn't worth doing. I've got seven years I've been trying this, then figured finally it was pointless to do.

Betty Staley

Geoff Robb, Fred Bassett, James Madsen, Paolo Carini

Fred Bassett and Hezi Haut

Amber Proaps, colloquium scribe

The Visible and Invisible: Electricity and Magnetism as the Interaction of Qualities Rather than the Creation of Pseudo-Phenomenal Entities

by

Michael D'Aleo

I would like to begin with a passage from Steiner's *Anthroposophy (A Fragment)*:

> But this is the only way we can consider things and beings of the world. We must necessarily state whatever we are capable of saying about them as views that hold from different vantage points. This is the case not only with regard to observing things with our senses; it is also true in the spiritual domain—although we must not let ourselves be led astray by this comparison and imagine that differences in points of view in the latter have anything to do with spatial relationships. Every view can be a true view if it faithfully reproduces what is observed. It is refuted only if it is proved to be legitimately contradicted by another view *from the same perspective*. That it differs with a view from a different perspective generally means nothing. Taking this position safeguards us against the insubstantial objection that in such a case every opinion must necessarily appear justified. When we see the tree from a specified vantage point, our image of the tree must have a particular shape; similarly, a spiritual view from a specified perspective must also have a particular form. It is clear however, that we can demonstrate an error in view only if we are clear on its perspective. [*Note: Emphasis is as it appears in the book.*]

From my perspective, there are two key extremes Steiner protects against in this essay. The two extremes are:

1) Dogma –There is only one perspective

and

2) Relativism – I am okay, you are okay—all views are justified.

What is being pointed to here is not a truth that is determined by only logic, but rather, one that is looked at in context and has truth only from a given perspective. If the perspective is a broad one, the truth has wider application. If the perspective is a narrow one, the truth is true for only a smaller set of conditions.

Note that not all views are true according to Steiner's statement. The key to assessing a view is to ask more questions of the person stating the view. Once you are clear on that person's perspective, then and only then can one can assess the truthfulness of the statement. From my perspective this weds truthful striving with an interest in the other. Those who are uncomfortable having questions asked about their view or uninterested in hearing the views of others actually inhibit this process.

It is my hope that working in the manner described above will allow us to have multiple perspectives. If a different view arises, let's clear it up, investigate its truthfulness and move on. I'd like to reread the poem I read last night, "Old Man, Old Man," (on page 13). I found this incredibly helpful as a scientist. The old man is essentially saying, "The answer is in here [Michael points to his heart as he says this]—in different relationships between the human being and the world." He differentiates between a simply material investigation of the world and a soul investigation that is penetrated with spirit. The poem below is also special.

Working Together

We shape ourselves
to fit this world

and by the world
are shaped again.

The visible
and the invisible,

working together
in common cause,

to produce
the miraculous.

I am thinking of the way
the intangible air

passed at speed
round a shaped wing

easily
holds our weight.

So may we, in this life
trust

to those elements
we have yet to see

or imagine,
and look for the true

shape of our own self,
by forming it well

to the great
intangibles about us.

– "Working Together" from *The House of Belonging* by David Whyte

The poem we are using in eurythmy, on the preceding page, is the poem I use for the Electricity and Magnetism block. The 11th grade theme is The Visible and Invisible Working Together. If students have any experience at all in this course it should be the line, "The visible and the invisible, working together in common cause to produce the miraculous." The students should walk away from this course with that experience. In order to teach the invisible, we have to link phenomenal impressions without linking them to a physical cause. This is precisely what Stephen Edelglass spent a good portion of his teaching career investigating.

We can have a sensation, such as an image of a hologram, without there being a corresponding tangible object as a counterpart. As we will see, we can also have this experience with senses other than sight. What Stephen was so passionate about was that what we conceptualize, say, an object-like entity such as the billiard ball model of the atom, as if it were a sensible phenomenal entity—you don't actually touch it, you don't see it visually. We give it a conceptual basis as if we could sense it without actually having experienced it with any of our basic sensory qualities. At this moment we create what Stephen liked to call a pseudo-phenomenal entity. We postulate the existence of an entity with the standard phenomenal impressions of touch and sight without actually having the sensations. This is a kind of trick we play on ourselves, creating a concept of an object because we are comfortable with that type of concept. The fact is that such a pseudo-phenomenal entity has no truthfulness as a concept for electrical phenomena today. Among good conventional physicists, the concept of the electron as an "object-like thing," as a causal agent of electricity, is simply simplistic and wrong. This is the key to the Electricity and Magnetism block from my perspective. How can we help our students have the same imagination as Michael Faraday, who never postulated the existence of a material causal agent when working with electromagnetic phenomena? This is huge. From my perspective this possibility of a nonmaterial view was Stephen Edelglass' gift to Waldorf education. Before he passed away unexpectedly about 8 years ago, he made a couple of statements which have been living in me and I finally feel I understand what he was driving at. I believe it has tremendous implications.

I am now going to give you the concept at the beginning, before the experiment, the opposite of what we do with the students. I will show you how it's done after, and then we can investigate the concept and the phenomena. The statement Stephen made was: "All electric phenomena interact in such a manner that it reduces the strength of the imbalance in the created situation."

One of the few things I have really held onto that Goethe said (it can be found in *Nature's Open Secret*) is that the fundamental phenomena of life is essentially "polarity and intensification." Polarity is an incredibly important starting point—the quality implies relational—the place where electric phenomena start. I'd like to walk through a couple of demonstrations quietly and have you observe and form the concepts you normally form, and suggest how you can go about them. I'll try to do it slowly and carefully enough so that I don't make any assumptions about what condition will create the phenomena and what conditions will not.

Bob Pickering

Geoff Robb

Fred Bassett

The day was over but the conversations continued.

Demonstration #1

This is 2 or 3 days' worth of demonstrations all combined into less than an hour's time.

These interactions have lawfulness. Within five days of this block you can sit down and explain some of the most simple but subtle electrical phenomena that only became public about four years ago, that it has been used in the past to create the American stealth bomber. In fact, its low radar signature was only one part of its secretive development. The other that we are interested in here is that it is able to fly "electrostatically" with a calculated 35% reduction in the conventional forces of lift and thrust because of electrostatic conditions that are generated across the aircraft. It was initially published in a book by Nick Cook, *The Hunt for Zero Point* (2001). It was later written up and published as part of a news story on CNN. When one of the companies alleged to having developed this work was asked by CNN about the existence of such a technology, the reply was essentially, "Yes, we are working on this and have no further comments."

If we can understand these specific phenomena we will make some real progress. Please note the kind of language and descriptions I use; hopefully you'll see the types of descriptions I avoid. Then we can have discussion.

I learned a lot about electrostatic phenomena myself through mistakes, where nothing happened. I then realized that it was important to show the students "when nothing happens." Every situation when you don't "get the phenomena you anticipate" is a learning experience. You learn more about the conditions necessary for those particular types of phenomena to occur.

[A few different materials are brought together and separated. Some are rubbed together, some are not. The materials consist of various fabrics, pieces of plastic, metal, wood, a piece of animal horn. This was done quietly and carefully with a number of combinations of materials. There was no talking at this time.]

I bring two materials into contact. I separate them. In some cases a new relationship has arisen. It is more important to describe the relationship as a new entity, not an object but a relationship that we can observe. This is similar to a relationship between two human beings. Note that the terms we often jump to, positive and negative, are meaningless unless there is a relationship. Every aspect of this block is about teaching relational thinking. There is a relationship between this rod and the piece of rabbit fur. How do I know? There is movement (in this case the hairs of the rabbit fur move toward the plastic rod when they are in close proximity) with no visible contact between the two (visually) opaque surfaces. I get movement with space in between. I can leave this on one side of the room and walk away. I come back and the relationship still exists. In Saratoga Springs the relationship begins to disappear in time, especially if I teach this block on a more humid late summer day. The relationship lasts much longer if I teach this block in December.

That becomes interesting. I have created a relationship out of no*thing* through my activity of bringing two dissimilar materials into contact and then separating them. What is the relationship? The objects are observed to be moving toward each other. It appears that they are attracted toward each other. If I bring them together ... and place these two objects here [the rabbit fur and plastic rod were brought back into contact and placed near a freely suspended pithball.]—nothing. If I keep the objects apart and bring one of them (the plastic rod) near certain other materials (the freely suspended pithball), I see a relationship established here. The first reaction is attraction. It usually takes me two days to get through this material. With electrical induction—these phenomena also interact in such a way as to reduce the strength of the imbalance—it takes me almost the first week of the block to fully investigate these phenomena. [A plastic rod was rubbed with one of the fabrics.]

Michael D'Aleo generating static electricity

Take this polarity—create a new relationship—similar relation (attraction). [The first rod was placed in a fine wire holder suspended by a silk thread from a stand. A second rod of the same material as the first was rubbed with the same fabric as the first rod. The second rod was then brought near the first rod that is freely suspended.] Now these two rods interact instead of attracting, we now have repulsion. That's not quite the right language. The language I am presently trying to shift toward is moving away or toward each other—because attraction and repulsion are already concepts while the moving toward or away from each other is what is actually observed.

From here it would be easy to get to positive and negative. I introduce this concept as we go along in the course because it is the conventional use. The key is: Positive with respect to what? Negative with respect to what? We need a reference point. The moment we have a reference point, we have a relationship again. If they only have meaning in reference, that is already a relationship. Note this distinction between what was just said, and note it is not that object-like aspects are the causal agent in the relationship.

Positive and *negative* as designations are just a convention to describe the difference. I could also describe the polarity as black and white or, say, male and female. It is always in respect to another polar quality. Phenomena have meaning in relationship—this is key. Why is this important? In 12th grade, it becomes very meaningful in the manner in which I teach the Visual Physics block. Understanding the origin of the polarization of outer (world) and inner (observer) is a key to understanding vision. This understanding is based on students' being able to develop relational thinking between two poles in Electricity and Magnetism class in 11th grade.

How would we look at it conventionally, using positive and negative? I take the rabbit fur and rub it on the plastic rod. The relationship can be seen by negative—rod [repels pithball], and rabbit fur [not much of a reaction].

So we have a polarity created. We take this polarity and now bring it here to develop the concept of grounded earth as the reference point. Our initial reaction is one of attraction. In that attractive quality we can begin to look at induction. The plastic rod that I observe has an electrical condition—by convention we describe this as a negative polarity—and will interact with the uncharged aluminized pithball. With more time I can show that objects that are sensitive to polarities are attractive on one side and repelled on another. This will become the basis for the concept of the dipole.

What I can find experimentally is that this uncharged metallic object will begin to polarize without being in contact. This polarization will have a polarity close to the rod (the polarity on this side will be the opposite of the rod) and the initially uncharged object will have same polarity as the rod on the far side of the object. Note what is happening here. Negative and positive polarities are the condition for attraction. If two opposites come into intimate contact, the imbalance is reduced. If two of the same polarities are brought into common space, there is repulsion.

With the conductor we have this new additional situation. The conductor tries to keep the imbalance with the plastic rod reduced while still trying to be internally balanced. The conductor simultaneously behaves to decrease the strength of the external imbalance (by the side nearest the rod having the opposite polarity as the rod) while internally remaining balanced (only achieved by the side opposite the rod having a polarity that is opposite that of the other side of the conductor). So, the fundamental interaction is constantly one of reducing the strength of imbalance, both externally and internally.

As a result of this, externally, the conditions for attraction (closer proximity between the conductor and the near side of the rod) are more potent than the conditions for repulsion (the far side of the rod is further from the rod). Finally the two objects come into contact. If you allow this pithball to come into contact with the rod a few times, the strength of attraction reduces. Over and over I am demonstrating the principle of reduction of the imbalance. If we take it further and begin to look at magnetic interaction later in the block, we do not see the need for creation of pseudo-phenomenal entities, i.e., electrons moving from one place to another.

When we were in high school, many of us learned the concept of the electron as if it were a small a particle. These were described to us as flowing through a

wire like water flows through a pipe. This is no longer considered an appropriate conception in any serious study of physics of how electricity functions. It is more a series of interactions, an effect that has an ability to affect things next to it, and a series of chain reactions occur. With this way of thinking, we can understand concepts of voltage, current and resistance and understand how electrical motors function (without using the concept of the particle-based electron). We see that the principle of non-material interaction has lawfulness. We can still grasp the concepts that are used in everyday physics—voltage physics—without a mechanical model. What we have just described is a powerful tool that is consistent with the type of thinking used in mainstream physics. We will still have given our students the basic knowledge for further education, and we are able to do this without assuming a material basis of the world.

As I have mentioned a few times, in mainstream physics an object-based concept of the world isn't the right way of thinking anyway. I take this kind of thinking in 11th grade—I actually have them spend time working through the historical concept of the nature of matter. The concept of an electron as we developed it above, a relational expression is incredibly helpful. If you look through the transcription of the AWSNA Chemistry Colloquium you will find a place in it where we discussed the nature of the physical world—primarily the nature of the atom. One of the participants was Robert Mays, who used to be a researcher with IBM in Chapel Hill, North Carolina. Robert has a PhD in (I believe it's) chemistry and is now teaching at the Emerson Waldorf School. So Robert comes to this colloquium prepared with "images" of "atoms" from some of the electron microscopes that he used to use in his research. At one point in the colloquium conversation, Robert slides this image from the electron microscope across the table (it was a beautiful piece of drama) and says essentially, "If an atom is simply a concept, then what is this?" But if we understand how an electron microscope works, then we see the image Robert placed on the table for what it is. It is a color-enhanced representation of the spatial variation in electrical field strength. It is represented as a visual image but the instrumentation is not able to "see," but instead measures with great accuracy the variation in electrical field strength as the *probe* is moved through a very fine area of space.

Now juxtapose this with what Steiner says in the lecture cycle the *Temple Legend,* lecture 9. Steiner states that the best way to think about the atom would be to think of it as condensed (or later, as coagulated) electricity. From what we have discussed this morning this can be though of as dense relational interaction. (See Rudolf Steiner's *The Temple Legend*, 1964 Edition, pages 112 and 113.) It is definitely worth reading the footnote in which Steiner quotes the address given by the British Prime Minister at the time, Balfour (see pages 381 and 382). This is the type of thinking that was already beginning to appear in 1905!

But we can ask ourselves: Can a Waldorf student really learn to think this way by 11th grade? In the Atomic Chemistry block in 11th grade, one of the companion courses to the Electricity and Magnetism block, we go through a bit of the historical evolution of the concept of the atom. One of the assignments I give my students in the 11th grade is to write a composition on "What is your concept and experience of the material world based on what we have studied in class, both experientially and historically." The students need to write this out of themselves and articulate

why they feel strongly about it. A number are quite good and solid. One particular year I had a student whose father is a local professor of math and whose uncle is a professor of physics at MIT. Without my knowing, the uncle was sent the niece's paper by her father. Although she had made a few small mistakes, she articulated her point quite well. I had given her an A on the paper. A few weeks after the block had ended, the father shared with me the comments his brother, the professor of physics at MIT, had made [emphasis in bold is as written by the physics professor].

> This is a **very** impressive paper. While she has a few details wrong, the technical content is correct in spirit and very logically laid out. I wish that my research group at MIT or my project shop could write persuasive prose of this quality. You can be sure that this is better written than most of my MIT student papers and would probably earn an A in undergraduate physics at MIT.
>
> On technical content, modern physics uses a model that matter is just a manifestation of a more fundamental quality. Electricity and Magnetism and all other forces, energies and materials are simply different perspectives on the same fundamental quantity (called the unified field). Higgs is the latest manifestation to be experimentally validated. Amelia lays the argument for the unified field theory in a clear progression and shows how this leads to her stated conclusions. This shows a very strong disposition to understanding physics—few MIT undergrads could have constructed this argument without discussions with someone who has had a graduate education in modern physics. Obviously, her teacher is **very** competent in physics and a brave (and clearly quite successful) teacher. I would not have thought that one could teach Higgs to high school students.
>
> Maybe we will make a physicist out of her yet!

This student was also a talented drama student. To me her success is a statement about what we can do. She could easily have gone into science. If her father had not been a mathematician, perhaps she would have! She did however play Galileo's daughter in a community production. I don't think her story is over yet.

I wanted to say all of this today for the following reason. The type of thinking I have been trying to describe is considered quite unusual. The student has to add her or his own comments. Yet here is a professor at one of the best science universities in the world saying that the thinking is consistent with much of the conceptual thinking in modern physics. I don't think you have to have all the latest and greatest apparati and laboratory to be successful as a teacher. Yes, in the end you will likely need a Van de Graaff generator and some power supplies, but we do not need everything. From the most basic phenomena and seeing the most basic interaction, we're able

to hold this imaginative picture that is consistent with those being developed by the better scientists of our time.

Finally we go to the human being—the pedagogical concern. What does this kind of thinking do for a human being? I recall, from teaching this block a number of years ago, a student made a statement upon completion of the final exam at the end of the block. The words were very close to the following:

> Mr. D'Aleo, I think I can speak on behalf of my class, I don't think we have ever worked so hard in a block before. We are exhausted but I think we have probably learned more in this block than we have learned in any other in a long time.

Why did she say this? I think it's because the students saw that the material of the block related to an essential aspect of their own being. If the world doesn't exist just out there, and I just in here, I have to take responsibility for this relationship. Then I am responsible. The world doesn't "just suck." If I change the inner, the outer also takes on a whole new quality. On a higher level, this type of thinking is preparation for a student to begin to work with the spirit aspect of the world, finding a lawfulness in the invisible. I believe that is why the students take such an interest in these things.

This year I taught this block in September—a gutsy thing to do in Saratoga Springs given the potential for humid weather. We were fortunate that we had a dry spell. We did have one wet day and fortunately the experiment that day wasn't too subtle, and I didn't need too much dryness. But we did do the experiment just to see if it was different. We did indeed get different results. The unexpected often helps you to see these different results. This is what it means to "live in the world."

I decided to share this with you today because if there is any subject in Waldorf education expressing what Waldorf education is all about, phenomenological science can be it. This class shows the power of this approach. Other aspects can be taken from 12th grade, but this is it.

Discussion #2

Paolo:

Appreciated that there was no assumption. The rod is what you are focusing on, not the rabbit fur. Question about whether the rabbit fur was charged. . . . You need to wear a glove—not easy. You need to have special electrostatic glove. Student commented—it's not . . . if you use the fur you won't get the interaction. It is discharged. Reality is never a mistake. I use cotton fiber rather than rabbit fur.

