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The Architecture and Dynamics of Intersubjectivity in Science Classrooms

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INTRODUCTION

In this article we examine instructional discourse from the perspective of how it involves the creation and maintenance of intersubjectivity. Specifically, we examine discourse from a Brazilian eighth-grade science classroom and explore some of the implications our analyses have for understanding the dynamics of intersubjectivity in general and for understanding intersubjectivity in pedagogical settings in particular. The illustrations we use allow us to examine how *speech genres* (Bakhtin, 1986) are involved in the negotiation of intersubjectivity, how they shape "bids" in such negotiation (Rommetveit, 1974), and how they may be resisted as well as accepted.

INTERSUBJECTIVITY

In a series of publications over the past few decades, Ragnar Rommetveit (1974, 1979a, 1979c, this issue) has outlined an account of intersubjectivity. This has been part of a larger project having to do with the nature of human verbal communication as an inherently social and dynamically negotiated process. As Rommetveit pointed out in his article in this issue, "we are not 'owners' of our common language, but 'shareholders' in it." From this perspective,

> the notion of an utterance deprived of its context of human interaction is as absurd as the notion of a fall deprived of the gravitational field within which it takes place. *What is made known* in an act of verbal communications can therefore be properly assessed only if we venture to explore the architecture of intersubjectivity within which it is embedded. (Rommetveit, 1979a, p. 93)

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Rommetveit (1979d) characterized intersubjectivity in the following terms:

> The basic problem of human intersubjectivity becomes ... a question concerning in what sense and under what conditions two persons who engage in a dialogue can transcend their different private worlds. And the linguistic basis for this enterprise, I shall argue, is not a fixed repertory of shared "literal" meanings, but very general and partially negotiated drafts of contracts concerning categorization and attribution inherent in ordinary language. (p. 7)

In Rommetveit's view intersubjectivity is a presupposition that we must take for granted in order to engage in acts of communication. Perfect intersubjectivity is a convenient fiction, never attainable, but "we must, naively and unreflectively, take *the possibility of perfect intersubjectivity* for granted in order to achieve *partial intersubjectivity* in real life discourse with our fellow men" (Rommetveit, 1979c, p. 161). Communication sets up what Rommetveit called *states of partial intersubjectivity*, which presuppose a complementarity of intentions, the capacity for decentered categorization and attribution, and reciprocal role taking.

In order to explore states of intersubjectivity, Rommetveit has outlined a three-dimensional system of coordinates within which one can locate the time of the communicative act, its location, and the identification of the listener by the speaker and vice versa. "Whatever is shared, presupposed, or assumed to be known already is hence shared, presupposed, or assumed by the I and the YOU within a temporarily shared HERE and NOW" (Rommetveit, 1979a, p. 94).

Embedded in this three-dimensional image is yet another factor: the particular language used by the speaker and listener. As reflected in his comments about "partially negotiated drafts of contracts concerning categorization and attribution inherent in ordinary language" (1979d, p. 7), Rommetveit clearly recognized this. Indeed, he proceeded from the assumption that intersubjectivity would be difficult, if not impossible, to attain if a speaker and listener did not share the same language. Given the traditions in theoretical linguistics he was criticizing, however, his emphasis has been on making certain that we understand that sharing a language does not guarantee or somehow mechanistically determine intersubjectivity. Armed with a somewhat different view of language, we have the aim of returning to the issue of the language used in communication and examining its place in the larger enterprise Rommetveit has mapped out.

In order to do this, we must first clarify just what notion of language is involved. Rommetveit's critique of literal meaning takes as its target views of language that assume it is some sort of decontextualized, logical system. However, other accounts of language that are grounded in the dynamics of communication and dialogue may be usefully employed when trying to understand intersubjectivity, a view that Rommetveit himself clearly endorses. This entails giving analytic primacy to utterances as opposed to abstract, decontextualized linguistic forms.

