SCIENCE TALK:
LANGUAGE AND KNOWLEDGE IN CLASSROOM DISCUSSION[*]

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INTRODUCTION

In this paper I look at the idea of "making sense" and the practice of "sense making discussions" in current educational reform. I have two goals. One is to think about the role language plays in this practice and related new practices. Another is to think about how this practice relates to larger concerns about schools and society. In the end, I want to argue that, like many other current educational reforms, sense making discussions fit well with themes and practices emanating from the business world in our new global, high-tech capitalism. I want to argue, as well, that meta-reflection on the form (structure) of language and social practices can constitute an important political intervention in education.

Sense making discussions are a progressive educational reform in which children engage in active and collaborative discussion around open-ended problems. Centered on the idea that all children bring experience, insight, and intelligence to the classroom, sense making discussions are meant to allow all children, regardless of their backgrounds, to express their own thinking and to witness the thinking of their peers rendered public. As children challenge each other and build on each other's contributions, the group is meant to achieve a level of sophistication and intelligence that may well surpass that of any individual in the group. Children are meant, as well, to come to respect diverse viewpoints and see the role of reasons and argumentation in school-based (academic) enterprises.

Any practice within an institution "invites" us to become, for a given time and place, a certain "kind of person"--for example, a certain kind of student or teacher, worker or boss, patient or doctor, husband or wife, acting and interacting on the basis of specific values, norms, and ways of thinking and believing. When we seek to create new practices within an institution like a school, we seek to create new kinds of people.

But Institutions don't operate in vacuum. The kinds of people they create are created in relationship to the kinds of people other institutions create. Sometimes a set of institutions come to "collaborate" in the production of a kind of person fit to move harmoniously between and among the whole set of institutions--for example, a certain kind of student "fit" to be a certain kind of worker. I will argue by the end of this paper, and have argued, on other grounds, elsewhere (Gee 1996; Gee, Hull, & Lankshear 1996), that reformed schools, businesses, and various social and governmental institutions are "aligning" themselves for the production of a new kind of person "fit" for our new hyper-competitive, high-tech, global capitalism.

Educational reform often results in paradox as new kinds of people and new practices come into tension with the remnants of old kinds and old practices, or with competing new kinds from other practices or the same practice used in a different context. The resulting paradoxes can, I believe, give us some insight into the new values and interests at play, before they have come to

taken for granted as "normal" and "natural". In this paper, I will use discourse analysis to study such paradoxes.

1. SENSE MAKING

I will start with an analysis of a full class sense making discussion in a second-grade science classroom. The whole notion of sense making is an increasingly popular type of classroom practice. The data I use in this section are taken from a tape and accompanying booklet produced as a "resource for teacher professional development in science" (p. 1) by TERC (all page references here and below are to Ann S. Rosebery, Gillian M. Puttick, and Mary Buchinger Bodwell, "How Much Light Does a Plant Need?": Questions, Data, and Theories in a Second Grade Classroom. Portsmouth, NH: Heinemann, 1996). The classroom dealt with in the tape and booklet is in Concord, Massachusetts (the town's real name is used in the materials). Concord is a quite affluent town to the west of Boston.

When I have shown the tape to my students who are student-teaching in urban schools in Massachusetts, they readily acknowledge that the language and collaborative skills of these Concord second graders are significantly "ahead" of the students they teach. We should keep in mind, however, that language scaffolds things like ability to collaborate, to engage in certain sorts of scientific practices, and to remain unfrustrated by certain sorts of classroom activities. There is no doubt that the language, thinking, and classroom practices of these Concord students are all deeply impressive.

Though I will start by overviewing the whole curriculum project the class carried out, my focus will ultimately be on the final full-class sense making discussion. The materials I am studying here are part of a "Sense Making in Science" series connected to a "Scientific Sense Making Project" (cover page to the booklet and p. 1). My argument will be that there are interesting and important anomalies in the language of this sense making discussion, anomalies which I believe are typical of this sort of practice in general. I will later argue, as well, that sense making discussions take on different functions in different sorts of classrooms.

The videotape and booklet from which I am drawing my data, in the words of those who produced them, tell:

> ...the story of a class of second graders who designed experiments to investigate their questions about plant growth, focusing on the work of one group [of three girls, JPG] that wanted to study the effects of light. In small groups, the students planned, designed, and conducted experiments over a period of four weeks. At the end, each group presented

> their observations to the rest of their classmates and invited them to help interpret their data. In this way their teacher ... introduced them to scientific ways of thinking and talking, which was the goal for this unit ... (p. 4).

This is, on first sight, normal enough; in fact, it is fully in step with contemporary reforms in science education, which stress learner-centered "hands on" science activities, collaboration, and discussion. However, there is an interesting tension in these remarks. The tension has to do with what constitutes "scientific ways of thinking and talking". This same tension will show up in the classroom talk we investigate below.

In one sense of the word "experiment", an experiment is a test of some hypothesis one has made about some data. A hypothesis is an interpretation about what is going on in some data and it is partially confirmed if the experiment is successful. I say "partially confirmed", because confirmation is never "once and for all" in science or in life. Running an experiment is "work" and if it "works" one has learned ("discovered") something.