Michael:

This point needs further investigation. There is a question here about the relatively low state of charge of the rabbit fur. Under some conditions some charging has been observed (in Saratoga Springs in midwinter), but significantly less that the plastic rod. The question that still warrants more research is how much of the discharging is occurring through the hand holding the rabbit fur and how much is through the individual fiber of hair into the hair. The second question has to do with the form of the charged object. Objects with sharp surfaces, such as the pointed ends of fur, discharge much more readily into the air than those with smooth, rounded surfaces such as a ball.)

John:

The Saran Wrap brings out what Georg calls the "ritual." If you use this domain of phenomena—it's so finicky, part of the phenomena, should not be ignored. You have to fiddle around a lot to get it to work. Again and again, you see how different it is from different locations—humidity, the day, etc. Different brands differ. Different composition. Saran Wrap brand of plastic is the only one that works. They don't make it any more because of environmental issues.

Michael:

Scotch tape works very well. One side is sticky, the other not. The key is the subtlety that John pointed to, the subtlety of the phenomena, and the weather—quite interesting to see the differences. What is this electrical phenomena archetypically?

Brian:

This fits so much better than what I learned in public school. So much of the pseudo-electric. This year the polarity really came clear. Real difference between the polarity. My question is: We get 4 weeks maximum time allowance, then, as teachers we need to take it farther—how do we reconcile that electron charges are quantified, etc.? You really get into details (with physics teachers). Everyone is still learning electrons in public school taking pseudo-phenomenal entities and applying them to time ... a whole lot of people are not thinking this way ... "What is mass, etc.?"

Paolo:

I can show mass as a relationship. A lot of what is on the news—particles—is a simplification for the public of something that is more subtle. As a physicist, when you are dealing with the concept, you find there is a relationship. What you are picking up is the popular science explanation of it. The relationship does not make you non-material. But it opens the door.

John:

I've had times when it's been very difficult to counter the unconscious habits of thought that are so present in our culture. In physics I don't think we are there yet. There are enough disturbing phenomena in physics that are causing the profound revolutions that happened at the turn of the century, such as with quantum physics, whereas in biology there aren't. In penetrating pictures of genetic engineering, there is dangerously oversimplification. Such as those pointed out by Craig Holdrege. So students can see that the striving to think in a different way is not tied just to the DNA. When you do, you have the potential to feel you have explained everything, when you haven't. This kind of thinking MATTERS.

The other thing—having worked with Hans Gebert—one can take this leading thought, electrical phenomena acting to reduce the strength of the imbalance. One can do this in electrical chemistry and work with it in several different contexts.

Brian:

This concept of electrical phenomena can be introduced in 9th grade. All phenomena are seeking balance.

Michael:

Polarity and intensification—creating separation creates the conditions for restoring the natural balance.

Paolo:

Polarity is a symbol. Contrast to life. You get this picture that nature wants to go against this polarization, to eliminate polarity. We are trying to get uniformity.

Michael:

Questions the use of nature. I would suggest it's without continuation of the life principle, this happens. I'm not sure physical "nature" is the right word either.

Paolo:

Physical "laws" is better than nature. Very interesting.

Michael:

There is a great article written in 2004 by a professor from MIT, Milo Wolff, entitled "Einstein and the Electron." In the beginning of this article the author references some conversations that energy physicists had with Einstein toward the end of his life. During this conversation Einstein made the statement, "I would just like to know what an electron is." I find this quote beautiful to see—that Einstein

himself was willing to go back to fundamental physics. Look at the weather changes, first global warming, now global cooling, oversimplification.

The same can be seen in the economic situation, first the difficulties are minor, now we need to pas this bill or else. The solution to this is seeing things as relational instead of linear thinking (which is perfect for 10th grade), but in 11th grade—relational.

Brian:

I think this relates to our discussion last night on the perception of the Waldorf science curriculum—popular science. This that you are teaching doesn't meet what I read in the newspaper which is over-simplification burgeoning on lies.

John:

In medicine there seems to be more willingness to see new perspectives. Craig's research into water contamination in England. Not just a case of the disease being caused by a factor, but the state of health of the people. Multiple factors interacting and affecting each others. But my experience in the physical sciences indicates that people have bought into the existing paradigm which works in a way. Why are you agitating to change the existing paradigm? I am interested in the discussion as to why this way is important.

James:

Probably most of us in this room were classically trained and we came back to this (also Hans and Stephen). What we received in our education was not phenomenally based. Then the mathematical modelers came in, then they reached a limit, then the mathematical physicists came in and tried to explain things in a new way. There is no way we can understand this except by this—but the electrician who wires, he understands. You can do modeling that is not "reality," but it can take us very far forward. Is that adulterating their experience? This tool is only a tool, a very useful tool. We don't want to throw them into their physics class at U. of Michigan and have them ask, "What is happening here?"

Bob:

Faraday used action as a distance to describe this working with phenomena. The point also comes for our students to be familiar with the language and solve problems with numbers, write exams. I feel an obligation to the students who are going on, to discover those practical skills. Equipping them with the hard skills to be successful. The high level theoretical physics can recognize what you are trying to do, but there is a path that takes us from here to there in which certain skills are needed. How do we reconcile those polarities? We live in the world physically not just theoretically. How do we relate to problem solving and exam preparation?

Hezi:

I have the same question. The time given to physics is a problem. Maybe for half of 11th grade or 12th grade, I believe we should have a skills-based class. This can help the situation—the students would feel comfortable in their first semester

(in college) rather than being wowed by this kind of thinking. How much are we being allowed in the Waldorf school to be able to do this? The need for science and math teachers is so great. I don't think the blocks are a place to develop the skills. In chemistry, students are shocked when they go to university. We are not providing certain assumptions—basic skills.

I wish we could have a multi-disciplinary science and math colloquium to discuss this non-material interaction. We have a problem throughout the movement with chemistry teachers. When you bring in a mainstream chemistry teacher you have problems.

Paolo:

It's much harder with physics.

Fred:

Prior to being a teacher, when I was in the communications field, a high level person came to me and said we can train artists to become technicians more easily than to train highly competent technicians to become artists.

We need to work with the University of California requirements; we need an initiative to get science skills classes going. Fred brought this idea from John back to his school. What do you take out (of the rest of the curriculum to put in a science skills class)? I observed at the Waldorf school in Berlin last year. Their curriculum is more centered around dramatic demonstrations. Normally the art classes use the particular room, and they also used this room—the art of science. How do we make a space for what amounts to skill-based art of science? One of the art teachers would be replaced if we did this. How do we convey that there is an art of science? Having other disciplines here would be great. Michael, you started with nothing and built it up from nothing. [The 12th grade elective science skills classes were put into the curriculum at the inception of the Waldorf School of Saratoga Springs High School.] We seldom do this.

John:

It's really important to try and keep this question on the one side—what is needed, how to do it—and the other side, how does doing that relate to the larger approach that we are looking at? Is that incompatible? How can they co-exist so we don't lose the deepening? Not either/or.

Brian:

One is thinking, the other is skills practice.

Discussion #3

Bob:

How do we build a picture of physics teaching that is balanced from a threefold perspective?

Paolo:

Before that, what do we say to parents? Sometimes the questions come from people who know only popular science. I come from many years of struggling with this. In discussion with a mainstream physics teacher and college teachers, I heard that the students can do problem solving but they don't know anything of meaning. We want students to do the thinking and also some problem solving.

The block system does not offer repetition that is needed in some subjects, including science. They can learn how to solve a few problems, but that doesn't mean they have the skills. I used to be concerned about this, but I am less concerned. By introducing year-long electives you can build skills. We have been a little bit successful with this [the San Francisco Waldorf School]. Still, students would not be able to take an AP test and pass it. The success came at the expense of something else—interesting questions. They were cranking out equations. Something wasn't happening there. Quantum mechanics? It is a bit of a compromise. I myself can solve an equation without knowing what is going on. We are lucky that in physics when you go to college you get an introductory physics course (not so with chemistry—they expect you to know the material from high school). Problem solving is tough the first year even if you've been trained to do it. Dropping out often is because it is too much work, not because the students can't do it or haven't had it. Do I apologize for not having brought skills strongly? No.

Brian:

I agree with you. I have tools to respond to the parent who comes to me. But the bigger problem is parking lot gossip about the strength of our science curriculum—often through middle school colleagues to the parents. I would love to sit in a room and discuss what the electron is and how we teach in a faculty meeting. Very few have the courage to approach me directly. Instead, it is passed on behind my back.

Michael:

From the beginning of the high school in Saratoga Springs, since I was there at the start, no one has ever raised the comment of our being only an art school. Still the question of our being only an art school comes up. It is there in the early grades and kindergarten parents. Conversation itself doesn't solve the problem. Parents need to be invited to the high school science classes. A kindergarten parent with an

engineering degree who visited my 11th grade class said he learned more in my class than in his classes in college. It was deeper. That was all the parent needed, and he is now on the Board at our school. This is a pattern—let them sit in. Then you will get the flip side, an appreciation for what happens in the sciences. The more you can be open with your class and then sit down afterwards with the parents and faculty and speak, the better.

In main lesson I bring the conceptual work. We have had an optional half year 12th grade elective course, opposite foreign language, 4 days a week since the high school's inception. We crack open a college physics text and crank through it. The students don't feel unprepared for physics in college.

Some of our students do drop out of engineering because it is too theoretical. These students are looking for something more hands-on.

In chemistry we had complaints. We also began an elective chemistry class using a text. Now the students say that "it was a struggle, but I got it." I don't think we can do justice to our schools if we don't have this track class. It should be optional. We have students who've gone on and done well.

Bob:

In the main lesson we teach to the whole class, provide a rich experience in physics for all, many of whom will never touch physics again. How do we meet their needs?

Beth:

Could we spend time answering questions by sharing observations about the students in our classrooms now? It is my sense the students have changed dramatically in the last few years in how they are able to be attentive, how much they are interrupted by the internet outside of school. We give them three days to visit schools or work on projects. They complain, "There's too much in our lives. The hours after school are from 3 to 10 PM. . . . No, it doesn't take 1 hour to do the problem, it takes 3 hours." They have to settle down, make phone calls until they actually work for 45 minutes. They are feeling panicked even though their work load is less than three years ago. They are frenetic. How do we engage them in will into thinking, and the inspiration to take up skill-building? Perhaps it isn't just what the school will allow, but also what is in us and who they are. They need something from us which is different from what we needed in our school years.

Brian:

I agree that, generally, kids who succeed in engaging in this phenomenological form (which can meet those of all intellectual capacities) are those who have calm in their lives. If they are incapable of developing this meditative calm, they may scribble the notes, but they don't understand. Some students are bringing a level of composure that works against this. I'm very interested in this question of how we measure success in Steiner's curriculum. It's really helpful to have this gathering and discuss how we can prepare students for science careers and also how science careers are today. I interned in science careers and it drove me away. It is quite sick as an institution. The climate change debates today show this. Compromises must be made to do some of this work.

Betty:

In Holland they divide the students into theoretical and practical tracks. They might share the main lesson and be divided afterwards, or they may have different main lessons depending on whether they are university-bound or not.

Hezi:

In Oslo the school reinvented itself and developed many different tracks. They had a common main lesson. [For more on this topic see David Mitchell's article "Rethinking the Waldorf High School" in *Research Bulletin XII, #2*.]

John:

We tried the science elective opposite foreign language. Students wanted both. I have to answer to the college the students are applying to that they have taken the most advanced courses. The college counseling office needs to take this into their guiding of students. It is easy motivation to get them to do this, but that slot didn't work.

For the kids who are not college-bound, they need to be addressed as well. We did get agreement to get the possibility to split the science courses. Then the humanities department reneged on this because they didn't like the mix. We can do it with science against science. Other teachers have differentiated their projects to meet different students.

Michael:

In order to see the differences in the students, a staff member sat in on one of my classes. Every student was engaged, including the ones with IEPs (Individual Educational Plans). We have to work harder and say to ourselves: Does the lesson include deep conceptual developments which they can relate to in everyday life? That's my job. I have to make changes. We have to remember we are teaching high school, not college level concepts. We need to hold ourselves accountable to get our work done on time, because what the students are struggling with, we are also dealing with. With my getting their work back to them right away, that continuity helped the students tremendously. It set the bar higher. I was accountable; they did the same. The students have changed in their will. The students who are the best conceptualizers in physics are not necessarily the ones who can do the mathematics. Dyslexics have a very free conceptual ability—a counterbalance to those who work mathematically. I wouldn't want to separate students during main lesson, but after main lesson in the skills class, yes. By developing the concept so thoroughly in the main lesson, we then get to Ohm's law and they get it right away. They also pull apart a boom-box or a music speaker, see how it works. We get to practical examples in which the principles are applied.

Bob:

Stephen pointed out that the will part of the main lesson is having to structure the main lesson from yesterday and find a relationship. It is not necessarily working in their books. The first part of the main lesson is more conceptual. The equipment comes out to explore how the principles are manifested.

Michael:

In preparing my teaching I ask myself these three questions the night before.

1. Why should the students care about this? (feeling question) How does this relate to my life?
2. Where have they likely seen this before?
3. Where is this used in the world?

This is 50% of their attentiveness in the class. Who you [the teacher] are as a human being is what the students learn. Our interest in the subject is what helps them.

Bob:

I still have questions about electrons. Is there room for "electrons" as a tool in trying to understand in a more grounded (possibly more precise or materialistic) way. You did include positive and negative signs in your drawing this morning.

James:

Playing with different models, students can see how models are an imperfect system. I don't see why introducing electron as an historical phenomenon is a problem. Doing it historically helps.

Paolo:

It is important to explain models. The problem is the students don't understand it is a model. If you can do the phenomenological work the way Michael showed this morning, then the model is fine. It's a question of whether the teacher is alive in this question. If not alive, it is useless. In quantum mechanics there are fields. We don't have to fear it. If you look at what experiments show, the electron is a source of an electric field. You have to know as a teacher when you are oversimplifying the material.

Brian Gleichauf

Building Machines:
Putting into Practice What Students Have Learned

by
Paolo Carini

I want to speak about three things that happened to me this year. Unlike Michael, I am not usually interested in poetry, especially English poetry, since English is not my mother tongue. But one did strike me strongly. That was Mary Oliver's "The Summer Day." What does it mean to observe phenomena? The poet could not say it better. Paying attention to the present moment is a spiritual activity at the base of any observation.

The Summer Day

by
Mary Oliver

Who made the world?
Who made the swan, and the black bear?
Who made the grasshopper?
This grasshopper, I mean –
the one who has flung herself out of the grass,
the one who is eating sugar out of my hand,
who is moving her jaws back and forth instead of up and down –
who is gazing around with her enormous and complicated eyes.
Now she lifts her pale forearms and thoroughly washes her face.
Now she snaps her wings open, and floats away.
I don't know exactly what a prayer is.
I do know how to pay attention, how to fall down
into the grass, how to kneel down in the grass,
how to be idle and blessed, how to stroll through the fields,
which is what I have been doing all day.
Tell me, what else should I have done?
Doesn't everything die at last, and too soon?
Tell me, what is it you plan to do
With your one wild and precious life?

What does it mean to teach using living pictures? I've always tried to figure out what people mean when they speak of "living pictures." In astronomy I was leading the students to understand that at the poles there is no sun in the sky for six months. They understood the idea, but they were not living it. So I told them the story of the penguins that gather together for six months in freezing cold weather to protect

Paolo Carini

their eggs and finally are able to see the sunrise! The students were now living what before they were only understanding. Some students couldn't remember what months the sun is above or below the horizon, but they could live the experience of a sunrise after six months of night time. If the pictures aren't alive in the students, we aren't teaching them anything. If the students aren't living in the pictures, everything will be forgotten. I realized I engaged students, but on the intellectual level. I started to perceive a distinction between intellectual curiosity and one that leads to a living picture. They may respond to an intellectual hook, but that is not a picture. I realized there must be something alive to which the students can connect. It's not so obvious how to connect the content to a living picture. I got very excited when it did happen. A lot of hook to the intellectual curiosity, but you can't rely on that. You have to give them something more nourishing that can lead to wisdom. Now it is like a nail in my head. I think about it when I prepare lessons.

Why do we do things? I tell about a conversation with my father who has rarely expressed interest in Waldorf education. He is in a moment of transition at the end of his life. He came to visit. On the shelf was a basket one of my children had made. My father looked at it and asked who did that. He took it and looked at it, the beautiful geometry of the weeds going in and out. He is an architect, and a child of the Italian political left and of historical materialism. He asked me why we teach this, and then he started to tell me about his life. His father was a founder, made bronze casts. My father flunked his first year of high school and his father sent him to trade school. A family friend recommended that he finish high school, so he went to high school during the day and trade school at night. That mixed experience made a terrific difference in his life. My father asked, why do you do this work with them? You are not teaching them to become basket makers, I hope. At his time, to learn the trade was a way to earn a living. But nobody earns a living making baskets today. He knew the value of his mixed education but he was challenging me to explain. Why make them? I tried to explain the importance of working with your hands. My father persisted, why are you doing this? I showed him the web page of the school. He commented, "None of this shows the importance of the work you are doing in your school. Why do you do this in the 21st century?" I couldn't give him an answer. This has become an obsessive question.

I always enjoyed building things. I had to get into my hands and started to do projects by myself. If I find it fun, the students should do it also. I have to give them an experience of it. I worked on it in the summer and presented it in the school year. Steiner tells us in Stockmeyer about the steam engine. He also talks about the negative influence of technology. This technological stuff is not necessarily positive, but we need to know about it. You go on a train, you have to know how it works. It becomes important for me to go back from principles to technology and vice versa.

9th Grade Thermodynamics

Which project do I bring to the students? I have an interest in engines—steam engines—students built a thermal engine. The point when I propose a project is you have to be able to do it without special machines. I went and got projects from Internet—plans to build Sterling engines. The students struggled. It was too hard. I gave a simpler one the next year. I gave a project based on the Christmas angels where the warmth of the candles turns them around. The 9th graders had to make a project in which the warming of a few candles could turn something. The principle is basic. You can build on it—angels, gnomes, ducks. They make it at home, and it is a great pleasure. None of this project is done in class- all done at home. I always strive to find an activity they will want to do. I ask for feedback and I try to get a sense of engagement. Last year one colleague picked up thermodynamics and made pop pop boats—it is like a steam engine. Put a candle in it and it pushes it ahead. In building the boat there is a little bit of free activity, open space to express yourself. So much of physics is focused on being accurate, precise, and careful. You need something to balance that activity.

