Hestenes lectures, Part 3

SCIENTIFIC DISCOURSE: A CRUCIAL OBJECTIVE OF TEACHING.

[Jane's summary: By discourse we mean all the interchanges in the classroom, including whiteboard presentations, which are crucial devices for focusing and directing discourse. Getting the students to talk is not enough! Classroom discourse is aimed at raising the level of talk to scientific discourse. A goal is for people to be able to justify beliefs and evaluate claims in life.]

We have the modeling cycle, but some teachers using the instructional modeling cycle get better results than others. What is the difference? I believe that one of the major differences is the way that discourse occurs in the classroom. I want to solicit your opinions on this because you are all experienced practitioners.

One of our objectives should be to engage students in scientific discourse. How do you talk about things in a scientific way? The Modeling Method is aimed at systematically doing that, and identifying the crucial factors. What does that mean? An important task of all of us in our society is to formulate and evaluate scientific claims. Scientific claims can be predictions or they can be explanations. How do you formulate a scientific claim clearly? How do you evaluate it? This, of course, is something we want students to be able to do in LIFE! A general capability! to be able to evaluate people's claims in life situations. But before you can evaluate a claim, you must express it clearly! From the modeling point of view, we need MODELS for evaluating the claims. We need:

1) models, to formulate and evaluate scientific claims,
2) methods to investigate the applicability of these models,
3) data, to evaluate the models.

All of this is aimed at justifying beliefs! We want students to have responsibility for their own knowledge. That means, instead of asking the teacher, that they must be able to come up with their OWN arguments.

I think it's worthwhile talking about this explicitly with students in class. If they want to be the victims of all kinds of unfounded claims which pervade our society, then they don't need to pay attention to these things. But if they want to protect themselves from unjustified claims, to be intelligent members of the society, they need to be able to make judgments on their own: they must evaluate evidence to some degree. That includes understanding the STANDARDS of evidence. That helps you evaluate whether someone who claims he's an expert really IS an expert. [David told how his daughter ran through a glass door and it sliced her arm lengthwise, and she needed reconstructive surgery on her hand. They consulted with two neurosurgeons. One, highly recommended, spoke in generalities, so Dave became suspicious. The second neurosurgeon gave them a detailed explanation of what was wrong, what he could do, and the prospects. They could evaluate it -- check it out; and the foundations were that the problem was EXPRESSED

CLEARLY and CONTAINED DETAILS. So a key to evaluating claims of so-called experts is to see what kind of details they come up with in their analysis.]

We know that there are differences in the way the discourse is handled in the classroom. I am setting up now an objective of improving the scientific discourse. That's a primary objective of our program. This raises questions about managing classroom activities and discourse, the subject of my next overhead.

[John Hollis, a teacher in the Leadership Modeling Workshops, pointed out that teachers have different ways of handling silence. A teacher asks, "Any questions?" Silence - and one teacher will go on, assuming that everyone understands. But another teacher will not be satisfied with silence and will ask further probing questions, to ferret out further misconceptions or to evaluate whether students really understand.]

[David Hestenes said in response:] What I want to promote is much richer discourse, not just direct interchange between teacher and student. The discourse will go on in different modes at different times, so there are different objectives. One is to improve the quality of interchange among students. We want the students to use terms correctly; to present coherent arguments. We know that in some of your classrooms students stand up and give wonderfully coherent accounts on their whiteboards. So the discourse includes the presentations of the students; not just questions and answers by the teacher; that's only one mode of discourse. The overall quality in the way things are talked about is our main concern. What we want to see in the classroom is a general improvement at that level, however it's achieved.

[John Hollis spoke on the importance of establishing a classroom attitude of respect for various viewpoints, rather than put-downs by teacher or other students. "If the attitude is promoted that the discourse is a healthy thing, and everyone is respected, and that they're expected to do this, then there's going to be much more success."]

[David Hestenes said in response:] You're exactly right; in fact, the FIRST thing the teacher must do is to establish a climate of openness, one where students feel free to make mistakes; where it's IMPORTANT to make mistakes, in fact! This is particularly developed in the discussion of the modeling cycle [in the American Journal of Physics paper entitled "A Modeling Method for high school physics", July 1995] as I reviewed the way Malcolm Wells did it. In opening the discussion to understand what's going on, Malcolm engages the entire class. He doesn't make an evaluation of whether the student has it right or wrong but tries to engage the students in doing the evaluation themselves, insofar as they have the tools to do that!