Having said this, let us return to the above passage. It may now seem strange for the passage to suggest that a group of children first run an experiment and then, having done it, invite their classmates to "help interpret their data". The children who ran the experiment, which turned out to be successful, in making and confirming, however tentatively, their hypothesis (which was "Light makes plants grow healthier") have already interpreted their data in one sense. They have discovered that certain plants are healthier than others because they got more light. To put the point another way: the experimenters don't just have "data", they have "interpretations", as well.

The passage seems to ignore the fact that the experimenters' work has resulted in something that they can make claims about (and these claims will be "interpretations" of their data). What the experimenters need help with, as does anyone who has just run a successful experiment, is in explaining their results at a deeper level, that is, in this case, in coming to understand why light makes plants grow healthier.

Note, too, how the passage first attributes a good deal of work to the girls: "the students planned, designed, and conducted experiments over a period of four weeks", on the basis of which they "presented their observations" to their classmates. Verbs like "plan", "design", "conduct", and "present" are "achievement verbs", that is, they imply that there is a result or outcome, that something has been achieved. When the passage goes on to say that, after all this achievement-oriented work, the girls are to "invite" their classmates to "to help interpret their data", it seems to efface their work and to fail to mark in any way their achievements as achievements.

We can ask, as well, in this light, why the girls are presenting their "observations" to the class, after their experimental work, and not their (however tentative) "findings". The former

term ("observations"), a fairly speculative term, seems, again, to downplay the work and achievements of the students in a way the latter term ("findings") does not.

There seems to be, in this passage, a certain tension between two models of science. One model, which I will call the "experimental model", is centered around the idea that science is composed of a certain sequence of work activities (e.g., hypothesizing, designing an experiment, running the experiment, confirming or disconfirming the hypothesis). These activities are meant to issue in "findings" or "results", which can, of course, be challenged by others, and which still require deeper explanations (the search for which may entail new experiments).

The other model, which I will call the sense making model, is centered around the idea that science is composed of "observing" data (the world) and making "observations" about that data. These observations are meant to be compared to other people's observations of the same or similar data.

I belabor this poor passage only because the tension between these two models is readily apparent in the actual classroom practice. Let us now turn, then, to the classroom interaction. The teacher starts his instructional sequence by encouraging the children, in small group discussions, to come up with predictions (hypotheses). In a discussion with their teacher (transcript 1, pp. 17-18), the three girls whom the materials focus on construct a prediction, something like: "Light causes plants to grow better (or be healthier)":

Krysta: I thought maybe it was going to grow best um over by the window and at the grow plant table.

Lia: Yeah.

Teacher: Do you think it will grow like- really good in the grow table and the window and not at all in the other places?

Krysta: Maybe not at all in the closet.

Teacher: Okay.

Ceysa: Because that would be pretty dark.

Notice that we have to infer exactly what the girls' prediction (hypothesis) is from the situated details of their talk. They are not asked to make it explicit or to worry directly over how to word it. We should not, however, just take this for granted as "natural", though it is, in fact, typical of most "hands on" science curricula. Most contemporary educational reforms in science education, and elsewhere, stress collaborative immersion in practice, albeit with teacher guidance, while downplaying overt instruction and placing very little overt focus on language itself (Halliday & Martin 1993). We will see below that this lack of focus on language creates its own problems and paradoxes.

In the next stage of the instructional sequence, the teacher engages in guidance (scaffolding), though not direct telling. Having engaged in this sort of instructional sequence before, the teacher knows that plants grown in places like closets are liable to be droopy and pale (thus, not very healthy looking), but may have grown fairly tall (perhaps, in trying to reach light coming from the top of the closet door). The children may be confused by these contrary signs (being tall, it looks health; being pale, it looks sick).

Thus, in further small group discussion with the girls (transcript 2, pp. 18-19), the teacher elicits from the girls the decision that "greenness" and "straightness", and not "height" alone, are criterial attributes of having "grown better" or of "health" (though this work is not rendered linguistically explicit either) [p. 19, the three dots below represent pauses or trailing sentences. In all other examples in this paper, three dots indicate ellipsis]:

Lia: Maybe they're a little bit more green if they're healthier ...

Teacher: Okay, so maybe it's not- maybe it's greenness too.

Lia: Yeah.

Teacher: All right.

Lia: Or whatever color it is ...

Ceysa: And like they're standing up straighter and dead ones sort of hang done ...

Teacher: Okay, so like if they're limping over ...

Ceysa: A lot ...

After such small group discussion work, the girls actually run their experiment, placing plants in various light conditions, ranging from plants grown 24 hours a day under a grow light to plants grown 24 hours a day in a dark closet, through various other conditions (e.g., in a window that is light in the day and dark at night). The experiment is successful, by and large confirming their prediction (keeping in mind, again, that confirmation in science is never once and for all). Some of the plants grown in the closet (a little light condition) have, however, grown tall, though they are pale yellow (not green) and droopy (not straight). Thus, however anomalous their height may be, they are not healthy by the criteria the girls have decided upon and so support the girls' prediction, nonetheless.

After the girls have finished their experimental work, there is a full class discussion in which the girls first give a brief presentation on their experiment, displaying their plants, and, then, as the booklet says, the other children are "invited" to help the girls "make sense of their data". This part of the curriculum involves a whole class sense making discussion.

We can note, first, that the activity has now changed in an important way; it has changed from small group discussions devoted to planning and carrying out "hands on" science activities to large group discussion devoted to "making sense" (certainly a less "hands on" activity). Concomitant with this change in activity, the sorts of identities and related talk the teacher and children adopt (or are expected to adopt) change, as well.