10th Grade Mechanics

The curriculum is mechanics. I work with free fall and projectile motion. The students build spring-loaded guns or catapults. There are some parameters they need to be able to change: the altitude and the velocity of the projectile. They need to gauge their launcher. On the last day is a celebration. They need to send a marble inside a bucket about 15 feet away. The team that succeeds with fewest attempts wins a prize. A lot of learning happens through trial and error. It is hard in class to have enough time to learn through mistakes. They are deprived of a valuable and essential experience if they don't have a chance to make mistakes.

11th Grade Electricity and Magnetism

The students choose among AC generators, electric motors, Tesla coil, Van de Graaff generator, and others. There are plans online for many of these projects, but usually I provide some basic plans. Often the complete grasp of the physics behind the machine comes after the students have already started to work on the project. It does not seem to be a major problem. The projects are built completely from scratch. The capacity of building things by hand and with cheap, easily available material is important. The project must be accompanied by an instruction manual that explains how it was built and the physics behind it. In general projects are not a replacement for a written assignment such as main lesson books, lab reports, posters, or class notes. Quizzes are always part of the evaluation. The point is to find an assignment that is meaningful to the students instead of giving them busy work that they don't want to do.

11th Grade Astronomy

I am fascinated with sundials. We go visit the Sundial Bridge in Redding as part of our astronomy trip to Mount Lassen National Park. The students experience a direct connection between science and art. Students make sundials specific to our latitude. They need to project the 24 lines onto the horizontal plane. It is an exercise

in projective geometry. I provide the instructions. The geometric construction must be accurate. I check their drawings. I discuss at length the connection between longitude, sundial time and standard time. Finding one's longitude is the reason why the mechanical watch was invented. The other assignments for this course are posters. It is fascinating because it is a way to connect different topics into an organic picture.

12th Grade Optics

I tried projects, but I was never satisfied. One of my students used a concave mirror to produce a real image of a light bulb that fooled everyone in the class. That was connected to the fact that we use parallax to judge distances. I also had a student building an inflatable mirror. Now I do something else. In general many don't want to write main lesson books any more. So I give them to go out in nature or the city to look for optical phenomena that we study in class, as they appear in everyday life. I want them to go out with their cameras, during weekends or weekdays, and hunt for visual phenomena. They present their projects as a slide show or a power point presentation with commentary. In these ways I encourage them to observe the world, see how what we are doing in class is related to the world around them. I also propose other projects, like posters or lab journals. I discovered recently that the AAPT has a photo contest for the best physics-related pictures from high school students. I encourage my students to submit their pictures. It is a nice way to be recognized in a field of science where usually only the most intellectually brilliant students succeed.

Discussion #4

James:

How do you work the project in 11th grade? It seems that it will take a lot of time.

Paolo:

They do research in books, on internet, and start to build it. They need to work at home. By the end, together with the project comes a manual to explain the project.

Hezi:

I give a project as an option in the last academic main lesson of their high school career. However, many ask to do a main lesson book because it is the last chance. One project is a creative project—choose three of the phenomena we went over in class. Represent each one from three different angles, usually drawings and paintings. Got some sculptures. Got comics. Computer program graphically along with manual.

[Paolo showed pictures on the screen.]

- Thermodynamics—candle turning appliances—pyramids, e.g., roasting marshmallows above candle, ducks. Cut pieces by hand. Takes time. Now I have tools in class they can use.
- Sterling engine
- Mechanics—group projects—2 or 3 people do it together. Built a projectile launcher.
- Magnetism—water generator, AC generator, Tesla coils.
- Optics—pictures from student work, reflections. Perspective. Refraction.

It's a different experience to watch something or to make it. I want the students to DO it.

Bob:

A professor asked home-schooled students the following questions to determine admissions.

What are your physics questions?
What were your math grades?
What have you built?

Brian:

It's completely done on their own time. How do you set it up?

Paolo:

I show examples of other students' project. I set up deadlines. They check with me along the way. By Monday they have to collect their materials. The next Monday they have to show me how far along they are. If it doesn't work, they have to fix it.

Brian:

Is this what you do? The primary activity is the long term project, taking notes, quizzes, and preparing for test. Thesis behind refraction.

Paolo:

You can assess their team work. It is a struggle.

There followed a discussion of grades, quizzes, kinds of assignments. The assignment has to do with what the intention is.

We need to understand what wireless technology is. How can we say there is no effect? There is so much research to show the effects. Is the technology driving us, it's a problem. If we can master the technology so it works for us, that is not a problem. It is a matter of awakeness.

The Surgeon-General in Germany said always choose a landline over a wireless connection. In a block like Electricity and Magnetism, put out the facts. Books such as *The Body Electric* and others are important.

The effects of cell phones on young children. At ten minutes per week—no effect. This study was done at a time when people weren't using cell phones regularly. The situation has now changed with much more usage.

FRIDAY EVENING: A discussion took place on teacher burnout, why colleagues left, or are considering leaving, Waldorf science teaching and where we might get more teachers. The content contained opinions that were personal and judged to be inappropriate to include in this Proceedings.

John Petering and Rick Malone

Successes and Challenges in Teaching Phenomenological Physics

by

Geoff Robb

When Michael called me and asked me if I would be willing to make a presentation, I had to think about it. It was a bit daunting for many reasons, but then I agreed to do it. What I am going to do is give you a sense of what I have been doing for the past 18 years, what I have worked with and struggled with.

Twenty years ago I found myself at Emerson College in the Foundation Year. I am actually a geophysicist and worked in the oil exploration field for ten years. I rode my bike from Vancouver to Mexico City in 1986, worked in a Quaker house for a year, then traveled by bus through Mexico and all countries in Central America and ended up in another Quaker community in the mountains of Costa Rica where I first heard about Rudolf Steiner, Waldorf education and Anthroposophy. It was a long complicated journey, interesting and a very transformational over 2 ½ years. I dived into the Foundation Year in 1988, which answered lot of my questions, and I met some very interesting people.

There were 3 or 4 in the Foundation Year who were scientists, a tiny minority. It was an interesting experience being a scientist that year. We got together and asked Francis Edmunds if he'd be interested in meeting with us once a week. This was just a few months before he died. It was a wonderful experience to hear him talk about science and teaching in a Waldorf school. And I realized I really did want to do this for my life vocation.

Francis Edmunds had to go out of the country, so he asked Hans Gebert to meet with us in his place. I had never heard of him. The one thing I will never forget is talking with him about the challenges of redeeming science at this time. On a beautiful sunny day, Hans was sitting in chair with a straw hat on and a wonderful smile on his face after mentioning how difficult this would be. He smiled and said that this would be our Michaelic task. This moment of inspiration is what has kept me going through the years through all the ups and downs.

I want to read from *Anthroposophical Leading Thought*s, Oct. 19, 1924 – "The Experiences of Michael in the Course of His Cosmic Mission":

> Michael cannot force the human being to do anything. For it is just through intelligence having come entirely into the sphere of human individuality that compulsion has ceased. But in the supersensible world first bordering on this visible world, Michael can unfold as a majestic,

> exemplary action that which he wishes to display. He can show himself there with an aura of light, with the gesture of a Spirit-Being, in which all the splendor and glory of the intelligence of the past is more true, more beautiful and more virtuous in the present than all that is contained in the immediate intelligence of the present day, which streams to us from Ahriman in deceptive, misleading splendor. He can point out how for him Ahriman will always be the lower spirit, under his feet.
>
> Those persons who can see the supersensible world bordering next upon the visible world perceive Michael and those belonging to him in the manner here described, engaged in what they would like to do for humanity. Such persons see how—through the picture of Michael in Ahriman's sphere—man is to be led in freedom away from Ahriman to Christ. When through their vision such persons also succeed in opening the hearts and minds of others, so that there is a circle of people who know how Michael is now living among men, humanity will then begin to celebrate Festivals of Michael which will possess the right contents, and at which souls will allow the power of Michael to revive in them. Michael will then work as a real power among men. Man will be free and yet proceed along his spiritual path of life through the Cosmos in intimate companionship with Christ.

I believe that this gathering is such a Festival of Michael, and I'm very happy that it finally happened and that we can do this work.

Just a little aside, when I was at Emerson College, I visited Michael Hall School and, of course, they needed a physics teacher. I observed their physics teacher and I thought it was something I could do. They offered me a job. But I realized, after being tempted, that I really didn't know what I was doing, and I better get some training.

At Wynstones School there was an opportunity to take the Science Teachers Training Course, a one-year full time course, run by Graham Kennish, Ron Jarman and Francis Woolls. I turned down the teaching offer and applied to do this training. It really changed my life and gave me a solid foundation on which to go forward with this work. I realized how lucky I was to be able to take 2 years off in my mid-30s to do a training course.

In January, Stephen Edelglass came over and taught us the Physics portion for 3 weeks. It was my first meeting with him. I can't thank him enough for what he did for me in putting this task we have into a context. I think he was able to do that in a very unique way. He started off by telling the four us, all of whom would be Physics teachers, "I know what you want, for me to tell you what and how to teach." On day one he said, "I am not going to do that." He proceeded to give us a foundation on which to build, which was how the Evolution of Consciousness pertains to science and the teaching of science. In our high school in Ann Arbor we have taken this up and have studied *Saving the Appearances* by Owen Barfield three times. The foundation of our high school is those thoughts in that book. Barfield takes us through the history of consciousness with this lovely description of where we have come from (original participation) and how we are going toward a new kind of participation (final participation). We hope we are helping our students develop

some capacities to help them move in freedom toward this final participation. This underlies everything I do in my Physics teaching.

Stephen talked with incredible passion about Phenomenology, the problems of modern science, and how phenomenology can take scientific thinking and move it in a healthy direction. This was moving to me, and he made a pretty convincing argument. We had 2 weeks with Hans Gebert, about 3 months before he passed away (August 1990). Hans continued building that foundation, working with us on curriculum and on the history of consciousness. We worked strongly out of pictures of the spiritual hierarchies and Steiner's thoughts about Michael. The foundation I was given helped me to put this Michaelic task into a context.

This was about the time their book *Marriage of Sense and Thought* was published. In the summer of 1990, Stephen and his colleagues organized the first science teachers' conference, which was followed by the second in 1993. In 1990 the physics workshop was on the optics block: light and color; in 1993, it was on electricity and magnetism. Stephen and Georg Maier, the head of the physics department in the Natural Science Section at the Goetheanum, were the leaders of these workshops, working with concepts of phenomenology and all the problems that come up, particularly as related to habits of thinking and observing, many that have come from our life experience and education, and how to overcome them when they become stumbling blocks. This has been my work over the years, overcoming stumbling blocks.

The biggest tension that I feel is how to give students a meaningful experience of science through phenomena which allows them to go out into the world and understand it, interface with it so that the science experience they have in the Waldorf school supports a healthy relationship with the world and doesn't work against it. So they can experience a total integration. Hans and Stephen both said numerous times that our job as physics teachers is to make young people feel comfortable in the world, that the world makes sense to them. It has become more and more difficult to accomplish this. You have to pick your battles and do what you can. In a way it's like armor to fight the Michaelic fight and resist Ahriman. If you're successful they have the feeling: "Yes, I know how that apparatus works, the basic principles at work there. I may not understand beyond that but you can't fool me."

I remember Francis Woolls saying: "There are always some students in the class who don't quite get what you're talking about. But even for them, they've had the experience: 'I didn't quite get what she was talking about, but most of my classmates did, so it's possible…' ."

The hardest part is to work with phenomenological differences, to go from purest form of phenomenology and connect it with the applications.

With that as background, I'll run through the basic physics curriculum of the four grades. We'll have to decide how to handle the questions and how to effect an interchange of information on curriculum. I won't give too much detail, rather high points and challenges.

Let's start with the Seniors and say that, besides the workshop with Meier and Edelglass, I had an opportunity to be taken through the 12th grade curriculum with Mathias Klimm, a former Waldorf student in Switzerland who became a teacher and had been teaching physics in England at Elmfield School for about 20 years. I

was really lucky to be exposed to all these different teachers. I haven't done all that much original research; I have primarily worked with theirs all these years.

Phenomenology of Visual Experience: Light and Color

I think the phenomenological approach seems to me to be best developed in this block. I have had pretty good experience with it. In other blocks I do some lessons in a phenomenological way and then come to roadblocks. With light and color you can get all the way through.

Light

I start with the basic lawfulness of illumination. How is it that this piece of paper is illuminated, that I can see it? It leads to this idea, a pretty simple concept, of looking from the illuminated object out at all the bright objects in the field of view. Georg Meier must have presented this at workshops, a little gimmick to "go into ant mode." He is an interesting character. He is Swiss and was sent to England as a child during the war. He went to the Wynstones school and speaks with a perfect English accent. He would say, "You see, it's very important to imagine you're an ant and you are crawling… Any time you want to understand illumination, pretend you're an ant, and you are on the illuminated object, and you look out. It's a combination of all the bright objects above your horizon."

A simple, but powerful concept! What's cool is that anywhere you want to look for illumination, you find that it is a connection to everything in the surroundings. This leads to the idea that light is the interconnection between everything, the manifestation of interconnection. One can build this up and use it to understand visual phenomena. It's an approach that works quite well. I have found it to be quite successful.

In just a few days you can get to working with a pinhole camera and easily understand how an image comes about on the screen of a pinhole camera by using "ant mode." You have students in the classroom standing at the screen looking through the hole to see where the bright objects are, where the illumination is coming from. And just moving against the screen and looking through the hole, the ideas of resolution and color and intensity of illumination are addressed… a pretty powerful picture.

My experience has been that when I show how a lens works in a phenomenological way, the students totally get it. They experience how a lens works very much like a pinhole camera, but in place of the pinhole you have a lens which uses refraction to connect the brightness of a point to a point on the screen or film. The concept of equal optical distance is a useful way to think of this connection. The bigger the lens, the larger the bright object seen from any point. There's a point in the block when students say they really get it. And you haven't talked about anything bending, an idea that lives in our modern consciousness. You have to face it and resist going there. You can make a pretty convincing argument without it.

Q: Do you take them through parabolic mirrors?

I used to but not any more. Not enough time in my case. I have 4 weeks for all of my blocks. I think we can make a pretty good argument for the importance of physics. We have a flexible schedule with different lengths of time for different blocks. I spend about 2 weeks on light before moving to color.

Color

I start with the boundary color experience which leads naturally into Goethe's Light and Dark Primaries. Then on to the two types of color mixing. Color-mixing exercises are pretty powerful and the practical examples are very common (color TV; color printing). Everything you do should relate to their experience. A day in physics that you can't talk about application is a disaster. It should be there in one way or another. Color mixing is important.

There is one question I always run up against and I've never figured out an answer to this. Maybe someone here can: When you have Goethe's colors and start overlapping boundary colors, in one case, green arises, and if you do it the other way, magenta arises. My question is, "What is the nature of this magenta? How does it fit in with the spectrum which is so linear?" I don't quite know how to answer what the frequency of the magenta is.

11th Grade Physics

Michael gave us a great introduction yesterday. I have followed a similar path. You build up a certain vocabulary in the first week from the phenomena of tribo-electricity. Then you move into practical applications of electricity and magnetism such as AC, DC, transformers, etc.; how everyday electrical things work. The challenge I find is how to be consistent with the language you've built up in the first week. How does one talk about current in a consistent and appropriate way? I find it to be a real challenge and almost awkward to go from a phenomenological approach and move into current electricity; how to make that transition, how to think about and talk about current, and avoid the idea of current flowing. Every year that I do this block I wrestle with it, and haven't broken through to clarity.

Then I move on, show them the Crookes tube and talk about cathode rays as a bridge to modern physics. I show them the gas discharge tube that duplicates Thomson's experiment that led to the discovery of the electron. I talk about what Thomson actually did in 1898. He took his understanding of Maxwell's equations and Newton's laws of motion and came up with an apparatus that led to discovering the first subatomic particle through the careful study of the cathode ray. I think this work of Thomson's was an incredible achievement which the students can learn from, and appreciate the cleverness of thinking behind it. To build up the rest of the atomic picture, I have found there's not too much in the way of phenomenology to show them. But you can present it through stories of the major discoveries by Rutherford, Chadwick and Fermi. The whole history is important, but how can we put electrons, neutrons, protons into a context that is appropriate for the 11th grade? That's a big question to me. I have always found the 11th grade students caught up in the drama of the Manhattan Project. I had the great fortune of sitting in on Alan Hall's class at Wynstones for a few weeks and saw him telling the story. I remember being glued to my seat as he told the drama.

Towards the end we get to a basic understanding about how a nuclear power plant works—the idea of a controlled nuclear fission reaction. So I start with tribo electricity and end with the nuclear power plant. I keep asking, "Is this the right thing to do here?" But I keep doing it. Understanding the world is very important. If I have time I will cover briefly particle accelerators and the particle zoo.

Q: After teaching about the cathode ray, it's a history lesson. Cloud chamber, cosmic rays and subatomic particles important to show students and can easily be done.

Every time I take this long journey over 4 weeks I'm always haunted by what Stephen Edelglass said, that he had found through his teaching that less is more. That is a very big question for me, where to draw the line in a block like this. Covering a lot of ground in order to provide the basis for and understanding of a lot of modern technology (i.e., how things work) versus immersing them in a thought process such as what Michael was leading us through. There's a tension here I haven't resolved.

Q: Can you say few words about why you feel your optics works so well? Why optics in 12th, how these topics really meet students.

The phenomenological approach challenges all they've thought in every way about light and color. What I've experienced is that a certain subtlety is required to face these questions and have a discussion. For example, the way students will unconsciously speak about reflection. To actually have a discussion and bounce questions back at them—*"Why'd you use those words?*—leads to great discussions appropriate for 12th grade. To try to figure out what's behind our consciousness in these topics and bring it to light and examine it seems perfect for seniors.

I concur with what Michael said yesterday—intellectual rigor is required to take simple phenomena and sort them out, grasp the lawfulness, then apply that lawfulness in more and more complex situations. I always experience a huge difference between the end of 10th grade and beginning of 11th. Students have really stepped up and are ready for something new, and different and challenging. The physics curriculum is right there.

10th Grade Mechanics

1st part: *Statics*—Again I was so lucky to spend a few days at the Goetheanum with Georg Meier on how to work with mechanics and in particular a graphical method of resolving forces based on the triangle of forces. I have had great success working with building bridges and the equilibrium of forces working in bridges. Students have been challenged by it and have very much enjoyed it.