In this connection we focus on what Bakhtin (1986) termed *speech genres*:

> A speech genre is not a form of language, but a typical form of utterance; as such the genre also includes a certain typical kind of expression that inheres in it. In the genre the word acquires a particular typical expression. Genres correspond to typical situations of speech communication, typical themes, and consequently, also to particular contacts between the meanings of words and actual concrete reality under certain typical circumstances. (p. 87)

Bakhtin (1986) included a wide range of linguistic variants under the heading of speech genre. On the one hand, he included instances in which utterances are tightly constrained in form and content, items such as "various everyday genres of greetings, farewells, congratulations, all kinds of wishes, information about health, business, and so on" (1986, p. 79). On the other hand, he included the "freer and more creative genres of oral speech communication" (p. 80) that do not involve such tight constraints on the form and content of utterances. In this latter category, he had in mind items such as "genres of salon conversations about everyday, social aesthetic, and other subjects, genres of table conversations, intimate conversations among friends, intimate conversations within the family, and so on" (p. 80). In general, Bakhtin's account of speech genres was quite broad and allows various criteria to be used in distinguishing one genre from another.

Coordinating the insights of Bakhtin (1986) with those of Rommetveit makes it possible to see how speech genres shape intersubjectivity. Just as it is difficult, if not impossible, to attain even partial intersubjectivity if a speaker and listener do not share a "national language" such as Thai or French, intersubjectivity is fundamentally shaped by the speech genres used. Using Bakhtin's notion of speech genre makes it possible to gain new insight into what it means for a speaker and listener to "transcend their different private worlds" (Rommetveit, 1979d, p. 7) in general and in the specific discourse realm found in science classrooms in particular.

Before leaving our review of intersubjectivity, it is worth noting one additional point made by Rommetveit (1979a) that has important implications for our study of pedagogical discourse. He argued (Rommetveit, 1979a) that the "direction of communication," or who controls the grounds for creating and maintaining a shared social reality, is an essential part of the picture:

> The speaking "I" has the privilege of pointing out the objects, events and states of affairs to enter the field of shared attention. Which of all possible entities of an experientially shared situation will be introduced and enter the slots of THIS, HERE and THAT, THERE of the formal skeleton of intersubjectivity is thus in principle determined by the speaker. The same holds true for any topic, whether introduced by deixis, by identifying descriptions, or by other means. The listener has to accept and engage in whatever social reality is introduced. (pp. 95–96)

To this we would add that the speaking "I" has the privilege of specifying what speech genre will be used in the communicative setting, a point to which we return in our analyses below.

SPEECH GENRES INVOLVING A "SECOND REALITY" OF OBJECTS

In order to develop our ideas about the speech genres involved in science instruction, we turn to a line of research on verbal thinking initiated by Luria (1976) in the 1930s and continued by scholars such as Scribner and Cole (1981) and Tulviste (1991) subsequently. These authors have consistently noted the difficulty that nonschooled research participants in various societies encounter in dealing with abstract concepts and word meanings. This research has involved tasks such as syllogistic reasoning and the categorization of objects.

In a review of findings about how participants justify their answers in syllogistic reasoning tasks, Scribner (1977) found it useful to use a distinction outlined by Luria (1976) between "theoretical" and "empirical" explanations. Scribner defined theoretical explanations as ones based strictly on the information provided by the experimenter. In contrast, empirical explanations are

based on additional information introduced by the participants themselves into the problem space. As an example, Scribner provided the following problem and types of explanation:

> All people who own houses pay a house tax.
> Boima does not pay a house tax.
> Does Boima own a house?

> A theoretical justification: "If you say Boima does not pay a house tax, he cannot own a house." An empirical explanation: "Boima does not have money to pay a house tax." (p. 489)

In her review of the patterns found in syllogistic reasoning studies, Scribner (1977) began by reporting the following:

> Non-schooled villagers overwhelmingly support their answers by appeals to fact, belief or opinion [i.e., facts introduced by the participant but not explicitly stated by the experimenter] ... . This appeal to real world knowledge and experience, which for the time being we will call "empirical bias," is the single most prominent characteristic of villagers' performance. (pp. 489–490)

At first glance, an empirical bias might seem to be a direct reflection of a less developed level of knowledge or skill in logical deductive reasoning. From this perspective the picture is one of stagelike development in which schooled participants demonstrate a higher, more abstract ("theoretical") mode of reasoning than nonschooled participants, who are restricted to empirical reasoning. Such an interpretation encounters difficulties on several fronts, however. First, it is not the case that nonschooled participants never use theoretical modes of discourse and thought. Indeed, one of the most important insights Scribner (1977) provided in her review of research on this topic is that nonschooled participants often do solve syllogistic reasoning tasks correctly, namely, in those cases in which they accept the premises of the syllogism. In such instances they are as likely to arrive at the correct conclusions as schooled participants are.