When there are crucial tools that can simplify or clarify the matter at hand, such as, early on, to discriminate between dependent variables and independent variables, that concept must be presented by the teacher. So the teacher must know how to make sharp and reliable definitions, not just vague definitions. There are many, many details that go into this. In fact, the whole understanding of physics is reflected in the discourse!

The concept of discourse includes all interchanges or communication in the class -- among teacher and students and among students. It includes the whiteboards themselves; in fact whiteboards are powerful devices for generating and controlling discourse. So the quality of the discourse will be reflected in the quality of representations that appear on the whiteboards. That's why establishing standards for what goes on the whiteboards is important. That has to do with the crucial role of MODELING in understanding.

So the first point about managing classroom discourse is that getting the students to talk isn't enough. Without the guidance of the teacher they will just ramble. The teacher must find means to control the discourse. There are all kinds of ways. There is no need to follow the modeling cycle slavishly. The modeling cycle was designed to incorporate all the features of modeling into it. But there are many variations of the modeling cycle. The crucial thing is TO RAISE THE LEVEL OF DISCOURSE: namely, how the students formulate and evaluate claims. A key to doing that is recognizing that formulating and supporting claims involves creating and evaluating MODELS.

HOW DO YOU MANAGE CLASSROOM DISCOURSE?

(1) The teacher starts by setting a classroom climate [of openness, where students feel free to make mistakes] and establishing the subject of discourse. This is often done by demonstrating a phenomenon and posing a problem. The teacher is responsible for leading the discourse so that issues and questions are raised and claims can be made that are WORTHY of investigation. This doesn't need to be something that students go into the lab to do; the investigation could be something that you go on the Internet to find out information about.

(2) Here's a crucial point. Communication requires shared meaning. That means, when you use the word "force", the student must ascribe the same meaning to the word as you do. Results of the Force Concept Inventory say that this is not happening in traditional instruction. The teacher is rambling on about forces and the students have a totally different idea of what those words mean. Consequently, the students are systematically misunderstanding.

How do you get to a common understanding? You get students to use the term to find out what it means to them. You don't condemn their usage, but you say, "Do you really mean this? or do you mean that?" You are adjusting the students' conceptual framework to the external frame. So a big initial part is setting up a framework in which everyone has a common understanding of the use of terms. As the students master the basic vocabulary, the basic ideas, things get better!

(3) Of course, scientific discourse is not just a matter of vocabulary; it also involves models, which are conceptual structures. The meaning of words, equations, and diagrams is constructed from situated use! This is a big emphasis in current research, not only in science education but also in linguistics and other fields. How is a common meaning of words constructed? From SITUATED USE: you see how so and so uses that term in a SITUATION. And these meanings must be negotiated.

(4) The quality of the discourse depends on (and this is a crucial point, where the Modeling Method differs very significantly from other approaches!):

- the representational TOOLS at the students' disposal, and how they are used,
- the structure of the arguments, and
- the standards of the argumentation (which are set by the teacher). We haven't said exactly what these standards are. This is a worthwhile job for one of our action research teams.

There is strong reason to believe that high quality scientific argumentation arises spontaneously among the students when they have the DISCURSIVE RESOURCES: when they have learned the right terms, when they have a suitable situation (created by the teacher).

Getting together a whiteboard action research team is important. There's been lots of talk among teachers about the appropriate place for whiteboards. Teachers use them in different ways. We could profit by setting up criteria for their use. There are issues about time management, pace, wait time, students' preparation, their role in criteria for grading, objectives, results. But the most important thing about the whiteboard is that the WHITEBOARD EXTERNALIZES OUR CONCEPTUAL REPRESENTATIONS.