2nd part: *Dynamics*—The transition Galileo made from Aristotle's ideas about motion and falling bodies, which is one of the first steps in modern science. Duplicating some of those experiments and leading to Newton's Laws of Motion. Copernicus and Kepler are also important historically here. Defining force is step one. I'm not giving much detail here. I'm pretty happy with the 10th grade block; it meets their needs, and I think it has phenomenological integrity.

Q: My experience is that I need to spend at least a quarter of the block on the mathematical concepts to be able to work quantitatively. How do you manage to do kinematics and statics?

One thing Georg emphasized was to use vectors completely in statics. He showed me a way to work with the triangles of forces graphically, to analyze the forces acting on 5 points in a structure such as a simple truss bridge by connecting them together. This can show the load supported by the foundation by tension and compression through the structural members. When the bridge gets beyond this length, things get more complicated. Think about a load crossing a bridge. The structural members

move from tension to compression. You can do a force analysis, with the longer truss structure in front of them. Is this under compression or tension? It's a wonderful exercise. Their guesses are pretty evenly split at first, but then they improve rapidly as they can start to experience these invisible forces working. It's really powerful, this picture of equilibrium. I don't spend much time with math but rather use the graphical approach.

> Velocity = distance over time, slope of distance vs. time graph
> Acceleration = slope of velocity vs. time graph
> Interpretation of example graphs; one graph from the other; practical examples; I don't do a rigorous math approach; not much math in my main lessons.

We do have an optional course in senior year, half a semester of mathematical physics, and another in mathematical chemistry. In that course I focus pretty much exclusively on mathematics of mechanics problems. Our purpose is to give students who will study science in college exposure to the typical approach they will be meeting. The feedback we get is that they feel confident and successful in their college courses.

9th Grade

1st half: *Sound and Communication.* Nature of sound is pretty straightforward. Phenomenology in 9th grade curriculum is a mixed bag. I don't have major questions. I work extensively with Faraday and Oersted. This seems very appropriate at the 9th grade level. Question of current comes up. In 9th grade, current is simply a movement on a meter. That's as phenomenological as it gets with me in the 9th , but you can still pursue how things work, such as converting sound into an audio signal and back (i.e., microphone/cartridge and loudspeaker) and digitizing sound. Modern communication: the basics, but not in depth.

2nd half: *Thermodynamics and Engines*. I have big questions here about the phenomenological approach: the whole question of heat; the phrase heat vs. warmth. I try to cover conductivity, expansion, convection, phase changes (water), boiling, condensation, applications in steam engines, ending with internal combustion (as many types as I have time for). It's difficult to know how much to do because I'm always heading for applications. Being in Michigan, I take my students every year to the Henry Ford Museum where one can see the whole evolution of the steam engine. We go there and I can cover it all right there. It is really wonderful.

Geoff Robb

Questions in talking about heat in 9th grade—concept of latent heat associated with phase changes. It's important to understand what latent heat is in a phase change. I find it difficult to know how to talk about it from a phenomenological point of view. I think students get it, but I'm looking for improvements. This comes back in meteorology because it is pretty fundamental there.

Discussion #5

Beth:

11th grade chemistry. Teachers come to joint imagination about what to do with?? I have a PhD in electrical engineering. All mathematical learning gave me no idea about how to work in everyday life. I had to turn to the *Sunset Magazine Guide to Home Wiring*. What does it mean to have to rewire your garage with your own equipment?

Michael:

I'll offer a partial answer. I made a note when Geoff spoke about overcoming stumbling blocks. Do you see that that phrase itself is a materialistic picture? Every place you mentioned about stumbling. My professional experience was in thermal physics which can only be done empirically. You have more flexibility in that field than most physicists. There was never a "heat-tron" Every one of your questions, Geoff, is a place where there is a noun. The way to deal with current, or heat, change to VERBS—this is the power of indigenous wisdom. Names are dynamic. In Hopi language there are no nouns. All nouns are verbs. If we're true to the concept of electrical current, it isn't a "thing" but "a happening."

Heat—it's the warming and cooling that we actually experience. This concept of heat came out of a humanities experience with warming and cooling. This was Stephen's gift, how do we use the word heat? For me the concept of current is a happening, which falls right out of the experience we have when charging or discharging a field such as when we use a Van de Graaff generator. We could follow this path further. Look at stumbling blocks as nouns, change them to verbs and they become alive!

How can you teach the invisible in 10th grade? I remember first reading and being passionate about the first lecture of Steiner's in the Light Course. Here he makes the distinction between Kinematics and Mechanics. The first involves the motion of seen objects, this a 10th grade student can grasp. The second involves the concept of some hidden causal motion, force, the invisible. In my mind this second level of understanding requires an 11th grade student's ability to think.

Paolo:

Can I add about verbs? In physics every quantity that is defined apart from a constant, it's the change that counts. If the meaning is only a change, then really it's a verb. Not heat, but heating. You only perceive a change. If you have a strong economic background, there must be a way to use a verb! An act of changing something becomes manifest … entropy, energy, and so forth.

John:

9th grade, we had a fellow who was a contractor without this background. Fine arts graphic painting, and something practical—modeling, sculpture …We inserted a unit on home wiring and it worked really well after physics when he tried to characterize making a verb of these things. What is voltage, charge? Dissipation in charge is manifestation of current and heat. Have students refer to those. We have 220, actually very AC or DC, parallel series, great for 9th grade, so practical.

2nd piece is question of method: How am I going to do it? … such as historically for part of the block. Another way: Carefully, systematically build edifice of subject. One downside, there's a lot of work that goes on for awhile before seeing what's going. Awful lot of work for 9th , 10th graders to see where it is going for so long. Textbook approach.

3rd: take piece of something, such as disassembling toaster or clocks. In the process come out the feelings, a total understanding for how something works.

4th: experimental.

[Michael reminded us that this came from an article from the Chemistry colloquium. All a method, be conscious, of which is working and bring those comments in. Important to see why that worked for you.]

9th grade: wiring seemed right on the money.

What I'm describing is in Mackenson, no judgment on it, keep in mind different modes people have mentioned, be conscious why did I use this mode, and how did it work.

Pros and cons to different methods—something we can reflect on, which methods for each did you find most useful. Figure how something is most illuminated depending on different approaches.

Betty:

Happening; the difference of noun and verb all of a sudden became a central picture of change of consciousness of the adolescent. Our task is to free the concept back into movement which touches on all the subjects in the Waldorf curriculum.

Michael:

In Otto Palmer's book, *Rudolf Steiner on the Philosophy of Freedom*, there is a wonderful statement that Steiner made in a lecture he gave to the Goetheanum workers. It is in the 3rd chapter entitled "Living Thinking" (pg. 21). Steiner spoke this beautiful sentence: *"We can see that thinking—not our thoughts, but thinking as a process—needs energizing."* That's what we're really after. The noun has given us incredible clarity, but can also give us a false sense of separation.

Paolo:

Building up subtle and careful ways of thinking. I feel it is a little bit of polarization. You are striving to do that. You end up talking with a technician with a more simplistic understanding, something the technician knows how to do very well with very simple thoughts, usually not phenomenological. We are trying to build very careful thinking. Polarization and not fall into excess. Are we training technologists

or theoreticians? Or do the students come away understanding relationship, mixed together….

Another point, I would like to throw in my work of pictures in the circle. When you experience that students are attentive, that the pictures are alive, meaningful, they can live through the experience. When I tell them about the Manhattan Project, you can see them gripping their chairs, they see it all. Just history—in some way you are sitting there and you are living it, it's alive in you and you are a part of it. Distinguish between carefully building up phenomenological approach—the list with beautiful pictures behind, when we are so satisfied with phenomenological linking together in a beautiful way, I'm not so sure that it is alive in the students. The cohesive pictures might not be alive in the students. Many times at my desk, I had planned a lesson so carefully, but it does not necessarily meet them. Steiner said teach with verb. I think I have done a perfect job linking everything, but yet the students don't seem to be there. It's a question for me. In the high school I think we are too concerned that all parts are logically connected, but I'm not sure that that's what speaks to the students. We don't want to give a chaotic picture but we also need to address that element: "Is that living in them as they are listening to me?" or are they just watching me? It's about internal activity. It's inner activity that is full of meaning. I live with it, and remember it 3 years later. What do you remember? My 7th grade teacher took acid, mixed it with something, and she drank it—that's what I remember! Why? Why is that what they remember? I think we need to learn a little bit about how to do that. I am so curious if any of you have a contribution to this.

Michael:

I wrote down Paolo's question. Do you remember what your points are and can you hold them till later? Can we start the evening conversation with this? I don't want to interfere with the presentation this afternoon.

Q: *Can you articulate questions so we can ruminate on them?*

Extra piece to Paolo's question:

Is it the right way to present it logically, carefully thought through? Is that how human beings discover things? Is it necessary—one of our goals in the science curriculum is to teach them about electromagnetism—but is it necessary to bring them through *all* of those topics before they leave high school? Is this essential?

Stumbling block—noun; how to think about the electron. I teach both Chemistry and Physics; spectra without thinking about electrons moving between orbitals and decaying back down.

My comment is more related to how students relate to it and make it their own. Teaching physics is not about disseminating information. They relate through human drama, that they remember an experiment of physics and a few experiments about that.

James Madsen and Tara Wyman

Hezi Haut and Paolo Carini

Bob Pickering, John Petering, and Tara Wyman

Brian Gleichauf

Film Presentation
The Green Meadow Waldorf School's Involvement in the First High School Engineering Design Competition

by

James Madsen

[It is recommended that you obtain a copy of the video from James and read the following commentary after viewing it. Ed.]

Robotics curriculum.

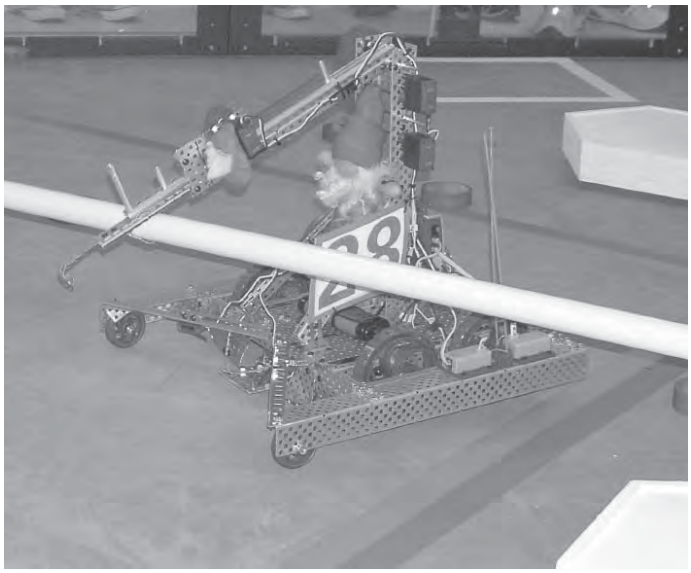
There are all kinds around the world. Mostly because when my children went through public school education, I was worried that American science and engineering was falling behind the rest of the world because students were not engaged.

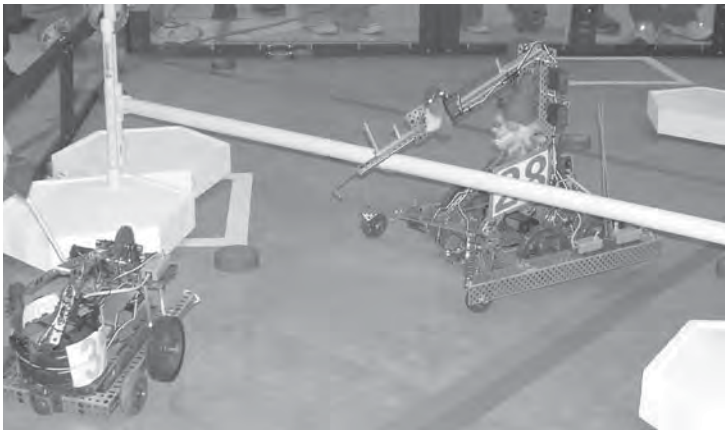
I wanted to make games that resembled sports events, and incorporated 'gracious professionalism' the big one that started 15 years ago evolved into an amazing place. $25K is inaccessible to most. We have played for $2K quite comfortably that most can get, maybe because there are parents who are excited.

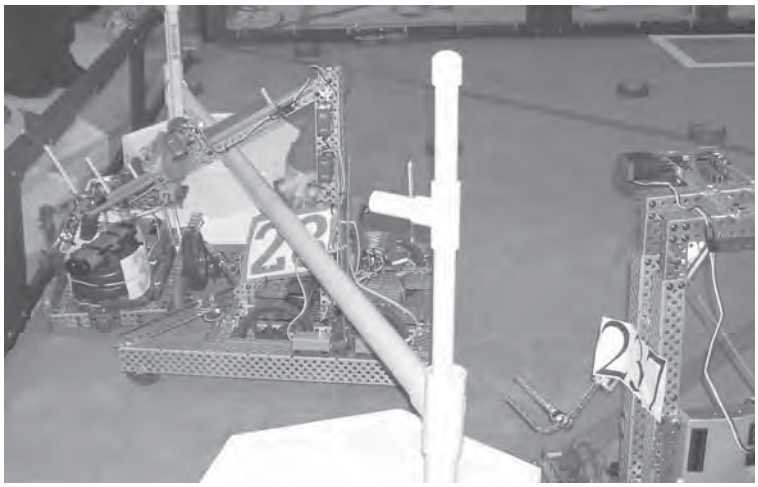
Strategy is very important. The world championship is in Atlanta each year. I'll show you our rookie attempt at that. The idea was to pick up rings and deposit them at moving goals. One pair of these goals are linked and there are 2 others there. We waved an arm around—player controlled not autonomous. We couldn't do much in the way of autonomous at all. My team wanted no part of improving their initial design; they wanted to start over again. First 20 seconds of match, we dumped our rings, and acquired a goal, to dump rings on. We had sensors, hard latch on it once we find a goal, autonomously. Then the rest was player-controlled. Picking up goals, we now had an intake system, limit switches, 4 wheel drive, no one could come and push us around or take our goal away. It was a question of leverage. We ended up with a very successful robot. The team decided to call ourselves the Poly-Gnomes. As we moved around the field, they automated a lot of actions. Subrouting became dumping rings. This played 2 on 2. In the morning are qualifying matches. Once we had a goal pretty full, everyone could go and take others. Lots of fun, fast and furious, engineers, strategists, fundraisers…. Really fun things.

Sons learned most about engineering happened during high school in the study of robotics, not during college when both pursued engineering studies.

Time management, deadline, working with teams, faulty hardware. PBS Nova program was predecessor to this. Hundreds of teams do this.







Note: The driver is a Waldorf gnome!

Robotics at the Green Meadow Waldorf School[1]

by

Winslow Elliot

They're called The Poly-Gnomes. They are a group of eight Waldorf students in grades nine through twelve who design and create robots.

And these students made up half of the championship alliance that won the Snow Day Showdown tournament in Hightstown, NJ, on December 15—an event that is part of FIRST, an international program designed "to inspire and recognize excellence in science and technology through robotics "co-opertitions."

Green Meadow Waldorf School's robotics team includes Alexander Evans, Nicolas Frei, Noah Kaplan, Gavin Langdon, Aidan Nelson, Charles Rudish, Sung-Pil Moon, and Sung-Ryul Moon. The team meets together after school every week under the guidance of GMWS's robotics coach and high school physics and math teacher, James Madsen. Together they strategize, plan, program, and build.

"FIRST calls them 'co-opertitions' because you have to cooperate as well as compete," says Madsen. "Sometimes during the competition someone from another team will help nudge a stuck robot, or we'll share software. The point is to help everyone do their best, as well as to win."

The FIRST Robotics Competition challenges teams to design a robot that will win against a robotics game designed by FIRST founder Dean Kamen and a committee of engineers and other professionals. Students are rewarded for excellence in design, demonstrated team spirit, gracious professionalism and maturity, and the ability to overcome obstacles. Scoring the most points is a secondary goal.

Winning means building partnerships that last.

All these goals are inherent in every aspect of the Waldorf curriculum, which may be one of the reasons for the Green Meadow team's success.

The game rules are different every year. This year's game was called Quad Quandary. "On the playing field there are a bunch of three-inch rings and different types of goals," Madsen describes it. "The teams are trying to gather rings and score them on the goals. The goals move. It gets pretty fast and serious." You can check out the game on the FIRST web site: http://www2.usfirst.org/FTC/2007GameAnimation/FTC_Animation_07_640x480.wmv.

The Poly-Gnomes spent a couple of months thinking about how they could create a robot that would win the game. "The students have to constantly apply all the physics and math they've been learning, weighing cost and benefits of using

1. Reprinted with permission from the *Waldorf Science Newsletter, Volume 14, #24*.

one design over another," says Madsen. "And without a lot of money to invest in research, you have to be more creative. There's a maximum of ten students on any team, which means that everyone needs to be active and participate.

"This is a terrific place for these students to be successful at something they are good at. It takes a lot of physics and programming to get the robots to do what they want them to do. They're computer whizzes; they are great at playing computer games, but with the program that FIRST offers, now they can get really creative.

"During the first twenty seconds of each match, the robots must operate completely on their own by following programming instructions written and pre-loaded by the team. After that, the controls can be taken over by the students for two more minutes. Team alliances are selected randomly, chosen two on two, in a mini-arena. In any given match another team could be an opponent or a partner. After numerous qualifying matches, the teams with the best scores choose an alliance partner, and one of the rules is that the top teams can't choose other top teams. The Poly-Gnomes team was selected by the winning team to be their partner because of their design and their collaborative efforts, as well as their software."

And so the Poly-Gnomes combined with Team Overdrive from Bridgewater, NJ, to win the scrimmage. They'll next be heading to NJ Tech Challenge in February, and then hopefully to the Javits Center in New York City in April.

FIRST emerged from a strong personality, a New Hampshire entrepreneur named Dean Kamen, who has several scientific patents to his credit. In the late 1980s, he saw something occurring in the United States that troubled him: Science and math heroes were simply not valued by young people in the same way as rock stars, athletics champions, and movie idols.

Kamen set out too create a venue that would inspire young kids to be scientifically and technologically challenged—something that would be as exciting as performing at a rock concert.

In 1989 he founded FIRST, an acronym for "For Inspiration and Recognition of Science and Technology." By 2007, 37 competitions had been held in places across the world—Israel, Brazil, Canada, and the United States. Kamen remains the driving force behind the organization and continues to gain support and publicity from major corporations, universities, and colleges.