As is typical in such cases, the children are not told explicitly how and why the activity has changed, though they certainly know the participant structures (the rules and norms for participating) have changed. What they may not know or, at least, where some children's views may differ, is exactly how this activity relates to the ones that have come before it (indeed, I have already argued that this is a source of tension in the booklet, which tends to efface the girls previous work and achievements just where this large group activity is introduced).

Given the rather open ended nature of such whole group sense making discussions as an activity, we might expect that the discussion will be composed of many different types of talk, and, indeed, it is. In such an activity, participants can introduce topics and sub-topics, and follow up on each other's contributions, in quite flexible ways. Different communicative functions (e.g., talk about controlling variables, talk trying to offer explanations for results, speculations based on everyday knowledge. etc.) can crisscross each other quickly and fluidly, creating a bevy of sequentially disconnected, but functionally related threads. Furthermore, there is here no "hands on" activity, with its distinctive recruitment of the material world and human bodies, to help structure the talk. The teacher does help guide the talk, but only with (as we will see) quite open-ended questions.

Again, I think that it is important not to just take such an activity for granted as "natural". It is similar to, and different from, in important ways, other sorts of discussions. For example, it is much bigger than a seminar or lab discussion among scientists, and in such a seminar or lab setting, participants typically get longer turns and their interlocutors often demand that they spell out their arguments, and connections to others' contributions, more explicitly.

It is not uncommon, in the critical and postmodern literature in education, to see such flexible and multiple forms of talk as found in our sense making discussion celebrated under the rubric of "hybridity", with citations to Bakhtin. And, indeed, we may very well want to celebrate "hybridity" in talk for political reasons, since it tends to undermine univocal and transcendent "narratives". Nonetheless, "hybrid" listening and understanding is certainly liable to be a taxing and extremely "higher order" cognitive skill, requiring a great deal of "prior knowledge". While it may be a route to "political salvation" for the sophisticated, it may be a less efficacious route for the uninformed or underprepared.

Let me give an extended example from the whole class discussion to exemplify some of the diversity of talk in this situation (pp. 32-37). This passage will also be the focus of my analyses of the (other) paradoxes apparent in this sense making curriculum:

Teacher: ...does anybody have any idea about why those [pale plants grown in the closet, JPG] might be that color [i.e., not green, JPG]?

Lia: Karen?

Karen: Because, um, that's in the dark and it doesn't get any light maybe.

Girl: It does get a little light.

Girl: It gets the teeniest bit.

Girl: Aleisha?

Aleisha: I think it's that color because it doesn't get that much light, and, it- it has- and plants grow with light, so.

Krysta: Michael?

Michael: Well, I think these are- there are these special rays in light that make it turn green and it's not getting those rays, so it won't turn green.

...

Michael: Like a laser and a light beam are almost the sa- are almost different- I mean they are different kinds of light. So, maybe there's this kind of light in the air that maybe we can't see, but maybe the plants need it maybe to turn green.

...

Anna: I think, um, the rays, um, gives the plant food, and um, they like store the food in the leaves and cotyledon, and the food like makes it turn green? And stuff.

...

Michael: Yeah, that sounds like an idea behind my idea.

Will: Um, maybe it's not the light. Maybe it's heat ...

[discussion about heat and air and other things]

Teacher: ...This never turned green. These became green for some reason, and that never became green.

The teacher here asks "does anybody have any idea about why those [the plants grown in the closet, JPG] might be that color?". This question is ambiguous. What is most relevant about the color of the plants grown in the closet is that they are not green, that is, they are not the typical color of healthy plants. Thus, a cooperative listener might well take the phrase "that color" to mean "not a healthy green color" and, thus, take the question to be why the plants are not green (healthy). However, a listener might also, since the plants are visible to the whole group, pay attention to the actual color of the plants, a pale whitish yellow, and take the question to be why the plants are that specific color and not some other color, like red or brown, say.

Note that, on the first interpretation (Why are the plants grown in the closet not green/healthy?) the three experimenting girls know the answer to the question (these plants did not get enough light); that was the sort of thing their experiment was set up to discover. On the second interpretation (Why are the plants grown in the closet specifically a pale yellow, rather than say red?), the girls need not have any idea as to what the answer is (the question, on this interpretation, amounts to asking why sick plants take on the particular color they do).

The teacher's use of "everyday" language here (a form of language tightly tied to an assumed shared local context) is typical of most such curricula. Some people hold that, in fact,

this allows "access" for a greater array of children. We might, however, worry about what good such access does one if it is based on the "wrong" interpretation of ambiguous language.

On the most natural interpretation (Why are the plants grown in the closet not green/healthy?), the question is a bit odd, and odd just along the same lines in which the booklet seemed odd. We might say that the whole point of the girls' experiment was to give them just such an idea (the idea that the answer here is "lack of light"). But the teacher's question ("Does anybody ...?") implies that, perhaps, nobody has "any idea" about the matter. It certainly fails to single the three experimenters out as just such "somebodies". Further, the answer to the teacher's question should have been obvious to everyone if the girls had, indeed, presented the results of their experimental work (their full presentation is not given on the tape).