The major difference between schooled and nonschooled participants in syllogistic reasoning studies, then, does not have to do with the logic of deduction. Instead, it has do with whether or not participants accept the premises of a syllogism, which may include information that they know to be false or information with which they are not personally familiar. Schooled participants were more likely to operate by using the information—and only the information—provided by the experimenter, whereas nonschooled participants tended to draw on other information available to them.

This is not to discount differences between schooled and nonschooled populations in syllogistic reasoning, but it is to view them as stemming from sources other than those often assumed in accounts of cognitive development. Rather than reflecting differences in a universalistic stage theoretical hierarchy of deductive reasoning, it seems to stem from a difference in the willingness or ability to participate in a specific, socioculturally situated speech genre (Wertsch, Hagstrom, & Kikas, 1995). This is a speech genre in which interlocutors accept the existence of hypothetical objects and attributes because they are talked about, rather than because they have been personally and concretely experienced. In this sense, the speech genre involves a "second reality" of hypothetical objects and attributes of those objects.

A second reality of objects and attributes was also at issue in other studies conducted by Luria (1976); Cole, Gay, Glick, and Sharp (1971); Tulviste (1991); and others having to do with catego-

rization. In this case the differences have to do not with accepting hypothetical information in order to solve a syllogism but with categorizing abstract as well as concrete objects. Specifically, they are concerned with categorizing abstract semiotic objects in the form of "decontextualized word meanings" (Wertsch, 1985) that emerge in connection with uses of language associated with literacy. As in the syllogistic reasoning studies, the nonschooled participants demonstrated an inability or unwillingness to engage in theoretical forms of discourse and thinking.

The sort of differences we have in mind are reflected in the following dialogue between Luria and a nonschooled participant from experiments Luria conducted in the 1930s in Central Asia (Luria, 1976):

> [The participant is shown drawings of a hammer, a saw, a log, and a hatchet, and the experimenter poses questions]:
>
> Which of these things could you call by one word?
>
> "How's that? If you call all three of them a 'hammer,' that won't be right either."
>
> *Rejects use of general term.*
>
> But one fellow picked three things—the hammer, saw, and hatchet—and said they were alike.
>
> "A saw, a hammer, and a hatchet all have to work together. But the log has to be there too!"
>
> *Reverts to situational* [empirical] *thinking.*
>
> Why do you think he picked these three things and not the log?
>
> "Probably because he's got a lot of firewood, but if we'll be left without firewood, we won't be able to do anything."
>
> True, but a hammer, a saw, and a hatchet are all tools.
>
> "Yes, but even if we have tools, we still need wood—otherwise, we can't build anything."
>
> *Persists in situational thinking despite disclosure of categorical term.* (p. 56)

As Wertsch (1985) noted, this interchange almost sounds like a comedy routine in which two interlocutors are using the same words but understanding them differently. The key to interpreting the systematic misunderstanding in this "dialogue" is that the nonschooled participant was using expressions such as *hammer* to refer to empirically real referents, whereas Luria was using them to talk about the decontextualized word meanings that underlie a form of theoretical thinking. What Luria was asking the participant to do was to group, or categorize word meanings, whereas the participant consistently understood the task as one of categorizing nonlinguistic objects that could be referred to with the same terms as the word meanings. In this case, Luria was using lan-

guage to talk about the "second world" of abstract semiotic objects, whereas his interlocutor was not.

In contrast to explanations that would focus on differences in cognitive stages, we again suggest that differences between schooled and nonschooled participants in such categorization tasks is more appropriately understood in terms of differential experience with speech genres. Luria (1976), Cole et al. (1971), and others have provided evidence that suggests that nonschooled participants' performance is shaped primarily by an unwillingness, or even an overt resistance, to play the language game that appears completely natural to schooled participants. Indeed, this is suggested by Luria's (1976) use of terms such as *rejects* and *persists*.