"The way these events occur is very exciting," says Madsen. "There's loud techno music, it's all highly animated, and it's very exciting for the kids. It's nothing like a spelling bee or a science fair; instead there's intense animation, excitement, yelling, screaming. And what's really great is that gracious professionalism imbues everything we do in all the competitions. Dean Kamen's ideal of helping your competitors permeates every aspect. Being a monopoly and destroying everyone else doesn't help anyone. Helping each other helps everyone, and you see that in the competitions. The students are all helping each other, sharing software, helping with spare parts."

What is robotics? Simply put, robotics is the science and technology of robots, their design, manufacture, and application. Robotics requires a working knowledge of electronics, mechanics, and software, and needs to be accompanied by a large working knowledge of many other subjects.

Although the appearance and capabilities of robots vary, all robots share features of a mechanical, movable structure that is under an autonomous control. The

structure of a robot is mostly mechanical; its functionality is similar to the human body, formed of links (bones), actuators (muscles), and joints.

The first program developed through FIRST was the FIRST Robotics Competition (FRC), designed to inspire high school students to become serious engineers by giving them real world experience working with professional engineers to develop a robot. The competition challenge changes each year, and the teams cannot reuse components created for previous robots. The robots weigh around 120 pounds, depending on the current year's rules.

"Competition on a stage brings as much excitement and an adrenaline rush to the participants as do conventional varsity tournaments that are sports- or performance-based," says Madsen.

Mr. Madsen's children attended the Monadnock Waldorf School through eighth grade, but since there was no high school there at the time, they attended public high school. "At the public high school there was this fantastic robotics team the students could join. When I got the job as physics and math teacher at Green Meadow Waldorf School, I wanted to offer the possibility for students to take part in the FIRST competition."

An interesting aspect of the Green Meadow Waldorf students' doing so well with robotics is that in the Waldorf curriculum computer science is taught only after the students are adept in algebra and physics, typically not until high school. In the Waldorf curriculum, children learn conceptually only what they can actually do in practice. They learn first how a computer is made and how programming works, ideally before they use it to play games or conduct research. In this way they become masters of the tool, not the reverse.

An educational environment throughout the elementary grades in which students typically make most things themselves, including their own individual text books, might ultimately be the best place to achieve real expertise in technology, and to experience all its creative, imaginative possibilities. Additionally, Waldorf interfaces particularly well with FIRST's ideals of collaboration, team spirit, graciousness, and perseverance. Any Waldorf school interested in getting involved in FIRST can go to http://www.usfirst.org/contact.aspx?id=2878 to find a FIRST contact person near them who will help.

Eurythmy

Sustainability and the Applications of Simple Technologies in Our Everyday Lives

by

Brian Gleichauf

Michael asked me to speak about *"Sustainability in applications of physics in everyday life."* I appreciated how Geoff started his presentation talking a bit about himself. I would like to follow that.

This circle consists of seasoned Waldorf teachers in North America. I regard myself not on the same playing field as all of you, but with plenty of energy. I think my work with both phenomenological science and anthroposophy is quite new, about 5 years. I discovered Waldorf education in 2002, so really not long ago. Before that I was a public school science teacher with traditional public school teacher training. This led me to despondency and despair and drove me away from teaching for several years. I moved to New York and worked in a church as youth and outreach director. I do not have a technical background, just a BA degree in physics. I knew I wanted to work with kids…. I received an MA in theology at the same time that I was discovering the Waldorf school in Chicago. I think I have a little bit of a different background, maybe just one step above a novice in this phenomenology. One of the jokes about me is that at Christmas I have always apologized for how poor my present was. I will try to resist doing this as it's a habit I'm trying to break. I don't know that anything I have to offer is going to add anything, but perhaps a different perspective. Okay, there are all of my disclaimers.

What I am going to present today is a rehashing of my teacher training project in New Hampshire. We will have a chance to play with the ram pump when we're finished talking. I want, first, to meditate on sustainable technology in the Waldorf curriculum. What are the best technologies for us to implement in a Waldorf curriculum to prepare students for what they are going to bring? What exactly are we preparing our students for? A world that is changing faster than it ever has before, particularly since I was young—that wasn't very long ago. And the pace is increasing. We are trying to educate human beings for true freedom. In some ways we don't get to see the fruit of our work, since we know that the students won't reach full adulthood until about 21, quite a few years after they leave us.

So, I will leave that thought. I have three little stories to tell you, vignettes, from my life… how I got here.

First

The day before yesterday I had this experience as I made my way to the airport. I live in Humboldt Park, west of downtown. There is a Blue Line L train, not too far from my house, that goes directly to O'Hare Airport. My first decision was, should I annoy my wife by waking her up and making her drive me, wasting gasoline, or walk carrying my baggage, or take the bus. After hemming and hawing, I decided to walk. The whole time I was walking, I was having doubts and thinking that I should just wait for the bus. All these considerations went through my mind. When I make it to the Blue Line, I wondered, should I take the elevator or walk up the steps because I am able-bodied? As I was walking, cars were whizzing everywhere, not a nice awakening because it is not a route I'm used to. Cars almost run me over, exhaust spews out. I pass a lot of infrastructure of the city, fire hydrants, buildings, and different features of the city. As I am passing them, I was thinking about technologies.

I get to the turnstile and swipe my CTA card which is directly connected to my credit card. The train goes underground for some time, and as I am riding the train, I have glaring fluorescent lights in my face. Then the train surfaces just as the sun comes up over the city and bathes the train in this beautiful golden glow. (I usually choose my seat when I ride the L in the morning so I'll get a good view of the sunrise.) The contrast between that warm glow of the sun and everything else is always striking. I pass the turnstile which records my exit, and security cameras capture me as I go. I take the escalator and I get to the level where you check in. Because I had checked in on-line the day before, I must pay attention to where the United.com check-in is vs. the regular United check-in.

After checking my bag, I buy a cup of coffee, croissant and a banana, all of which, of course, come from different countries. I walk through security. Unfortunately, I bought my coffee too early, so I had to throw it away. Now I have to go through security, take off shoes, belt, everything out of my pockets, etc., taking out my laptop, putting everything in separate bins. An older couple is confused by this process, so I'm patient and wait for them to get through. Even though they took my coffee, they let me take my banana and croissant through.

When I get to the gate, the plane is delayed because a work crew has the jet engine open, and are doing something to it, consulting a manual. The crewmember has to do it by the book according to FEMA, exactly the way they say. Although they got the repair work done in 20 minutes, we had to sit on the tarmac for 20 minutes because they had to first complete the paperwork before we could take off.

My trip to the airport is a meditation on the invasion of technology in my life, whether I like it or not. The only image that was positive was the sunrise. The only other positive experience was the lift-off of the plane. It's an incredible feeling, that buoyancy and lift.

Second

Even though I love the outdoors, I am a city boy. I've come to terms with it. The second picture is from the 10th grade. I'm the advisor for the 11th grade. Every year we go to different locations for the 10th grade service trip. My co-advisor for 11th grade and I took them to Vermont to work with Dave Maynard (Orchard

Valley W.S.) and the Yestermorrow Design School. At Yestermorrow, they had adult classes going on too. One group was timber framing with non-power tools, which was fascinating to compare what they were doing with what we were doing. During the first week at Yestermorrow, they taught us basic carpentry skills; then we built a sheep shed, which was our gift to the school.

In the second week, we camped out on the property and learned "primitive skills." The picture I wanted to paint for you… When we arrived, it was raining, and it kept raining for 7 days. Vermont is a rain forest; I should've made the connection with why it's so lush and green there. No one ever goes down there to where we were going to camp in the pouring rain, so there were no paths. We were wading through knee-high grasses, getting soaking wet. It became rapidly clear that shoes were a hindrance. We had plans to learn certain primitive skills—everybody got to make fire, rope, forage. But if you were to ask the kids what they remember about that 2nd week was that it was viscerally hard to live in that element. They would wake up in morning and everything was wet, there were slugs covering everything. We walked on rough ground with sharp grasses. It took 15 minutes to get to the composting temporary toilet. Everything slowed way down in this experience. Everything was more difficult and you could not multi-task. You couldn't walk and ponder, you had to focus on where your feet were going. This was very different from the city experience. We all agreed that it was a really tough week. While everyone was miserable, at the end, for the first time ever, some students expressed deep gratitude for the gut-wrenching experience, which was without the technologies that we use and take for granted.

Third

My wife and I are reading the *Little House on the Prairie* books. I find those books fascinating. All of them cover a progression, but they take place just before oil came on line, and the incredible acceleration of new technologies. In the books, you can see foreshadowing of what is coming. There is more connection to the town in *On the Banks of Plum Creek* than in *Little House in the Big Woods*. Laura's father is now working in town, whereas before they were living on the land. *Farmer Boy* is specifically about the encroachment of technology into traditional farming life. Alonzo doesn't really know whether to work in town and become a wheel maker or to be a farmer. Most people today don't make that choice, or don't even have the opportunity any more. In *Farmer Boy*, Alonzo's whole life was that we have to get the potatoes out or pick corn in a rush.

As a side note, I'll just say that I was struck by how Alonzo's father treats him with great independence. Alonzo puts a few potatoes in the fire to assuage his hunger. The potatoes explode and burn him badly. His father checks him, makes sure he hasn't lost an eye, and sends him back out to pick potatoes. Another time his father builds him a sledge, and he falls in a ditch, and his father continues hauling wood and lets his son figure out how to get himself out of the ditch. Clearly, Alonzo's father feels that it would hurt Alonzo's growth and development if he were to help him out of the ditch, instead of letting him figure it out himself.

All these three examples have to do with technology and how it affects our lives today. When thinking about technology, it occurred to me to do what our students

always do: Consult Wikipedia! I looked up *technology*: "Technology is a broad concept that deals with a species' usage and knowledge of tools and crafts, and how it affects a species' ability to control and adapt to its environment.… In many societies, technology has helped develop more advanced economies (including today's global economy) and has allowed the rise of a leisure class." Many technological processes produce unwanted by-products, known as pollution, and deplete natural resources, to the detriment of the Earth and its environment. Various implementations of technology influence the values of a society, and new technology often raises new ethical questions.

There are some interesting terms I came across in this definition, that I had never hear of. Maybe you have:

On the anti-technology side:

- Neo-luddites = anti-technology folks
- Anarcho-primitivists = advocate for deindustrialization

And, on the pro-technology side:

- Trans-humanists: people who believe that the human being can be enhanced or perfected through technology
- Technoprogressivists: people who generally see technological development as always a good thing

We had a student do a senior project on nano-technology and the final slide had a human being stretched out with a rainbow background and various technologies surrounding him, essentially elevating a human being to a higher level by transcending limitations. I would say at that moment in his life he was interested in trans-humanism, escaping normal human life. I would also say that, after reading those definitions, a strong strand of technoprogressivism runs through our popular media every day.

This is where my original project starts. First, technology, then sustainability. I taught a class at school called Science Elective. We built a solar water heater out of spare parts, and we built a wind generator. Out of this I read about different approaches to sustainability.

1) The first group is broadly characterized as tree-huggers, which is to say there are many who, when they think about sustainability, focus on minimizing the negative impact of human beings on earth. It is based on the inherent assumption that most activities human beings engage in are not for the health of the earth. They want to promote the health of the earth, feeling that the earth would be better off without human beings. This group includes The Nature Conservancy, Green Peace, the National Wildlife Federation, and Al Gore's film *An Inconvenient Truth.*

2) A second group is the peak oilers, folks who think about sustainability as an energy equation—using too much energy and not producing enough. If

we can find a way to curtail our needs and increase our production, then everything will be okay, just like balancing an energy equation. This includes the National Renewable Energy Laboratory, a lot of folks who are home project people, *Home Power Magazine*, and folks interested in that aspect of the energy while trying to get off the grid.

3) A third group is Permacultures. I think this has a lot in common with anthroposophy, because Permacultures begins by speaking about the human being. One of the problems with our understanding of technology, and with the first two approaches to sustainability, is that *the human being is not present.* But the Permacultures' main goal is primarily for the health, wellness and happiness of the human being. I think it makes a difference.

This may seem a little antithetical; it seems that there are a lot of human beings who are incredibly comfortable right now. But are there really? I don't think there are a lot of comfortable human beings in our current state.

The first story I told was about a lot of choices, not particularly happy choices. The time was a time with very few choices, but in that lack of choice, in an incredibly beautiful place, we had deep and interesting conversations around the campfire about sustainability. One of the questions I asked was: What are the best technologies for us to use to influencing human culture? Most of the world assumes they are just tools available to us. But, the Wikipedia definition says that *technology by its very nature implies relationship*. It is interesting to think that any time you choose to use a technology, you've established a relation with it just as you would with another human being.

That's what I think is wrong with our current culture, a lack of understanding of the relationship that every technology demands. For example, why do we not have a mass-produced electric vehicle now? I think the reason is that human beings haven't decided to have a relationship with an electric car. Rather, we desire a relationship, in fact, we are addicted to a relationship with our gas-powered cars. Some technologies lead us to an addicted relationship and others to a more sustainable relationship. What is the nature of the relationship with that particular technology?

I'll tell you one more story. My wife loves gadgets, and I chose to get her an iPhone. A new version came out after our anniversary, so, for the first and only time ever, we waited in line on the first day it came out. It's fascinating to me these folks who regard it as a useful use of their time to stand in line and get one of these things. That's this addictive relationship that I'm speaking about. We can say, "Oh, my God, what a bunch of idiots." But that's most of the world. The problem is that passive consumerism implies an addictive relationship.

What's the best technology for students in a Waldorf school?

1) The relationship between the human being and technology is clear.
2) Inspire some kind of idealism.

Recycling is a good example. It's incredibly hard to get people to change their recycling habits, or lack thereof. Everyone has a relationship with their type of

trash or refuse, and it's usually neglectful. In that way I think recycling has a deep connection with our etheric bodies, the habits that we have. Habits have to change. Every technology we take up has a deep connection to our habit life. I think people are going around life unconsciously impacted by these things.

Worm composting is another good "technology" that also demands a change in our etheric. It also has an attraction because it allows kids to get directly involved in stirring the worms, depositing food, schlepping things around, etc. It is important for high schoolers to get involved with forms of technology that are not high tech, simple technology with which you can develop a relationship, e.g., a solar water heater.

I guess all of that explains why the ram pump is interesting to me in a Waldorf curriculum. It is a technology that demands a reciprocal type of relationship, and it is just for that reason that I think so many people don't use them. The electric pump costs a lot more money, uses more materials, breaks more easily, but probably is more preferred because it doesn't *seem to* require any relationship from us. Some history: The first ram pump wasn't a true ram pump … not self-actuating, but required a boy to make it work. Related to the Lunar Society—Joseph Priestley, Benjamin Franklin, Erasmus Darwin, inventors late 1700s who were meeting when the moon was full to try these inventions. They did this when the moon was full to make sure they could get home at night. In 1772 John Whitehurst of Cheshire in the United Kingdom invented a manually controlled precursor of the hydraulic ram called the "pulsation engine," but didn't perfect it or pattern it, rather the Frenchman Joseph Montgolfier invented the first self-acting ram pump for raising water in his paper mill at Voiron. He is best known for inventing, with his brother, the *montgolfière* style hot air balloon, globe *aérostatique*, or airship (1776). Early ram pumps failed at first because they were made of wood and blew up. But they became wildly popular in the 1800s. When I was building one, I went to the hardware store seven or eight times. They asked me what it was, and there was only one old guy who knew what I was talking about. The ram pump moved into obscurity because of the recent expansion of the electric pump due to the 'relative' inexpensiveness of oil.

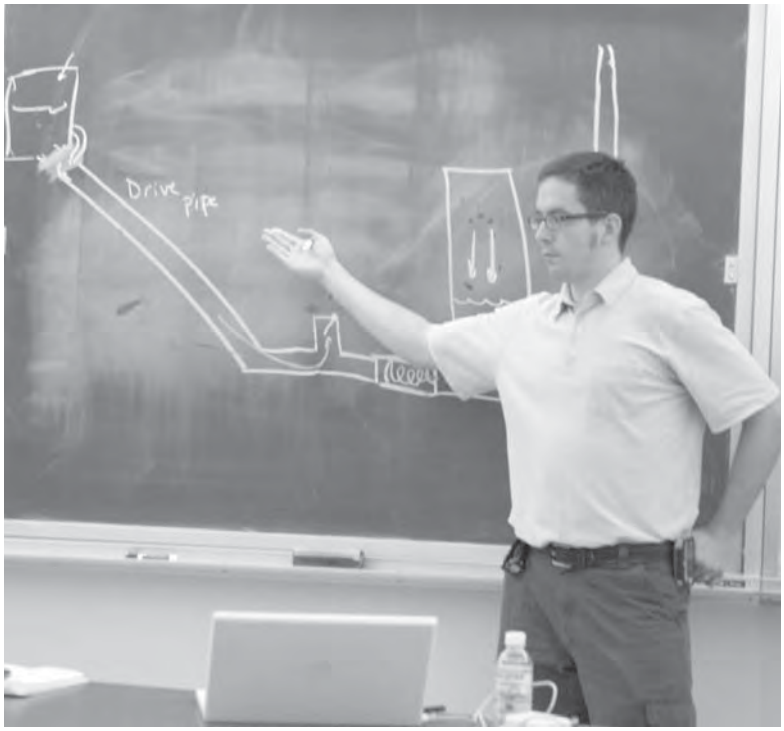
To understand how a ram pump works, it's much more helpful to think about it as an oscillator, the oscillating medium being water, put in relationship with 2 valves that operate in polar ways. When one is open the other is closed and vice versa. You have a long drive pipe, which is the most important piece. One question for further research: *Does the drive pipe always have to be straight?* Another interesting question to research is: *Can the drive pipe have different geometries?*

When I first attempted make a ram pump, after building it, I tried using a rain barrel at the top. It didn't work. I almost gave up in misery. But I noticed that when I unhooked the thing, then it started to work! This led me to realize that it's necessary for the drive pipe to be open with liquid/water flowing in at all times.

So, the steps of the pump's working are: There is a flapper valve at bottom, which is open due to gravity pulling the flapper down. Water will rush out, but forces the flapper to slam shut. The water pendulum will swing forward, toward the spring check valve, and the pressure that has been rerouted then forces open the spring check valve. Then an air reservoir is reached. Give pendulum a few kicks. It starts to fill a chamber and air pressure increases. When the air pressure is enough, what will

happen is that the pendulum will start to swing back on its own. It will rush though as long as pressure in the air pocket is less than the water pendulum pressure. When the pressures equalize, the spring check valve closes, trapping the pressure, the water pendulum swings back, the flapper valve opens, and the whole process repeats.