Karen (note that the three experimenters, rather than the teacher, get to call on people who are raising their hands, so here Lia has called on Karen to respond to the teacher's question) says: "Because, um, that's in the dark and it doesn't get any light maybe". Her "um", her "maybe", and the way in which she says this utterance (with a raising pitch at the end) indicate that she is treating the answer to this question as "uncertain" and "news".

Aleisha, then, announces that she too "thinks" that the answer has to do with light, showing that she also believes this is "news" and open to "speculation". Neither student's response indicates they are aware of the epistemological status of the claim they are making about light, namely that it follows from the logic of the experiment the girls have carried out and presented to the group. Furthermore, Aleisha uses the generalization "and plants grow with light, so" as a piece of general knowledge unconnected to the experiment the girls' have carried out.

Following Aleisha's turn, Michael and Anna engage in talk that more genuinely takes off from where the girls' experiment has ended. They attempt to help the girls explain (not just "interpret") their "results". Explanation requires going beyond the mere casual claim, which the girls' work has established, that "light causes plants to grow better (healthier)", by discussing things that might mediate between light and health. Michael introduces "different kinds of light" and things "plants need". Anna goes yet further and introduces a true mediating variable (between "light" and "health"), namely "food" which the plants "store in the leaves and cotyledon" and which "makes it turn green".

This explanatory talk is, however, not followed up on. Will returns the group to another type of talk that is also pervasive in the whole discussion, namely talk about what variables were and were not controlled for in the experiment (rightly part of the earlier activity of experimental design). This is, of course, a logically prior concern than explanation (which assumes the correctness of the casual claim to be explained). Will suggests that heat and not light might be the important casual variable.

After the talk about heat to which Will's contribution gives rise, the teacher says "These (the plants that had been given ample light, JPG) became green for some reason". The teacher's "for some reason" implies that this reason is waiting to be discovered as "news" through the process of discussion (much as Karen and Aleshia had assumed). But that is exactly what the girls experiment was designed to discover.

In entering the sense making discussion, the children have entered a different activity, one in which the casual claim "Light makes plants grow better (healthier)" is "up for grabs". In the prior activity sequence (experimentation), it was, however, the end product, the achievement, and in that sense no longer "up for grabs". Thus, as in the booklet, there appears here to be a tension between the initial activity sequence (experimentation) and the final activity (sense making discussion). The two are "married" in a rather paradoxical way.

Like all activities, the activity of whole group sense making is composed of a myriad of sub-activities and smaller actions each of which recruits different forms of language to carry out different functions. In this discussion, the children engage in such actions as "explaining", "guessing", "hypothesizing", "critiquing", "questioning", "suggesting", and others. Characteristic of such sense making discussions, these actions occur, interrupt each other, and reoccur in a fairly flexible way, depending, in part, on how different children interpret the teacher's questions, other students' contributions, and the activity they take themselves to be in.

Such open-ended and flexibly "hybridity" raises, as I have already said above, interesting questions about how different children in the discussion understand what is going on; how they come (or fail) to learn and use specific forms of language; what identities they do or do not take on; and how these relate to the identities they have taken on in other activities in this classroom and elsewhere. We can see, I think, that in this discussion, Michael and Anna function (in regard to their language, what they take the activity to be, and their identities) quite differently than many of the other children. For example, Michael and Anna consistently, here and elsewhere in the discussion, treat the task as adding an explanation to the girls' achievement of the casual claim that light makes plants grow better and healthier.

I would argue, then, as I did in regard to the booklet, that the teacher (and curriculum builders) here are operating with two different models of what science and science education are. One model, what I called above the "experimental model", is centered around a sequence of logically related activities: making a prediction, designing an experiment (e.g., controlling variables), gathering data, interpreting data and looking for anomalies, confirming or disconfirming (aspects of) the initial prediction, and then seeking to find a deeper explanation (in this case, for why light makes plants grow better and healthier). The other model, what I called above the "sense making model", is centered around the idea that people make sense of their observations of the world through open-ended (i.e., less sequenced and constrained) collaborative

talk with each other, pooling their knowledge and building upon each other's contributions in a quite egalitarian way.

On one model, "results" stem from work (and discussion is but a part of that work). On the other model, "sense" stems from discussion (and work is subsidiary to that discussion). It is paradoxical to place an activity based on the latter sense-making model (with its great hybridity and open endedness) as the last step of an activity sequence based on the experimental model, the place where "deeper explanation of one's successful prediction" (a much more constrained activity) would, on that model, occur. There has been here, we might say, "slippage". The last stage of the "old" model (experimentation) has been replaced with a core activity of a new model ("sense making discussion").

What seems to be happening in the sense making discussion we have looked at is that some children treat the discussion as just such an explanatory endeavor. Others (and the teacher) treat it as a more autonomous activity in which the experimental work already done can be revisited in ways that sometimes ignore what has already been accomplished and appear to return the girls, who are at the end of a set of tasks, back to where they began. In this respect, knowledge does not "accumulate", for the girls or the group.

I believe this is fairly typical of many contemporary "constructivist" or "progressivist" pedagogies, even ones with the sort of guidance that this teacher does, indeed, offer (see Cazden 1992 for some of the issues). "Accumulation" is backgrounded, perhaps, because sense making curricula value creativity, participation, and "process" more than "products" ("facts", "correct answers", "results", etc.)