We need conceptual representations. A good whiteboard is something that people can SEE. We know that there are verbal representations, but I do not think that a verbal representation should BE on the whiteboard. There shouldn't be long sentences describing what you did. A few key TERMS should be there, an appropriate GRAPH, maybe even some illustration of the experimental apparatus. A DIAGRAM of some kind -- it could be a single free-body diagram. You need to think critically about the representations. The whiteboard then forms a focus for discussion; and the students' understanding of what's up on the whiteboard can be explored by asking questions. That's all part of negotiating meaning: the meaning and understanding of these external representational tools. These representational tools are primarily diagrams, graphs and equations of particular kinds. The role played by WORDS is mainly DISCUSSING these external representational things. Words are difficult to survey when they are written down.

THE ROLE OF TEXTBOOKS

[Ludwik Kowalski noted that the teachers in the group have many different attitudes about the role of a textbook. Some ignore them, saying that they interfere with what they are doing. Others say that textbooks are important references. He asked David Hestenes for his view of the role of the textbook in the modeling method.]

The evaluation of any textbook or tool must be based on the question, "How does it contribute to the overall objectives?" I know of only one example of effective use of a textbook in instruction, and that is by Eric Mazur at Harvard. Mazur has the students read the textbook but he doesn't go over the material in the text. When the students come in each day, they must answer a question about what they have read, to see if they have read the material. The question doesn't require deep understanding. In his case, the textbook is a major source of knowledge. He assumes that the students can read the textbook, and by and large Harvard students can read textbooks. But not as well as you might wish, for the reading of a science textbook requires special skills. Most students don't realize that to be an effective reader you must read with a question in mind; they must be asking: "What do I want to get out of this?" You don't just read one thing after another. I like the definition of a book by the philosopher and literary critic, I. A. Richards. His definition of a textbook is "a machine to think with." The textbook has coded information, and you must learn how to get the information out. I have learned most of my physics from reading scientific books and papers, but this is a skill that takes a long time to develop; so we should be helping our students to develop skills in reading. It is a non-trivial matter!

Unfortunately, textbooks are not written in a way that's conducive to learning. You have to understand the material in order to get what's in there; that's why a physicist or physics teacher doesn't have much trouble reading the books. But the student is unable to discriminate between basic models and peripheral information. The models that we're considering are not unique to our program; they are inherent in all textbooks. But the models are BURIED in the textbooks. To understand the textbook requires being able to RECOGNIZE THE MODELS. This is acquired by long experience by physicists and physics teachers, who develop these models implicitly, without being aware that they are doing so. There's plenty of evidence that they have these models and use them. A good example of the evidence is if you give physicists a projectile motion problem. They don't read the whole problem before they do it. They read one sentence and say, "Oh, that's a projectile problem." Then they start drawing a diagram and solve the problem. They are SELECTING A MODEL at the beginning, and that's what the students need to do; to ask, "Is there a model here? and if not, do I need to make one?" THE MODEL IS THE OVERALL STRUCTURE - WHICH THE STUDENTS DON'T SEE IN TRADITIONAL INSTRUCTION. Our objective is to make the models explicit and transparent for the students. So I encourage people, if they have effective ways of using a textbook, to tell us. But because of the way the textbooks are written, many teachers find they are not helpful, especially in high school classes.
[The group broke for lunch.]

KATHY MALONE spoke on her IMPROVEMENTS IN METHODS of discourse and reflection

(1) Tests. After a test is graded and given back, students must look at their mistakes, write down what they were thinking - explain their error, and find the right answer, and turn in the test again in order to get a grade for the test. (Allison Lide did this, too.) Easy to do, doesn't take much time.

(2) Reflective journal. Kathy reads them, and then students must answer Kathy's questions completely and turn them in again, before she accepts their grade. Took much time.

(3) She notes which test questions are commonly missed, and then gives similar questions on the next test. Thus she can SEE the improvement in understanding.

(4) She has students tell which questions are associated with which of Newton's laws.

[Later, Kathy wrote 2 pages of decription of these activities; available upon request from jane.jackson@asu.edu]

Other teachers contributed good ideas to the discussion on discourse, too.

Dave Hestenes noted that we want students to learn to evaluate themselves. He suggested that EXEMPLARY WHITEBOARDS BE PUT ON THE CHALKBOARD, AND THAT EXEMPLARY LAB REPORTS BE HANDED OUT TO THE STUDENTS.