The elastic medium is the air that compresses. Then you can open a valve on this end and use pressurized air to pump water to higher elevation. One thing about this device that is so beautiful is that it is so simple and so hard to break. The parts are hardy. I think it has a lot of potential in the area of research. Companies who make this typically shape the reservoirs almost as an egg (perhaps for strength). An interesting area for research: *Shapes for reservoir.*



Brian Gleichauf

Demonstration #2

Hydraulic Ram Pump

by

Brian Gleichauf

Today ram pumps are used only in extreme rural areas. Could all of society use this technology? Yes! Particularly because the materials are so cheap and the design simple. Clemson University has a website that describes how to build one. This is only the third time I have made this work, when I have understood how. Start off with the valves both closed in order to manage the water pressure.

1) Turn on the water. Drive pipe fills. When water spurts out the other end, then we know it's full. Leaving the water on, turn down its flow.
2) Next 'prime' it to increase pressure. See the valve begin to rise. With a longer drive pipe, can build pressure. It is a pretty sensitive instrument, in terms of the period of oscillation. Many factors affect that.

Materially-speaking, for a ram pump that will be actively used, PVC pipe is not advised, but iron instead.

Based on the water source, every ram pump will be different. Installation and use must have relationships with the landscape.

Spring check valves are available at any hardware store, though I've noticed that there seemed to be just one type. It is possible that the pressure rating may be indicated on them if they do vary.

Water never stops moving, so it won't freeze in cold temperatures. To lift water over a hill:

1) It is possible to have a series of ram pumps working together over a large distance, or
2) Extend the drive pipe length for even as far as a ½ mile.

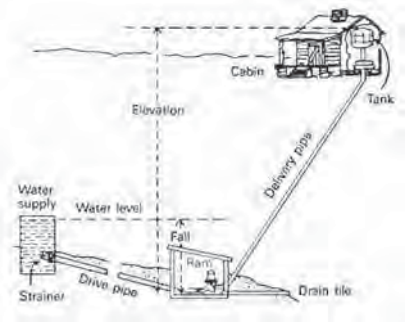
There are minimum and maximum drive pipe requirements, otherwise the ram pump cannot work. If it is too long, it will shake itself apart. To alleviate this problem a stand pipe can be built (somewhere along the drive pipe) to dissipate the shock waves.

You can squeeze the flexible tubing to influence the frequency of the strokes, and it will function like a clogged artery.

There are constantly 2 pulses, one traveling up the tube and the other back. The pulse runs back and forth. If you place your ear at the top of the drive pipe you can hear the pulse.

Another version of the ram pump that I have seen has a check valve that is a big flap of rubber: the flowing water of the drive pipe flows over it. It is the Bernoulli effect that closes the flapper. There are two companies, Rife (www.riferam.com) and Green and Carter (www.greenandcarter.com), who have been making ram pumps continuously for over a hundred years.

Briefly, here's how a Hydraulic Ram operates: Water flows down the Drive Pipe #1 to the Ram #4, developing power in accordance to its weight and velocity. The water then flows through the Outside Valve until it reaches a certain velocity. The Valve #2 then closes shut and water continues through the Inside Rubber Valve #5. When the water pressure in the Air Chamber #6 equalizes and overcomes the driving force behind it, the water in the Drive Pipe rebounds, or backs up. When the rebound takes place a small amount of air is sucked in through the Air Feed Valve and lodged in the upper portion of the Base. It is then forced into the Air Chamber when the next blow takes place; this prevents the Air Chamber from filling up with water. This operation is repeated from 25 to 100 times per minute working on a Hydraulic principle, building up pressure in the Air Chamber, which in turn forces water through the Delivery Pipe #3 up to where it is desired.



Brian Gleichauf and participants building a Hydraulic Ram Pump

Discussion #6

Paolo:

You can talk about it in a lot of ways: potential/kinetic energy, momentum, extra energy that is imparted by oscillation, also pressure.

Michael:

The key word Brian has used is harmonic, it sets up a resonance phenomenon.

Brian:

Initially, I had a rain barrel set up high, directly connected to the drive pipe. The only way to make it work was to disconnect it and run a hose flowing openly from rain barrel to drive pipe. The open hose went directly into drive pipe. You can then change the incoming water flow.

John:

I think it's also interesting to know if it wouldn't operate with a high pressure hose. I think there's something important going on with the drive pipe.

Brian:

I should also say that Michael suggested this topic to me because of a comment that Rudolf Steiner made: If you really want to understand the human heart, you have to understand the ram pump. When you feel it, it feels uncannily like a human pulse. Harmonic tendencies of the heart that connect = classic physical/life science.

[Michael told of a series of meetings he had had with an anthroposophical doctor every other week over the course of a year, exploring the mechanics of the human heart, some of which they have been able to confirm, but is still unfinished. This is such a crude simulation. If there is a connection, it's a rough connection. If anything, it's two ram pumps working in tandem. Have to look for something else… Steiner says "it's a place to start."]

Brian:

At my school, what I realized is that I have never been able to cover the topic of pendula. I think a block on harmonics, every aspect of it, they'd love.

John:

Great experience I had was having one of the students BE the pendulum. The "Aha" moment is strong when they realize that the frequency is the same for smaller and greater weights….

If we look at what public schools are doing, there are lessons in which the students ARE the experiments, such as with skateboarding and snowboarding, how inherently in these sports are kinematics principles and laws.

[Quote written on the blackboard:]

> *The rush and pressure of modern life are a form, perhaps the most common form, of its innate violence. To allow oneself to be carried away by a multitude of conflicting concerns, to surrender to too many demands, to commit oneself to too many projects, to want to help everyone in everything, is to succumb to violence.*
>
> – Thomas Merton

James:

The motor boat is still connected to nature in some way. Very different experience: we carry you or a motor boat carries you. Here you are working with elements of the natural world which are not mediated by…. Electric motor is an electric phenomenon, but somehow you still feel much more distant from it.

Part of this relates to the question of what we put in the 3-4 weeks of main lesson. I spend a lot of time on energy utilization. I think it is so important for them to know about this, which they may never see again. But in order to do this, I have to give something up. If I talk about safety of cell phones, we need to develop also an understanding of how they work.

Brian:

Why I brought up the camping experience, of going into nature, was just to experience that you don't need much to survive. These technical conveniences are convenient for one, but they have consequences and fundamentally alter your consciousness if you choose to use them.

John:

I would like to offer two thoughts: I am struck again by all that you [Brian] brought. People think of physics as a multi-million dollar industry, as with subquark quantum physics stuff. And yet this is physics, too! *Physica*. Whatever version you teach them will be a wonderful accomplishment.

Brian:

E.F. Schumacher—"Small is beautiful" stuff. I guess I didn't know it at the time. I didn't know why I was attracted to the work, but because it is easy to have a human relationship with technology, because you can fix it. You can't fix a cell phone, most can't fix cars. Then they become trash if they break down. In reaching human beings, teaching through human relationship to the subject, then these technologies are appropriate and beautiful in that way.

Zero Emissions Research Institute (ZERI):

Their goal is to study nature, and their main thing is that in nature—a cliché but true—there is no such thing as waste. Goal is to look at industries that already

exist and see how they can symbiotically feed into each other. *Upsizing* is a book of theirs.

One idea that strikes me about technology today is that it is quite crude. For instance, in the electricity and magnetism block, there is a huge moment when even though we have fancy ways of heating, we simply need water, create steam, heat wires… crude for all of its complexity, it's not particularly elegant.

Paolo:

As soon as we meet magnetism, a wall appears. Sub-nature of forces, as Steiner says, you're in a very different world. Suddenly you take an electric motor which is very simple to understand. It is an electric motor, but something is lost in the connection. This has to do with the quality of electric forces that bring you farther away from the connection you are talking about, which drives everything.

Brian:

More gaps you go between, water to heat to steam to electric magnet to … lose human connection.

Michael:

I can share with you from an essay I wrote and posted on www.Sensri.org., "The New Environmental Aesthetic," an article on first page. I recognized the key question for me out of technology. I came out of electronics—I love this practical hands on. But for me, this is my gateway question: Does the result of technology create greater opportunity for human consciousness and awareness or cause us to go to sleep to the world? If a technology gives us greater connection or experience in the world, then it is noble if the result is a greater awakeness, a greater sensitivity then. But if we fall asleep to a controlled environment and lose connection and end up in "my own world," then, perhaps, it is no good.

It is "easy" that we want. So much of technology is to create ease. "Ease is the rejection of the will." The leisure idea is that we don't have to work. For me the huge irony is the leaf blower. Put all these resources into this device, put on headphones so you don't hear the noise, feel an irritating vibration, awful smell, and blow leaves around. I watch my neighbor do this, and then he rides an exercise bicycle. What about the rhythmic exercise of raking? It's better than getting in the car to go to the gym.

While waiting in the airport for my flight to leave, I noted the patterns that raindrops made as they moved toward the ground while stuck to a pane of glass in a window. There were many different forces at work here: gravitational, the adhesion of the water to glass, the cohesion of the water to itself, the wind.… There are so many interactions happening right there in these simple phenomena.

I became very passionate about this and convinced the art teachers one year to give up a block so I could investigate with the students the harmonic relationships of form to rhythmic processes. The block was a combination of biology and physics. We studied the stream and how fish move in a stream. We then killed a trout and looked inside, at the relationship of efficiency and form. Much of this work was inspired by Victor Schauberger, who, born 20 years after Steiner, I call "the other

Austrian." If you want a book to spend your life on, read the book by Callum Coates, *Living Energies.* If you can understand that book, you will see a window into the whole of technology, every aspect of our world, the harmonic relationships—it's like a Holy Grail of what technology could be. This is the essence of what I call my hidden project. Can I help to educate human beings enough to take that next step? Imagination that weds what I think has been the essence of these four presentations.

Betty:

I lived for 35 years with a wood stove by which I was totally connected with temperature and nature. Now my new place is on a thermostat. I do nothing and am totally asleep to nature. It is really bothering me (although it is so much easier). Previously I looked for wood and had a relationship to nature around me. Now, I have to compensate in other ways, so I just planted a winter garden. But if the thermostat allows you to connect in another way, then perhaps it has a benefit.

John:

Pedagogical question: Why is it that somehow all teenagers I am around love tech? Such as iPhone, robotics, computers—both girls and boys. I have some sense why. It gives the sense that 'I can create a lot of ease while at the same time....' A teacher in the school got students to agree to go one week without any media devices. They did it this during senior year. In what way can we sow seeds? Do you we have to wait for senior year? How do we find ways to get them to do inner work as a counter-balance to what will always be around us? I have always been intrigued to see how many elements of this I see in the teens. Why aren't students shuddering as I do. They are so young, still in the immortal phase. Teens engage in super-risky behavior because they're not thinking about what will happen in another stage. We can't be neo-luddites, so what are we going to do to counteract? We could do wilderness retreats. Get someplace where you can't get away from yourself and there is no one else to distract you. Again and again they come back with a sense of how incredible the experience was for them. They would reflect on it as one of the most significant elements in their life thus far. Is there a way to bring about this experience earlier?

Ruth:

Here's an anecdote to share for this conversation: Where a lot of technology is going is a crude replacement for where our higher faculties are supposed to be going. When my husband and I were first together, we could communicate regularly over distances. Then I got a cell phone. Since then this ability has been diminished. We strive to do the inner work to remain connected; however, it has diminished. Through eurythmy, though, we have been able to keep this quality alive.

Ahriman and Lucifer are both in technology. Ahriman influences the passive consumer. My job is to be as helpless as possible, buy more stuff, as President Bush said post-9/11.

Transhumanism idea might sound a little nutty, but most people believe it, implants in our brains someone improves our imperfect human bodies.

Do we hide in a cave? I think our task is to redeem technology somehow, find way to transform it.

Beth:

What does technology demand of us? I like this question of yours, Brian. I think it could lead in a positive direction. It's not going to go away. It's harder to be human, but technology requires us to consciously work on our habits and consciously develop our etheric in ways we weren't so forced to do, as before it was a natural gift. How do we help students see the value of face-to-face human interaction? For years my husband and I knew naturally where we were throughout the day. Now since cell phones, it is so easy to forget to have that connection. In the Waldorf school we have the opportunity to teach kids how important the human connection is. How do we do that? One idea we have been experimenting with is team teaching. Students see two teachers working together—how two can interact, disagree, be prepared, not prepared. They get to see adults practicing something. It didn't occur to me until now that they can see us modeling this kind of interaction.

Brian:

The Little House books are so much fun to read because they harken to a time when people didn't have to override their etherics.

Michael:

First, I start my astronomy block asking: Can we spend the first week by giving up technology and noticing biological patterns tied into rhythms of the sun? I think that's one opportunity we have to help our students develop their awareness.

Second, I have been working with another idea for a while and find it builds in time. There is a good positive quality to all of this busyness we have. As life speeds up this will force us out of the materialistic world view, to be able to live in the dynamic aspect of life. The incredible ability that comes with the mindfulness they can have in chaos and in motion—that is the future. In order to live in a dynamic world that is not materially based, we can't live in the past or future, we have to live in the here and now. All cell phone conversations are the same—reporting in where you are and have been and are going. The "here and now" is gone. This mindfulness I describe our students have better than we do, but if they are not careful, they will lose it. What could make us conscious in the present can be lost. It is a struggle. Bring rhythm into the astronomy class. Let's try this and see what happens. Take them places where they can focus. In astronomy I give them the option. I take them to a place in mountains and we arrive at night. We have to cross a narrow bridge, 30 inches wide, over a stream, no lights, and we don't use any electric lighting the whole night. It's fantastic. I take them off the trail at night with no artificial light. Can we find our way? It's incredibly profound. The world is more alive under a full moon, more dynamic than in sunlight—a most unexpected quality. I didn't have a concept that I was trying to give them. I just wanted to give an experience of what it means to be human under these different conditions.

Bob:

I think our alumni look back on us as touchstones. I think it often felt flat, that we were preaching to them. We leave them at age 18, but they are not fully adult.

We need to look at our alumni, to help them to ponder their relationship to inner development and their relationship to technology.

Fred:

This came up in our school recently: "How much is too much?" Here's humanity and here's technology. Usually we think only of one or the other. Are there parameters that allow for both. Deconstruct 'better'? Does it make you more conscious or less? Would I rather be carrying water right now? Not a yes or no answer. If it is done day after day, does it then becomes less conscious? Maybe as some have come in their lives to the point one realizes I no longer know where I am, then there is the need to rejuvenate. Choosing to carry water is a choice.

Michael:

There is an aspect of society that we don't have a choice. It's why I don't badmouth WalMart anymore. We have a slightly higher level of choice because we have the opportunity to have or not to have. This makes us slightly more responsible. Welcome to the age of Consciousness Soul. With individuals, in this situation right here, right now, this is what I choose.

[A question was asked about what we do as a rhythmic warming-up activity at the beginning of a main lesson.]

Fred:

In optics I also do form drawing as an extension of wave forms. I've been kicking myself—I gave up electricity block and am regretting that. Had some pretty good ideas. The fellow who took it over is a metal crafter who works with copper. I don't know how I could be precise with how that is connected. I also work with one of the English teachers who teaches Parsival and brings traditional sword activities into the quest. There is an extension of the self through the sword, study on the side. With 11th graders, she's thrilled with the effect on focus and disciplined exercise. Fantastic way to set children up to go into Main lesson- go to woods every day. They're quiet and focused on it.

Michael:

If you can create an atmosphere of quiet and focus in teenagers, I don't know that it matters what you are doing. [Laughter] But if you can create some activity that brings them into focus, that is huge and not to be taken lightly. Isn't that the intention of the exercise, to start from the same place with focus?

Paolo:

Now the only thing I do that I have found really exciting is to read a play. I read a scene every day for about 15 minutes, living into the moment of the time of the personality. Really beautiful and really helps. It is really a challenge. I have tried eurythmy before astronomy but we dropped it, didn't seem to work, being in the morning. We tried gymnastics when I was teaching projective geometry but the experience was the same. "Why are you asking me to do strange movements?"

they asked. You can be as successful as it is meaningful for you. I would love to hear experiences shared by others. Bertolt Brecht?

Michael:

Procedurally, we can take a few minutes with this theme, but we have other questions we left that were meaty from the morning session.

Brian:

10th grade as well, I was struggling with something to do and came up with this idea. On the first day of the block—bean bag activities for the Kinematics (Mechanics) block. I pair partners, everybody at the same time, throwing while walking in circle. Lots of variation—it really worked well.

Fred:

Astronomy—distributed pictures of the galaxies on black paper, with white pencils. Students pick a galaxy and do their own artistic rendering.

John:

Through my original mentor, a fan of speech work, I was inspired to take it up. I started taking it up but dropped it for awhile. Ten minutes in morning (we only have 1 hr 35 minutes in ML) reading the *Almanac*. 11th grade reads *Uncle Tungsten*. I've been reading it myself, so many pieces that could relate to every student. They were so into it. It can be done, they were into it.

Tara:

This day in history—something in science, born or died, an event, something about the world that happened and spurs discussion, i.e., the anniversary of Chernobyl.

Michael:

Constantly scanning news for interesting and related stories. Mechanics block—in Miami a woman fell off a 4-storey balcony and landed on an awning, exactly the day we had developed the equation to calculate this. A gift out of mainstream news! We figured how fast she had fallen, and her deceleration rate of the awning = 3-4gs. "'Ah, someone can survive that." Another year I came across a website where Wile E. Coyote sued the ACME company for all of his falls and misguided trajectories. This turned into a number of homework problems.

• Sketch a rock or write a poem about a rock. Practice using all your senses. They really love it and I couldn't believe it. And they love to read them out loud.

• Music or speech. I am a campfire musician, so I play my guitar. Work on with class until performance standard. One each.

Brian:

Piston dance—thermal physics. Performed in the 9th grade. It was great. I found at recess the juniors trying to recall the moves.

Gentleman visiting from SWS:

Pick different videos with themes- ultimate scientific methods song. Walking on beach one day… can't get rid of it no matter what you do. Ends up at heaven… moral of story if you find a box on the beach, don't open it. Steve Martin, "Grandmother's Song." We can get a theme for each one, extra credit on the quiz.

Geoff:

I've tried all kinds of things—a few poems in astronomy to help remember the constellations and zodiac. Francis Woolls had some good stuff which I believe is in in Norman Davidson's book.