My analysis here bears, as well, on the controversy as to whether progressivist pedagogies "hide the rules" of activities, identities, and forms of talk from children who do not already know them based on their experiences in other (including home) settings (Delpit 1995). This "hiding" is arguably a result of the way in which these pedagogies avoid overt instruction and efface meta-discussion about activities, identities, and talk, as well as more explicit forms of language.

The classroom we have looked at not only "hides the rules" (does not render them overt), it actually elides different sets of rules (models) and freely mixes different functions and forms of talk. In this particular classroom, these issues are muted (but not removed) by the fact that the classroom exists in a very affluent community. They become more salient, however, when we consider sense making discussions in other contexts, as we will now do.

2. SENSE MAKING IN ANOTHER SETTING

"Sense making" discussions are commonly advocated for schools with children from much less economically privileged homes than those in Concord, Massachusetts. In these settings,

sense making discussions are thought to “level the playing field” by allowing all children to leverage their intelligence and distinctive home- and community-based experiences, regardless of their prior academic experiences.

In the case I want now to look at briefly, the sense making discussion was pretty much the whole curriculum. It was not preceded by a sequenced, teacher guided set of science activities. The children did engage in experimental activities, but ones that came out of their own previous sense making discussions, were designed by the students themselves without teacher scaffolding, and were meant to lead to more sense making discussion. The teacher in this class felt that teacher talk tended to silence those students who had less academic preparation.

The data I am going to discuss here come from a 1994 AERA session put together by Cindy Ballenger, Ann Rosebery, and Beth Warren of TERC and devoted to their research and intervention work. I participated in the session. TERC is, of course, the same organization that produced the booklet from which the previous “sense making” data came. My analysis will draw on short samples from two long transcripts characterized by the researchers who collected them as follows (I remove names):

> The ... transcripts (Rust I and Rust II) are from [N. N.'s] fourth grade class. [N] teaches in [town], a culturally diverse, working class town just outside of [a major city]. In the school year 1992-93 [N] decided to experiment with "science talks" modeled after talks Karen Gallas (1991) holds in her elementary grade classes. Science talks are devoted to the consideration of a question chosen by the students. The children sit in a circle and discuss their ideas with one another, while the teacher mostly listens and takes notes, only occasionally participating in the talk.

In a first session the students had discussed "What makes rust?". Some time later, the children watched the videotape of this session and developed a set of questions about rust they wanted to answer (e.g., Does ordinary water cause rust? Does rain water cause rust? Does paint protect rust? Do other things besides metal get rusty?, and others). They then "set up a series of comparisons to study the 'variables' identified in their questions: painted/unpainted metal in rain/tap water."

The following exchange occurs after the children have carried out their experiment and when they are assessing its results. In my rendition of the transcript, I remove obvious speech errors and hesitations, and I place in brackets my interpretation of what contextualized bits of the talk mean.

The children have placed a number of metal and non-metal objects in tap water and rain water to examine whether and what "gets rusty", as well as a variety of other questions. In this segment, they are talking about a metal bottle cap that had been laying on a plastic plate immersed in the water (they have drained the water and are inspecting the items):

Elizabeth: Do you think plastic would get rusty?

Philip: No 'cause we've got this [plastic plate here and it's not rusty]--maybe [it would get rusty] if something metal was on this [plastic plate]

Jill: It [the plastic plate] will get old [and old things get rusty]

Philip: [If it was old and got rusty, then] Metal got on it like [it got on] this plastic plate

Jill: Cuz like the bottle cap where the rust is from, the rust got off the metal [bottle cap] and went on to the plate

Philip: But without the metal on top of the plastic [plate], you would never get, it [the plate] probably wouldn't ever get rusty

Jill: You wouldn't get marks

Elizabeth: Why these marks here [on the plastic plate]?

Jill: Because the rust comes off the things and it goes on to there and it stays

Philip: And the rust gots nowhere to go so it goes on the plate

Jill: But if we didn't put the metal things on there [on the plate] it wouldn't be all rusty

Philip: And if we didn't put the water on there [on the metal bottle cap / on the plastic cap plate combination / on the plate?] it wouldn't be all rusty

Jill points out that rust comes off rusty metal things like the bottle cap and leaves marks on other things, like the plastic plate the bottle cap was sitting on. She later points out that if the rusty metal bottle cap had not been placed on the plastic plate, then the plate would not be "all rusty". Philip formulates his last contribution above as a direct "copy" of Jill's immediately preceding contribution, pointing out that if water had no been placed on the metal bottle cap (and the plate its on), then it would not be "all rusty":

Jill:
But if we didn't put the metal things on there it wouldn't be all rusty

Philip:
But if we didn't put the water on there it wouldn't be all rusty

This whole segment is typical of "everyday language", and, in fact, reflects both the strength and weakness of such language. In everyday language, when we are trying to make sense of a problematic situation, we use patterns and associations, repetitions and parallelism, what might loosely be called "poetic" devices, to construct (or, as here, to co-construct) a senseful (sense making) design. Far from wanting to denigrate everyday language, I have elsewhere celebrated it (e.g., Gee 1991) and have no doubt that it has given rise to some of human beings "deepest" insights into the human condition. But it is not how science operates; in fact, historically, while the discourses of various sciences most certainly grew out of everyday methods of sense making, they developed partly in overt opposition to them (Bazerman 1989).