Michael D'Aleo

Discussion #7

A perfect description of phenomenology is "Everything Is Waiting for You" by David Whyte. Michael shares this poem with his 12th graders.

Everything Is Waiting for You

Your great mistake is to act the drama
as if you were alone. As if life
were a progressive and cunning crime
with no witness to the tiny hidden
transgressions. To feel abandoned is to deny
the intimacy of your surroundings. Surely,
even you, at times, have felt the grand array,
the swelling presence, and the chorus, crowding
out your solo voice. You must note
the way the soap dish enables you,
or the window latch grants you freedom.
Alertness is the hidden discipline of familiarity.
The stairs are your mentor of things
to come, the doors have always been there
to frighten you and invite you,
and the tiny speaker in the phone
is your dream-ladder to divinity.

Put down the weight of your aloneness and ease into
the conversation. The kettle is singing
even as it pours you a drink. The cooking pots
have left their arrogant aloofness and
seen the good in you at last. All the birds
and creatures of the world are unutterably
themselves. Everything is waiting for you.

– David Whyte

How some teachers spend the time in their blocks:

- For one with 120 minutes, 30 are spent on Main Lesson enhancement.
- For another with 105 minutes, 15 spent on Main Lesson enhancement:
- For the benefit of addressing the needs of children with artistic sensibilities, for all who learn in different ways, for those who learn kinesthetically. And without the expectation that it is carried by the Main Lesson teacher.
- One had considerable success working with eurythmy during their physics block, because their eurythmist knows how to present polarity. Spatial dynamics teacher presented the theme of balance through movement, which, too, was effective. It has all been a grand experiment, though it has been difficult to document results. Overall it has worked to deepen the themes of the Main Lesson.

Beth:

It would be helpful if every teacher could share concrete examples, for pictures of possibilities that aren't so much qualitative. Such as eurythmy taught in conjunction with projective geometry, because for some students they will have a different experience of the infinite.

Another suggestion is form drawing used to support the lessons of atomic physics, so the students have experiences with spiral forms, investigating the form of the infinitely small. Then this involved them into Celtic knots.

Michael:

To get back into the conversation we had this morning, I will make a few statements to bring us back into that conversation.

When I teach a block, I don't have to do a perfect job of linking the pieces. Rather, I have to create the conditions where the students have to link the pieces. In my class I'm not proving anything. I am creating conditions for students to think though various phenomena. I will regularly walk into the room without a fixed definition about what we will be investigating. Because my response as a teacher is to acknowledge when they have arrived at a truthful definition of their own. They have to come up with something the rest of the world would agree with. This is absolutely an essential part of my class. In this case you're practicing your judgment as you're asking them to use theirs. If there's a problem, I don't say, "That's wrong," but I ask a question that helps them find one that's right.

Paolo:

Rich conceptual understanding and practical abilities are polarities, and are not oppositional. We should be clear about the distinction between dualities (opposites) vs. polarities which are two poles that are connected and are a part of a greater wholeness, the same.

There are 3 elements I would like to acknowledge from the different presentations we have had. All 3 are present in a good main lesson block:

1) Past: We need to recognize the wisdom we find in traditional cultures, what is held to be true over time. That, to me, includes the phenomenological heritage of those who came before.

2) Present: There's a conscious conceptual understanding of our present science and technologies and that's making sure our students can find a way to form an appropriate picture when they hear a scientific term of the present day. They need to be able to say, "I understand the basis of an electric motor, a camera…."

3) Future: The conscious creation of what we could call sustainable technologies. Taking the best of the past and bringing it forward. Out of bringing the past forward and being mindful of the present, then a true sustainability can be reached for the future.

I would recommend the book *World Changing,* available at Worldchanging.com-Abrams Press. The editor is Alex Steffan, who wrote a most brilliant introduction. You want the introduction. One of the most brilliant 8 pages I've read. He mentions that the problems of present society will not be solved by governments or NGOs, but rather by individual human beings in community, sharing their ideas freely together, what they've come to know and understand. What follows are articles about different things people have done for sustainability. I'm not saying they're all right, that's something for you to decide. By the way, he is a graduate of the Green Meadow Waldorf School, a student of Stephen Edelglass'. Here we go, we have some allies in our Waldorf graduates!!!

Classic Phenomenology: mindful, articulation of cosmos, and not necessarily adopting it.

In my own life, I have had different balances at different times. Sometimes my class, sometimes I need to develop a new aspect of something in me. And my sense is that if we're a city school, we may need to have a different balance than a country school. And that depends on our students.

Brian:

That's a beautiful synthesis of what we've been talking about and what we're trying to do with the physics curriculum. It's an ominous situation with the state of the world and it's remarkable in a certain way. Folks like us are responsible for this materialistic world view that reigns supreme and is inhibiting society. We can also be the ones who redeem the situation.

Rick:

I haven't gone through the training, or been exposed to Waldorf education for a lot of years, and I'm afraid I'm not getting a lot of this. I wonder if I may ask some questions about the concepts behind the phrase "materialistic world view."

Michael:

The whole world is ultimately made up of billiard ball-like particles, and anything that is real—show me, let me touch it. If I can grab hold of it, then it's real. If I can't touch it, then it's in question. For example, a rainbow isn't real, a hologram is just

a trick, and, because it is intangible, music is just atoms vibrating in air. We look to a causal agent for everything we experience. We want a material basis—it gives us a firm ground to stand on and there we feel comfortable. Why I chose electricity and magnetism for a presentation for this colloquium—because we can't interact with it. We keep coming back to: All phenomena must be object-like. In *Marriage of Sense and Thought* (p. 36), Edelglass quotes Galileo's distinction between primary qualities/senses and those that are secondary as simply the result of the interaction of primary qualities. The primary qualities are simply those associated with a concept of matter—shapes, numbers and slow or rapid movements.

Rick:

We get into string theory, modern physics, and describe them as fields, then the whole thing about reductionist people, emergent systems 'these things come…" Something that is moving that has effects that we call electrons for short. It's a good model for predicting how things will work.

Michael:

I have a mechanical engineering background as well. The model is useful, but are we conscious about what it prevents us from seeing? I used to work on free convection cooling in the electronics industry. I had one design I couldn't get to pass a required test… I built 100 different models and they didn't work. Finally, one day out of complete frustration I gave the machine shop a new design. A machinist said, "Are you crazy? This is going to start a fire." I replied, "None of them works; I want to be sure I know why something doesn't work." The design almost passed the test! While sleeping, I realized I had been imprisoned by a model I had learned in college. Next day I set to work, within two days we had passed the standard. At age twenty-two I learned from the beginning that what I had learned—rules of thermal cooling for electronics that were appropriate for vacuum tubes—had to be thrown away when the industry went through its huge phase of miniaturization. Rules keep changing. In time I recognized that I couldn't work in models because I had to work empirically. Models get so far but actually create a barrier. First 100 times and then I learned, next time 20-30. Now it takes me about 3. I walk in with fewer preconceptions.

Brian:

In teaching kids: The general public school way of teaching science *is* because there is no understanding of developmental learning, and education is regarded as filling a vessel with knowledge. If we get them to understand atoms as quickly as possible, somehow their thinking will free up when the time comes. This is a deadening way of understanding; the world is not met by this way of teaching. No one could answer, "Because my teachers think the same way." The world is a dead place, deterministic, with no living world. I had vivid memories, one of my most vivid in college physics was when I got to the idea of electron refraction. What blew my mind is you keep track of electrons whether or not refraction pattern happens. Keep track—that makes NO sense! The problem with a materialistic way of teaching is it violates a trust that kids place in us as their teachers not to lie to them. When they find out you've lied, they no longer trust the world is lawful.

Rick:

I wish I was good at it. It's going to take me years. I look at it as an awesome tool. I give my students the questions: What are the limits of our knowledge and how can we expand that? Humanistic element to bring it alive. How do we know the things we know? There are many ways of knowing—verifiable, mathematical… and pseudo sciences. Where human beings have such rich experiences that we can think many correct interpretations of events, politics. But the scientific method is what we're obligated to teach, bring to them part of it.

Phenomenology is very cool. My interpretation—give students part of yourself, allow them to observe. Why can't we do both? Is there a downside to doing both?

Beth:

Craig Holdrege recently gave a talk to our school's faculty and parents. George Hershkowitz was inspired to write a summary of it. He quoted part of our mission statement: "This is an education that takes human spirituality seriously." What does that mean? When Steiner wrote *The Philosophy of Freedom*, spiritual activity moved back to a verb quality. He equated spiritual activity with freedom. In order to have real freedom, you need to experience inner activity to know what it is, who they are in their innermost selves. Without it, you're giving up your possibility for freedom. This is not a religious spiritual activity, but finer senses-to-sense feelings, thought. This is the opposite of materialistic. If a human being cannot begin to work in inner space with consciousness, then he or she loses the possibility of freedom. This is what we're trying to give our students. Greatest oppositional force is illusion which comes in the form of strength-enhancing drugs, video game competition with a thing, TV giving pictures (not real imagination).

George believes the strongest force comes through technology many times. He also said that Steiner, who went through a scientific training and was a scientist, said that man cannot come to spirituality through mysticism. There are repeatable phenomena in a non-tangible world. Thinking is a spiritual activity. I can think my way into a concept, thinking comes before speech. I can think through to a concept from many different sides and illuminate a concept. With Brian's pump today, it's repeatable. The possibility we have with these kids, bring them to explain as simple harmonic phenomenon. If we develop these skills, students can eventually attempt to understand and work with it. Can we do both? In principle, possibly. If err on one side, I would say phenomenology because they can get the other any place else. This is unique to this education. They can get anything else on their own.

In terms of penetrating current sophistication, I usually pick one thing and penetrate it as far as I can. Take the Manhattan Project—what it was. They'll have a sense of the path materialism can take. They don't need to hear it for everything. Important to do well with one thing, then they can take it into other areas on their own.

Brian:

I would add, an aside—much the way projective geometry relates to Euclidian. You can become a phenomenologist and still understand everything the materialists are talking about and MORE.

Paolo:

You can also be a materialistic phenomenologist. We are discussing it now… these are tough, important questions. You can also look at all materialists as mainstream scientists. As with Farmer Wilder and Einstein, such wonderful nature—VERY alive, very alive. You can see that there was something very strong there. Not everyone is like this, of course. I have met many anthroposophists who did not have this quality.

Michael:

Dogmatism IS materialism.

Paolo:

I need to find meaningful relationships in the way I teach the kids. If I had to add to what Beth said, if dogmatic, better to err on phenomenological side. We really think something is good, right, and we try to follow it. The more we follow it, the more it is right, then it becomes increasingly wrong. If you think you've really got it, this guarantees that whatever you chose becomes wrong. Then you have to start again in a different way. There is not an absolute sense of continuing to search. From the point of view of the students, they are our reality check.

Michael:

Paolo, you gave a great description of ethical individualism. You don't work out of any preset assumptions. In every situation, this is the razor's edge, where you're constantly aware at every moment. This is exactly the path that Alfred Wegener took when he was developing his theory of continental drift. A movie needs to be made of his life. The theory of continental drift—he was attacked his entire life for it. Yet he still stated through out his entire life, "Further, we have to be prepared always for the possibility that each new discovery, no matter what science furnishes it, may modify the conclusions we draw."

This openness you describe, you can read Steiner pointing in this direction himself if you read the Appendix in the last edition of the Light Course. I see this vulnerability as a strength not a weakness.

I have one more poem in here, D.H. Lawrence's poem "The Phoenix."

The Phoenix

Are you willing to be sponged out, erased, cancelled,
made nothing?
Are you willing to be made nothing?
dipped into oblivion?
If not, you will never really change.
The phoenix renews her youth
only when she is burnt, burnt alive, burnt down
to hot and flocculent ash.
Then the small stirring of a new small bub in the nest
with strands of down like floating ash
shows that she is renewing her youth like the eagle,
immortal bird.

– D.H. Lawrence

I've been jokingly accused by one of the anthroposophists in our school community of teaching materialism. I teach Galileo in the 10th grade with my full heart and soul. Materialism gives us the consciousness of the present, but it isn't the end of the story. Appropriate for a time, then we need to move beyond. To receive a patent in the U.S. you have to prove it isn't an obvious extension of what already exists. Logic is not the scientific method, rather it grounds the intuition because our openness allows us to see a relationship between two or more phenomena that hasn't been seen before. Everything we've learned from masters was THEIR intuition. Intuition is what gives us the initial idea, logic is what allows us to explain it to another. It is not only one or the other, we're interested in teaching both. Be sure to keep intuition alive, while teaching the logical side that they don't have naturally.

NY state standard curriculum—all existence is atoms.

John:

I remember a conversation with a professor from Colorado. I had the impression that he had a rich inner life—reflective, introspective, evaluating his values. I asked him, "How do you reconcile this world in which you perceive yourself as a spiritual being with the world you live in as a microbiologist?" He answered, "I don't. I put on a microbiologist hat and use those models, and then I put on a different hat." I have this inkling, partly from conversations with Stephen Edelglass, that there is a way to make a bridge. When I am sitting here and focusing on my thought of the memory, who is the "I" who is holding that thought? Some would say the "I" is an illusion of biochemical reactions of neurons. From another perspective, how do you relate the modern worldview with your inner experiences that you hold true? There's this sense that I know that we are beings beyond the physical. To the degree that I can build science that encompasses that—that would be worth pursuing. I can only speak of that as direction that I've come to, but to my students I say we can talk out of class. The razor's edge is that it is right on the border of becoming dogma. Hopefully in a way that it meaningful for them, the real subtleties usually comes around 12th grade.

Brian:

Related to our dinner conversation—fundamentalism and the various movements and atheism—two manifestations of materialism applied to the spiritual world. My sister and her husband read *The End of Faith* and a "Letter to a Christian Nation" by Sam Harris, who is an atheist. What I found so fascinating is that it shares with certain fundamentalist Christian worldview. I interpreted it as essentially saying that "I have a concept" there is a God that is this way, or there is no god. Either way I prove that I am right. Why do we need to read Sam Harris to look at world and start to make observations or go to fundamentalist church to have someone tell us what we think? What's interesting to me is how my traditional science education, and in my college physics classes I was surrounded by atheists…. In general what I think I was trying to say, I find them equally to be pressuring me to stop validating my own observations of the world. My father is a fundamental Christian, I felt pressure not to follow my own observations. As a Waldorf teacher I feel free.

Ruth:

I have read those books and found them fascinating. One of the arguments Harris made in those books is that the great danger we face is moral relativism. We are kind and politically correct, which is the most dangerous thing of all. I think what's floating here is that we have to be doing the work, thinking and moving by our example, engaging in spiritual activity. We cannot be wishy-washy, sloppy, and just be nice and muddle through because the world is at stake.

John:

I find it is not difficult for me to cope with someone who is a blatant atheist. I grew up in a family that was somewhat Fundamentalist. If I'm quiet and patient enough, there are spots where we can overlap. There are moments when we can sort of meet. And then we can have a real experience. The other part was just an exercise of saying what we feel we need to say. I love Owen Barfield's "residue of unresolved positivism…." In a nutshell, those who accept the way that general thinking goes, that residue of going along with it is FAR more difficult to deal with. You have to do a lot to wake them up. That's what I do in the classroom. I think that's good science. Reconsider. Re-examine. And anchor in scientific work. Look in the Astronomy course. Steiner says, I'm going to go into something that's not direct observation, but it's just one step away. I took that as a suggestion that there might be another. For example, Schad in an article about Chemistry, about a scanning tunneling microscope showing a picture of an atom. If I delve into the phenomenon of the picture—it's just a representation. Penetrate with your thinking the real phenomenon, then get a fuller picture. At least once in a while really wrestle with something, and that can give the sense that my thinking can actually do something.

Paolo:

I try to bring a picture in line with modern science, but often if I give them a question three weeks later and… To a certain degree I think you have to live with that. In one of his recent books (*The Universe in a Single Atom*), the Dalai Lama writes about having meetings for ten years with modern experts on physics. Arthur Zajonc was involved in some of his conversations. To a certain degree, you can expect he is not a materialist as a spiritual leader, but he has embraced what the modern world has brought, good progress, etc., but we have to realize that it's a metaphysical assumption, it is a choice, not based on anything. Behind the science today which came out at the beginning of the century, it became clear that people have made unconscious choices and assumptions that were not based on anything that is empirical. I only look at nature. I am biased. It is false. You have to dig into it. That's what Michael mentioned with Galileo. You can get a lot of work done, that while you are thinking about relationships, if you are to wire a building. To a certain degree you have to accept that you have a certain way of thinking that will produce specific results, but you are shutting down an opening. The Dalai Lama, of course, is an adult with a lot of experiences. Conveniences are great, but he knows also that they are assumptions. You need to know it is such. I would love to work that way, but the students are too young to understand that. They can grasp the simple picture, easy to grasp with specific results.

Michael:

[To Paolo] Do you find that true for juniors and seniors because they know intuitively that there is something more. True for 9th and 10th, but not the older? There's a hunger for more.

Paolo:

I try to give them a picture that is a little deeper. They are also unable to find anything but forces. It's experience. They'll listen to me, why 2 weeks later I have balls on my desk. There's an effort to break that. Almost the easy way out. So, when you ask them to think that way, it's harder. For an adolescent, if they think I'm allergic to balls, they go.

Complimentary and renunciation. If you've given them confidence. Yes can do stoichiometry—you can do it that way, but it's not the ONLY way. For me to push them through the window, that's dogma. My job is to show them there are several windows. Trouble is that I haven't quite figured it out. I guess I just have to say this is the way I've been thinking about it. There's where I feel I've been caught. A lot of it has to do with thinking, and finding a way to discipline the self to FULLY think in terms of verbs, actions, and not things. It's really hard, in our world today, to break the habit. That's why we quit smoking to give a good example. It shows them it's possible.

Michael:

I've been deeply influenced by the Tibetan concepts of Relative Truth, and Absolute Truth. Relative Truth, if we know the perspective, it is very harmonic with the relational knowing we have been describing. With a specific set of conditions, it forces you to be in the here and now. I went to Ann Arbor, MI, for a three-day teaching given by the Dalai Lama on the nature of Compassion and Wisdom. I went with my wife, and I can't tell you how many times she poked me and said, "That is related to phenomenology." Relational knowing in Tibetan system has been extremely helpful. In my own working I have been going back and forth between scientific and traditional wisdom.