Everyday language allows for juxtapositions of images and themes in the creation of patterns (like "it wouldn't be all rusty"). And, as I have just said, this is often an extremely powerful device. But, from the perspective of scientific discourse, or even academic discourses generally, it can create a symmetry that is misleading and which obscures important "underlying differences" (e.g., the underlying difference between "a plastic plate that is all rusty" and "a metal cap that is all rusty"). Unfortunately, in science it is often this "underlying" level which is crucial.

Of course, the notion of there being an "underlying reality" that is "more real" than the "mere appearances" is an ideology deeply embedded in scientific discourses. But that is another matter. We are here considering what learning science might amount to, not (now) considering its ideological underpinnings.

The children's everyday language obliterates a crucial distinction and it obliterates the "underlying mechanisms" (here cause and effect) that are the heart and soul of physical science. Jill and Philip's parallel constructions above (in particular, their uses of "all rusty" and "if we didn't put ... on, it wouldn't be ... ") obscure the fact that these two linguistic devices here mean (or could mean) two very different things. Rusty metal things "cause" things like plastic plates to "be all rusty" (namely, by physical contact) in a quite different way than water "causes" metal things to "be all rusty" (namely, by a chemical reaction).

Further, the plastic plate and the metal bottle cap are "all rusty" in two crucially different senses--that is, crucial for scientific discourse, though not necessarily for everyday discourse, which is content to pattern them together through the phrase "all rusty". In Jill's statement, "all rusty" means (or could mean) "covered in rust", while in Philip's statement it means (or could mean) "a surface which has become rusted". In other words, the distinction between "having rust" (a state) and "having rusted" (a process) is obliterated.

It is important to notice that some of the children appear to realize that metal rusts and plastic doesn't, at least at the level of the claims they make, e.g., Philip says "no" to Elizabeth's question "Do you think plastic would get rusty?", and later claims that "... without metal on top of the plastic, it probably wouldn't ever get rusty". Therefore, in a sense, for some of the children, at least, their "cognition" outruns their language.

And it is this fact, presumably, which may make some people believe that such "science talk" is a developmental device, i.e., a way to develop cognition prior to the development of specially scientific sorts of language. But cognition and language cannot be so easily separated. What counts as "scientific thinking" is <u>not</u> a private mental act, it is a public move in the "game" of science (or science education), and that move is made and distributed to the other "players" by language. Ironically, this is, in fact, one of the purposes of sense making discussions: to render one's own and others' thinking public through collaborative talk. But meaning isn't really "public" if it is not "fixed" for all members of the "learning community" in relatively similar ways.

There is here, too, another important point to make, one that we discussed at the end of our earlier discussion about the Concord classroom. When cognition and language "mismatch" as they do here, such that children are making claims that linguistically look the same when they are, in fact, different (or vice versa), then children who "already know" are advantaged against those who don't. A child who does not already know the distinction between "being covered in rust" and "having rusted" or between association (contact, correlation) and causation will most certainly not get it from this language. In fact, such a child may simply be confused. Yet it is a key purpose of scientific language--and, again, a goal of sense making discussions--to render "cognition" and important "conceptual distinctions" overt and public. That is part of how sense making discussions are supposed to level the playing field (along with the access they give for all

children to participate by not very strictly limiting the sorts of contributions that can be made at any one time).

3. PARADOXES OF SENSE MAKING

Sense making discussions contain a number of paradoxes, some of which we have discussed above. First, they are intended, in part, to level the playing field by downplaying prior knowledge. But, work in contemporary cognitive science has repeatedly stressed that "deep" sense making requires fairly intensive and specific knowledge about a domain, including factual knowledge (for an overview, see Bruer 1993). Cognitive scientists refer to problem-solving methods that use domain-specific knowledge as "strong methods" and those that use only general knowledge as "weak methods". This is, presumably, one of the reasons the Concord classroom grafted a fairly traditional model of science education onto a culminating sense making discussion. This allowed at least some of the children to leverage "strong methods" by using more domain-specific information.

A second problem arises in connection with this first issue. Sense making discussions are intended to be "egalitarian", allowing all children to make contributions based on their distinctive intelligence and experiences. But children with a good deal of prior school-based and domain-specific experiences, whether from home or previous schooling, can engage in "deeper" sense making, using "strong methods". Such children get to practice "higher order" skills at the same time as, and in the same enterprise where, other children are practicing "lower order" skills. We saw that this was a problem even in the Concord classroom.

Sense making discussions are meant to remedy this second problem by rendering the cognition of such "advantaged" children public, so that all the children in the group can make use of it. But here a third problem arises. Sense making discussions privilege everyday language. At the

same time, they eschew both overt instruction and meta-talk about language and social practices. They do this precisely because to do otherwise would, it is thought, simply recreate the conditions of traditional schooling. Relying on everyday language allows everyone to participate. However, everyday language and a lack of a meta-reflection on language leads to language that, because it is ambiguous in ways that often effaces important "specialist" distinctions, is not really public. Such language is, in fact, meaningful in different ways to children "in the know" than it is to other children. This, in turn, mitigates the egalitarian goals of sense making discussions.

Finally, there is a fourth problem stemming from what we called the "hybridity" of sense making discussions. The way in which different functional forms of talk, and different topics and sub-topics, crisscross each other (a feature of some forms of lively "everyday" conversations, as

well) would seem to require a good deal of prior knowledge to tease apart and relate the different strands of talk. While such multiplicity is celebrated in postmodern social and literary theories, one would like to be assured it is not, again, simply advantaging those children with a great deal of prior school-based cognitive and linguistic "sophistication".

4. "SENSE MAKING" AND THE "NEW CAPITALISM"

Pedagogies like sense making discussions are "attuned" to the production of new kinds of people that are just the sort "new capitalist" businesses are currently calling for (Gee, Hull, & Lankshear 1996). And, indeed, such an alignment is often rendered overt when educators are seeking grants from the government, foundations, or businesses to study, implement, or disseminate such pedagogies.

Our new global capitalism represents a disavowal of the large hierarchical corporations of the past. In these corporations, bosses and middle managers controlled (relatively stable) "knowledge" and workers carried out mindless decontextualized tasks. In our new global high-tech economic conditions, knowledge goes out of date too fast and markets change too quickly to sustain the old system. Our "new times" require, it is argued, new kinds of work and new kinds of workers.

Today, work is not about stable jobs. It is about team work and projects. Teams band together, change, and disband as projects and market niches arise, get transformed, and die. Each worker is supposed to be proactive, self-motivated, "empowered", and totally committed on each project. Each worker is supposed, as well, to learn new things quickly and well, especially technical things, understand whole systems, and be able to communicate and share knowledge with co-workers and mangers. Diversity of all sorts is "in", since a business may be able to use any worker's specific sociocultural experience and knowledge to innovate new practices, products, or services.

Workers are now each independent entrepreneurs, moving from project to project based on the ever changing skills and achievements they have accrued in their "trajectories" through diverse projects. Workers are no long "jobs" ("I'm a data processor"), but a set of ever growing and (on one's resume) rearrangeable skills, achievements, and experiences "sold" on a project by project basis.

The premium in this new world, then, is on a) learning to learn (especially in regard to science and technology), rather than on fixed knowledge, since knowledge goes out of date quickly; b) being able to innovate on the job, not so much accruing knowledge as transforming it; c) being able to collaborate with others, since work is team-based; d) being able to communicate with diverse viewpoints and perspectives, since teams will be "cross-functional" (made up of

people with different functions and types of expertise); e) being able to express and transfer one's knowledge--making one's tacit knowledge public, so that the "system" can leverage it; and f) being able to cross borders and boundaries that separate different tasks, different bodies of knowledge, or different sorts of people, since hierarchy and divisions are "out"--they simply slow things down. Sense making discussions in a science classroom are a near perfect match of these features; they are, in this respect, then, a perfect device for the new capitalism.

What could possibly be "wrong" with any of this? There is this: The oft-used phrase "knowledge workers" hides very different kinds of new workers in the new capitalism. There are, for instance, what Robert Reich (1992) has called "symbol analysts". These are the true leaders of the new capitalism, people who create new knowledge, new systems, and new practices. They often have a great deal of specialist knowledge in addition to their ability to be "creative" and "make sense".

Then there are what I have called elsewhere "enchanted workers". These are the new high-tech workers who will understand and leverage technical information on the job, continuously adapt to change, render their tacit knowledge (knowledge gained in practice) public and usable, and understand the whole system of which they are a part. But these workers, paid much less that symbol analysts, are meant to live uncritically and uncynically within the sociotechnical practices and environments that the symbol analysts create and, in the end, control.

Then there are the vast hoards of "service workers" and "brute workers", people with no particular knowledge to "sell", only their bodies. They would be glad to become "enchanted workers", if they could just gain some "technical knowledge" that "sells", no might how little the price might be.

I believe that in today's schools we are in danger of creating a new tracking system. There will be a track for new symbol analysts replete with both traditional knowledge and skills, "strong methods", and the ability to innovate and "make sense". There will be a track for new enchanted workers replete with the ability, using "weak methods", to collaborate and communicate within systems, and to use and transform relatively low level technical skills and knowledge. And there will be a track for service workers and "brute workers" replete with traditional skill and drill and an early exit from school. It is at least interesting to ask whether what we saw in Concord is training for future symbol analysts, while what we saw in the less advantaged school is a way to sort future enchanted workers from future service workers.

5. META-REFLECTION ON FORM AND FUNCTION

Sense making discussions are based on a set of hidden assumptions, such as a) people learn because they are talking; b) people learn from listening to other people talk; and c) mixing

and matching different levels and forms of talk in a communal discussion does not give rise to any important interpretive problems. None of these assumptions impresses me as transparently true. I believe it takes prior work of a certain sort--work on language itself--to make them true. And this work is rarely done in contemporary schooling, including in current school reforms. So let me turn all too briefly to language.

The form of any piece of language has a "reflexive" relationship to the context in which it is used. The form helps to signal what we take the context to be and mean (e.g., "predicting as part of a scientific experiment" or "speculating as part of a group discussion"). But it is also true that what we take the context to be and mean helps us to determine what meaning we assign to that language form (e.g., We might conclude that the utternace "I thought maybe it was going to grow best um over by the window and at the grow plant table" must be a prediction of some sort given what the context appears to be and, indeed, the form of this utterance seems to encourage this construal of the context). This may all sound circular, but it really isn't, because what we are actually doing is finding a "best match" between form (which has only a limited range of possible functions, delimited yet further in context) and context (which, at any one time, has only a limited range of possible construals, delimited yet further by each new utterance). That is, language and context are what cognitive scientists call "soft constraints" on each other.