Another good reference book is *Native Science* written by Gregory Cajete, a Native American out of New Mexico. I was speaking in Wilton, NH. I think it was John Cronin, who now teaches at Hawthorne Valley, who recommended this book to me.

You know the Dalai Lama is very clear about saying that the traditional Tibetans have a developed sensitivity to taking care of the people's spiritual needs. But he goes on to say that the Tibetan's didn't do as good a job taken care of the material needs of the people. He continues: While in the Western world you have a focus on the care of the material needs, perhaps you neglect the spiritual needs. The materialistic view of reductionism is the Western world's gift to the world. Stephen Edelglass ends *Marriage of Sense and Thought* with the intention to help human beings to relate to the world as a whole. Traditional cultures have some gifts, Western cultures have some gifts. I like the intention of having students make projects in which they actually have to do the work. If we could marry the three elements that I described earlier—this is the world I want to live in in my next incarnation! But it is very hard work!

In the past few days some of you articulated the accusations and questions you have received from parents that the science we do may not be grounded. My challenge to you, the questioning you receive is a gift because then you are forced to go deeper. The "Dan Dugan conference" that took place in 1999, was very challenging but by the end of the conference I had developed a little more courage. Because the questions he brought gave me homework I needed to work on at that time. We don't need to know all the answers to the questions our students ask. Their questions become our homework. It's okay to say, "Here's what I know and here's where I am open." Then I am still respected as a teacher. However, I will lose credibility if I don't begin to address a question shortly after the time it is asked.

We start where we are. That's our biographies, our individual path; Steiner asked us to embrace that path. That's the real feeling. All thinking and intuition are actual thinking that comes from our own experience. Then, can I go beyond that individualized experience and look for the truth that is true beyond "only-me" perception. Straight out of *Philosophy of Spiritual Activity*.

On the opening night I asked that we place our ideas out there, then allow for space to see if they resonate with another. If it doesn't, maybe you can help me see what I am missing, or vice versa, that I can help you see what you may be missing.

Brian:

As a recent teacher education graduate, I encourage you to jump in as soon as possible, encountering it for the first time. You can ask really pointed questions when surrounded by other new people encountering this. There's a lot to think through, a lifetime of work.

John:

Remember teaching as a verb. It's not an end project. I think it was in *Study of Man* that Steiner says: "At the end of the school year, you'll have the experience that I made all those mistakes. You would've taught differently, not better, rather than striving to push through something. Not that you have to be at a certain place, but that you need to be moving, the delta, the rate change."

Michael:

To close the evening: Please think about those summary elements that might be living in you. I would like to preface the next step forward and remember sustainability. Let's not commit to something that we cannot do and follow through with. Also, I ask that you sleep on the possibility: Share a personal impression of this weekend. For those of you who are more experienced, might help the person reading it get more of a flavor for it. Out of freedom, just if something resonates.

[Michael ended the evening by reciting Mary Oliver's poem "Fish Bones."]

Fish Bones

Maybe Michelangelo
or Picasso
could have imagined
these dream shapes,

these curves and thongs,
snow-needles,
jaws, brain-cases,
eye sockets—

somebody, anyway,
whose mind
was in some clear kind
of rapture

and probably
in the early morning
when the sun
on its invisible muscle

was rising
over the water.
I don't think
it was just a floundering

in the darkness,
no matter
how much time there was.
This morning

I picked up something
into practice what students have learned.

– Mary Oliver

Closing

Betty:

The grant came from a trust from Pasadena through a donor to the College. He helps us to get scholarships for the High School training. He asked what I felt was especially needed, and I said, Science, science, science. I will write up a report for him. I feel this is the largest challenge in the movement. I look around and there is a lot of stability here. Here you are the senior teachers in physics, and that's a big deal.

Appreciations were expressed from all, and procedures for keeping in contact were addressed as the colloquium ended.

Reflective Comments from a Participant

by

Hezi Haut

As I am currently teaching my third physics main lesson block since I came back from the AWSNA Physics Colloquium in California, I decided to try to put my reflections of the colloquium down on paper. It was a real stretch to make myself available and find ways to cover my classes and my other school duties while I was at the colloquium. I have to admit that I debated whether I should go. This is my fourth year of teaching and, looking at the participant list, I really had to convince myself that I belonged with that group of teachers. With my limited experience, I was not sure I could really contribute to the colloquium. After the colloquium ended, I was able to say that my experience of it was one of realization and inspiration.

Throughout my time in Fair Oaks, I became increasingly aware of the need for Waldorf science teachers to support each other. I found out that many of my fellow Waldorf physics teachers struggle with the same questions I struggle with. We all struggle with the same need to convince potential families that the phenomenological approach to science is not just a valid one, but it is the only reasonable and truthful approach to science that can support humanity in its advance toward the future. The thought of standing alone trying to represent a different approach can be quite discouraging. The awareness that we are part of a living movement can be a great strength.

My teaching experience is limited so I cannot compare the students who come towards us these days to past students, but I can compare them to my experience as a high school student, and I have to say that my impression is that they are different —not worse, but different. The high school student today is exposed to so many technological stimulations in ways that present real challenges for us as educators. The main ones are: "How can I, as a physics teacher, help the students to connect more fully to the world around them?" and "How can I slow them down and perhaps help heal the process of the alienation from the world?" It is my opinion that the only way we can face these challenges successfully is to adopt the phenomenological approach. My experience as a teacher of students at all levels suggests that any other way of teaching just supports these processes.

One the main expectation I had of the colloquium was to learn about new ways and tools to face the above challenges successfully. Two of the presenters in the colloquium, Paolo Carini and Brian Gleichauf, spoke directly to the questions I had—Brian in his presentation about sustainability and technology and Paolo in his presentation titled "Building Machines: Putting into Practice What Students Have Learned."

An amazing transformation took place over the four days. We all arrived in Sacramento on Thursday night with feelings of fear and worry: How do we provide a phenomena-based science experience for our students *AND* prepare them for traditional material-based science courses that we hope they will take in college? By the end of the colloquium, fear had given way to optimism and a new vision: The best preparation for a traditional material-based college science course is a phenomenological high school science curriculum.

In a very clear way Brian presented the main questions we should ask ourselves when we choose to use a specific technology: What types of relationships do we build with the technology we adopt? What is it that a specific technology demands of us when we choose to use it? What is the price we pay for using it? As someone who does not use a cell phone on principal, I am conscious about choosing a technology, but never have I posed the questions as clearly as Brian did in his presentation.

Paolo's presentation basically changed the nature of my physics main lessons. As a kid I used to take things apart and rebuild them. I constructed many things: wooden carts with wheels that I used to drive down the hills of my Israeli mountain city, tree houses that I used to spend weeks building, different types of motors and small engines and levers that I could use to lift heavy loads to my parents' third floor apartment. When I asked my students what they build, I found out that most of them 'have no time for it.' My strongest memory from a science class in high school is building a working small missile launcher in my 11th grade chemistry class. Currently, I am teaching my third block since I came back from Fair Oaks, and it is the third block in which I require the students to build machines as part of the block. Never in my four years of teaching have I seen so much satisfaction in the students' eyes as when they presented their working DC motor or Van de Graaff generator. The process they go through—from 'I cannot build things' to 'I built it and it works'—is amazing. The light in the eyes of the academic support students who present the working water drops generator they built is a sight to remember. These types of activities are the best answers to the challenges I mentioned earlier.

All the presentations were very helpful for me. It is the third time I have heard Michael D'Aleo presenting his approach to the Electricity & Magnetism block, and every time I hear it, I learn more than I learned before. Geoff Robb's presentation about his take on the phenomenological approach was enlightening, and the discussions we had between and after the presentations contributed a lot to what this colloquium meant for me. I hope that the strength and personal motivation I carried with me back from the colloquium to my school in Kimberton will continue to support my teaching and will help my students on their way towards becoming real citizens of the world.

I want to thank each and every one of my colleagues for making this colloquium such a fulfilling experience for me. I want to thank especially John Petering for making the Sacramento Waldorf School's new science facilities available for us, Michael D'Aleo for leading us in our discussion in his very sensitive way, Betty Staley for initiating the idea of this colloquium, working very hard to make it happen and hosting us in the Rudolf Steiner College.

Last but not least, I want to thank Ruth Bucklin for leading us twice a day in eurythmy. Her sense of humor and beautiful eurythmy interpretation of David Whyte's "Working Together" brought a whole new meaning to the poem.

I want to finish by expressing my hope that gatherings like this one will happen more often. I cannot underestimate the importance of it to me as an individual and as a Waldorf teacher. I am convinced that the entire Waldorf movement benefits from gatherings like this one.

Summary and Overview
Physics Colloquium

by

Jeff O'Brien

Session 1: Thursday Night

We gathered in a classroom at Rudolf Steiner College for a late dinner. As we dined on soup, salad, and bread, we had a round table discussion.

Where Are We Coming From?

Each individual was coming to Sacramento from a particular physical location and their own emotional place. For some it was a long day of traveling from the East Coast. Others had traveled only a few hours. Some had come from long careers at established Waldorf high schools, other were in the early stages of the experience at very young schools. As we introduced ourselves around the circle, we celebrated the common joy that is our work. We shared points of concern in our Waldorf high schools. There was one overpowering common theme of concern: *How do we provide a phenomena-based science experience for our students* AND *how do we prepare them for traditional material-based science courses that we hope they will take in college*? Truly this was the largest question on all our minds.

Session 2: Friday Morning

The Visible and Invisible: Electricity and Magnetism as the Interaction of Qualities Rather than the Creation of Pseudo-Phenomenal Entities

11th Grade Physics

This session focused on the 11th grade physics main lesson. In 11th grade the difference in the approach to science in a Waldorf school becomes much more noticeable. A traditional school typically approaches the topics of electricity and magnetism through a brief introduction to molecular particles. Students memorize the names and properties of these particles and then learn the concepts of electricity and magnetism as by-products of these particles.

The 11th grade physics main lesson starts with the phenomena. When two materials come in intimate contact with each other, a new relationship between the materials arises. We ask students to describe the relationship. From this phenomenon, students

can begin to understand the concepts of static electricity and electrical charges. The beginning of this main lesson is critical. Once we get our students to understand static electricity through observing phenomena, we should also be able to provide phenomena that allow them to understand the concepts of current, potential, and resistance in the same way.

Some gems from the session:

- All electrical phenomena are interactions that reduce the strength of the imbalance of the created situation.
- All life is polarity and intensification. (Goethe)
- Instead of attraction/repulsion (which implies force) use moves toward/moves away.
- Positive/Negative are random human labels. Could be male/female or north/south, etc.
- When introducing the electron, go historical.
- An atom is just coagulated electricity. (Steiner, *Temple Legend*)
- Electron microscope only shows images of electrical imbalances.

Session 3: Friday Afternoon

Building Machines: Putting into Practice What Students Have Learned

Paolo Carini led this session. He began by emphasizing the importance for our students to be present in the moment while observing phenomena. This is connected to our goal of providing experiences that allow wisdom to grow in our students. Wisdom is different from intellect. Intellect can be taught, memorized, and recapitulated. Wisdom comes from experience and reflection on those experiences. You can look in the eyes of students and see if your students are gaining wisdom or intellect.

Paolo does a lot of projects in his classes. It is through these projects that students gain experiences that allow wisdom to grow.

In 9th grade, his physics students build an engine of some sort: Sterling engine, Christmas candle twirly thing, a pop-pop boat, etc.

In 10th grade, his students build a trajectory machine: catapult, trebuchet, sling shot, etc.

In 11th grade, electric motors, AC generators, Tesla coil, Van de Graaff generator, capacitor, water drop generator

In 12th grade, students take photographs of visual phenomena: reflections, refractions, color, perspective

In Astronomy, it's sundials.

Each project has a written component. Each student must write a manual for his/her project.

The remainder of the session was devoted to a discussion of what other teachers do in their classes. Other ideas discussed included: chose a phenomenon and present it by painting, drawing, sculpture, computer, making cathode ray tubes, making a video, making posters.

Two films were discussed: "A Private Universe" and "Simple Minds."

The role of technology came up. Michael gave a quote from and unknown source: "It's fine to drive a Rolls Royce. It's a problem when the Rolls Royce drives you."

Session 4: Friday Evening – Round Table Discussion

Why do young Waldorf teachers burn out?

What do I, as a Waldorf teacher, get out of this deal?

- We work very long hours for very little money. Answer: health.
- Much of the work is meetings. Meetings are killing us.
- Our schools need to transform themselves from places where everyone knows what everyone is doing to places everyone doesn't know what everyone is doing. Everyone needs to be okay with that.
- Meetings need to be events during which things that don't need to be discussed are not discussed and where we have the courage to discuss the difficult things that need to be discussed.
- Steiner wanted the majority of the faculty meetings to be devoted to pedagogy.
- Many decisions should not be consensus.

Session 5: Saturday Morning

> *The goal of human consciousness is, through freedom, to move towards final, full participation.*
>
> – Owen Barfield

The primary goal of phenomenological science is to make the students more comfortable with the world, to show them that the world makes sense. This is becoming more and more difficult to do.

Working backwards….

In grade 12 the topic is the phenomena of visual experience: light and color. We can study illumination by imagining a miniscule ant on a table looking at the vast "sky" from horizon to horizon. Each point on the table is illuminated by light from every source that the ant sees above. The goal of this lesson is for students to understand that light is a manifestation of an infinite number of interconnections. The camera obscura demonstrates this "ant-mode" on a screen. Geoff also includes prisms, lenses, and color into his 12th grade lesson.

The discussion of the 11th grade lesson was short because this was the topic of our discussion on Friday morning. Geoff did emphasize that his lesson starts out almost identically to Michael's. Geoff admitted that he has trouble making a leap from statics to current. It is fairly easy to develop the concept of statics phenomenologically. It is much more difficult to develop the concept of current. It is so easy to resort to just explaining it to the students and using the plumbing analogy. Geoff avoids this by turning the lesson into a history class: cathode ray tube, J.J. Thompson's experiment (discovery of electron), etc.

In the 10th grade mechanics lesson, Geoff focuses his attention on forces. His students build bridges to understand how forces in trusses are balanced. History is also a large part of this class (Aristotle to Galileo to Newton).

Geoff's 9th grade physics lesson includes sound waves and communication, loudspeakers and microphones, as well as the traditional heat and engines.

We need to change the nouns in science into verbs. Electron, force, velocity etc. are not nouns. They have no meaning as "person, place or thing." They are verbs and have meaning only when there is activity present. We should words like "warming" and "cooling" instead of "heat." We should use "the exchange of electrical activity" instead of "current." As a child develops "picture thinking" (percept/noun/passive thought), we need to help our students turn these into "living pictures" (concept/verb/active thinking).

Session 6: Saturday Afternoon

Sustainability and the Application of Simple Technologies in Our Everday Lives

Brian led a talk on technology. He described his trip from his apartment in Chicago to the airport. He detailed all of the technology that touched him in his travels.

Human responses to technology range from the neo-luddite to the transhuman.

Some technologies are addictive; others are more balanced.

Technology makes us "busier." We check our email at home and suddenly we are at work.

There is a pervasive form of contemporary violence which is activism and overwork. The rush and pressure of modern life are a form, perhaps the most common form, of its innate violence. To allow oneself to be carried away by a multitude of conflicting concerns, to surrender to too many demands, to commit oneself to too many projects, to want to help everyone in everything, is to succumb to violence.

The frenzy of our activism neutralizes our work for peace—it destroys our own inner capacity for peace, it destroys the fruitfulness of our own work, because it kills the root of inner wisdom, which makes this work fruitful.

In Chinese the symbol for "busyness" translates as 'Heart Killing.'

–Thomas Merton

Brian brought a Ram Pump with him. We went outside to observe the Ram Pump in action. In observing the Ram Pump, it is easy to see the evolution of technology. The Ram Pump works by converting the movement of flowing water into pressure that will pump a small portion of that water to a higher level. The Ram Pump requires the user to be familiar with its workings. It requires its user to have a relationship with it. How far we have come. An electric pump is in many ways inferior to a Ram Pump (doesn't work well in wet or freezing weather, limited capacity). So why has the electric pump completely replaced the Ram Pump? The electric pump is easier to use. You don't need to know anything about how it works to make it work. You just plug it in. No thinking required.

Technology has progressed to point where we no longer have to a have a relationship with our work. We no longer have to think.

Technology is inhibiting the development of our higher capacities.

A question to ask yourself when using technology: Does this technology give me a greater awareness of the world or does it put me to sleep to the rhythms of the world?

Technology affects the gaps between us. Cell phones keep us in constant contact with our loved ones, when really we should trust that they will be home on time. Automatic check-out lines at the grocery store remove human-to-human contact, when really we should chat with another human being as we buy our groceries. It is the Christ impulse that lives in these gaps.

Recommended readings:

"Being on Earth" on the www.sensri.org website
Living Energies by Callum Coates
Zero Emissions Research Institute (www.zeri.org)

Session 7: Round Table Discussion – Saturday Evening

Preparing Our Students for College

A variety of things were discussed.

- Bringing the arts into the science main lesson
- Poetry, form drawings (spirals, Celtic knots), reading the play *Galileo* by Bertolt Brecht, eurythmy, *Uncle Vanya*, this day in history (science related)
- Don't connect the pieces. Let the students make the connections. Create conditions for students to understand the connections. Draw it out of them.
- Finding the right balance between a rich understanding and practical skills and gaining a conscious understanding of modern science and technology
- Bring the best of the past to the present and look to the future.
- Materialism is part of phenomenology just like Euclidean geometry is part of projective geometry.

Session 8 : Sunday Morning – Saying Our Goodbyes

What did this conference mean to you?

- A+
- Just teach what you know.
- Teach your experiences.
- I had a rough year last year. This conference has saved my career.
- This conference has given me a feeling of affirmation in what I do.
- We were all doing good work on our own, we are now working together.
- I used to have a feeling of working in isolation. I'm anxious to get back to school, but I am also anxious for more experiences like this weekend.
- I am scared of plateaus. I loved the first three years of teaching. I got 50% better each year. Progress is now slow. I need to be patient. I need to look for change now inwardly.
- This conference encouraged me. I found courage.
- This conference has given me courage to continue as a Waldorf high school science teacher. I have courage to try to bring science electives to my school.
- I have new respect for the impersonal encounter.
- Something magical happened these past few days.
- It would be great to get all science teachers together (Physical and Life Sciences).

Next Steps:

- Email
- Phone
- Face to Face
- Newsletter
- Regional meetings in 2009, another national meeting in 2010