Within any interaction, we are continuously, but usually quite unconsciously, using "guesses" about form-context pairings to build up (tentative) answers to each of the following questions:

a) What <u>action</u> or actions are being carried out here (e.g., "predicting", "speculating", "making observations", "stating common knowledge", etc.)?

b) What <u>socially situated identities</u> ("subject positions"), with what socially situated purposes, emotions, and values, are speakers/writers and listeners/readers taking on here (e.g., "student experimenter" or "collaborative sense maker")?

c) Who are the <u>actants</u> here: i.e., the people and things being talked/written about and/or acted upon and what socially situated meanings and identities are being attributed to them (e.g., green color as a health variable in an experiment or green as the color of plants in our everyday experience)?

d) What <u>social practice</u> (or practices) are the above actions, identities, and actants being used to help constitute (e.g., an experiment in a specific model of school science or sense making as a specific school-based collaborative activity)?

e) What Discourse or Discourses (or "culture" or "community of practice" or "form of life") are these actions, identities, actants, and social practices part of (e.g., "hands on" constructivist school science of a certain sort; science as a particular form of observing and sense making; or traditional school science of a certain type; or mixtures thereof developed in a specific classroom or school)?

When we don't know at least tentative answers to these questions, we don't know what we are doing. When people in one and the same interaction are answering these questions quite differently, they are doing different things, sometimes in a coherent, but not necessarily fair, way (e.g., the advantaged are practicing "higher order" skills and the disadvantaged are practicing "lower order" ones within the same activity) and sometimes in an incoherent way. But, when we do know tentative answers to these questions in an interaction, we very rarely can articulate these answers in any very explicit or coherent way.

We have seen that the use of everyday language in sense making discussions can actually undercut the egalitarian goals of the pedagogy. Everyday language is deeply contextualized in and tied to a local context of shared experiences, events, spaces, and objects and, thus, leaves tacit many distinctions that are important in more specialized languages. Furthermore, everyday language is tied to answers to the above questions that are often quite different from the answers more specialized languages are tied to.

On the other hand, it is often mistakenly held that specialist "social languages" ("registers"), like those used in the sciences or in academic discourses more generally, are "decontextualized". They are no such thing. Rather, they are "decontextualized" from the local context precisely so they can be recontextualized in a shared body of more esoteric experiences, that is, experiences with special sorts of texts, procedures, practices, and identities (I associate this idea with Jim Wertsch and with Courtney Cazden). Such specialized languages are tied, in turn, to "esoteric" answers to the above questions.

Simply using specialist languages, instead of everyday language, however, will simply advantage those who have had the requisite esoteric experiences, and disadvantage those who have not. However, overtly focusing on--naming and talking about--how language form and context match up to answer the questions above carries the possibility of "disadvantaging" everyone in an efficacious way. Everyone can think about what the "rules of the game are", whether and how they make sense, and who has and has not had the requisite experiences, and why. The "advantaged" are forced to think overtly about what they have heretofore known only

tacitly in practice. The “disadvantaged” are allowed to see just what sorts of assumptions are at play and what sorts of background experiences and values are being assumed.

Furthermore, such a focus quickly leads to thinking about the “worldview” of any enterprise. Imagine, for example, that we overtly reflected on why certain scientific social languages would want to render the distinction "being rusty" and "having rusted" important and explicit. We would have to connect this to these scientific languages' interest in a clear distinction between causes and correlations. In turn, we would have to connect this to their yet more general interest in a clear distinction between "underlying realities" and "superficial appearances". With this distinction we come to the heart of the worldview of certain sorts of scientific endeavors. We come also to the dilemmas and dangers of carrying this worldview over into other domains (e.g., creating such things as "general intelligence" or the "average male" as “underlying” or “deeper” realities), and to the historic and changing relationships among science, technology, nature, and society.

Or imagine, in the Concord classroom, that we overtly focused on what predictions and explanations look like and what role they play in specific scientific practices. Imagine, too, we overtly focus on what different sorts of discussions look like and what role they play at different stages of a scientific investigation. This would force us to confront, for ourselves and our students, our model or models of science and pedagogy. It would force us to confront where "strong methods" are appropriate and where "weak" ones are, as well as who is using which for what where. The "slippage" we saw in the Concord classroom, rendered overt, and reflected on in its own right, would force us to confront our changing views of science, learning, and the relationship of schools to work in the new capitalism. It would, perhaps, also render the practice in this classroom more “coherent” for all the children, all of whom would gain insight into the multiple practices and identities in science, and the multiple ways of doing science in and out of school.

One of the morals of the Australian “genre movement”--at least, one of the morals I have drawn from it--is that an overt focus on the <u>form</u> of language can constitute a <u>political</u> intervention (Martin 1989, 1991; Kress 1988; Kress & Threadgold 1988). I have here construed an overt focus on form to mean an overt focus on how form and context are matched in answering questions about actions, actants, identities, social practices, and Discourses. It is political because such an overt focus forces us to name and discuss who is doing what to whom in whose interests and for what reasons and with what values and worldview. It is to center the curriculum in the relationships among Discourses and the ways in which they create the geography of sociocultural space. It might allow more people to walk more widely through that space or, at least, to understand more deeply how and why they are excluded from certain of its regions.

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