There are many ways to describe and differentiate various speech genres, but our focus here is on whether or not objects from a second reality are involved. Again, such objects are hypothetical and come into existence because—and only because—they are talked about, not because they have been otherwise experienced. Any language has the "semiotic potential" (Wertsch, 1985) to be used in such speech genres, but it takes systematic use of this potential in "literacy practices" (Scribner & Cole, 1981) to make this potential emerge into a semiotic and psychological reality for speakers.

The ideas about theoretical and empirical reasoning that we have been discussing have usually been harnessed to examine cultural and historical differences in groups' cognitive functioning. In what follows, we harness them for a somewhat different purpose, namely, to provide insight into the dynamics of discourse in pedagogical settings and how intersubjectivity is—or is not—attained.

THE NEGOTIATION OF INTERSUBJECTIVITY IN SCIENCE CLASSROOMS

Generally speaking, classrooms are places where the teacher "has the privilege of pointing out the objects, events and states of affairs to enter the field of shared attention" and the students have to "accept and engage in whatever social reality is introduced" (Rommetveit, 1979a, pp. 95–96). As we argued earlier in this article, this line of reasoning can be extended to speech genres: A speaker has the "privilege" of selecting a speech genre, and the listener must "accept and engage" in whatever speech genre is selected. Specifically, with regard to science classrooms, the meta-contract underlying communication is based on the assumptions that (a) the teacher has clear, undisputed understanding of speech genres and the meanings of the terms he or she uses, and (b) the students' task is to try to understand and "master" (Wertsch, 1998) these genres and terms.

In our view, the making of meaning in classrooms is always dialogic in the Bakhtinian sense that listeners understand utterances by placing them in an active dialogic context provided by their responses. However, it is often assumed that teachers speak in some sort of "univocal" way (Wertsch, 1991) and that problems in understanding reflect students' failure to "receive" and "decode" the message that teachers "transmit." Related to this is the tacit belief by teachers that the meanings of the words they try to convey in classroom discourse are transparent and clearly rooted in real entities of the world, even when those entities have nothing to do with tangible things. This qualifies as the sort of view of language that Rommetveit (1979d) criticized as "a fixed repertory of shared 'literal' meanings" (p. 7).

Coulson (1955) provided a good example of just how powerful these assumptions can be. His statement reflects the strong temptation to misrepresent the entities of science as "real" things that

are transparently referred to in the discourse of science. The resulting confusion seems to go unnoticed even for sophisticated practitioners of quantum chemistry (Coulson, 1955):

> I described a bond, a normal simple chemical bond; and I gave many details of its character (and could have given many more). Sometimes it seems to me that a bond between two atoms has become so real, so tangible, so friendly that I can almost see it. And then I awake with a little shock: for a chemical bond is not a real thing: it does not exist: no-one has ever seen it, no-one ever can. It is a figment of our own imagination. (p. 2084)

In terms of Rommetveit's perspective on intersubjectivity, we can say that when students are invited to speak in the traditional "Initiation–Response–Evaluation" (IRE) pattern outlined by Mehan (1979), their role is limited to completing an utterance to which they are listening. As speakers, they perform largely from the perspective of the teacher because they have to anticipate what they will hear next from the teacher and answer accordingly. In more open approaches such as that provided by "reciprocal teaching" (Palincsar & Brown, 1984), students can perform more actively in speaker-related roles. However, even in this case, "the negotiation of intersubjectivity from the point of view of the teacher" seems to direct student speakers to anticipate teachers' utterances.

Thus even when students, for example, initiate a dialogic sequence or ask "authentic questions" (Nystrand, 1997), they normally try to do so using a prespecified speech genre, theme, and approach, all of which ultimately belong to teachers and more generally to the sociocultural context of formal instruction in science classrooms. This reflects a limitation—perhaps a natural and necessary one—in the range of options provided. Such limitations reflect more general dimensions of schooling activity in modern societies, where asymmetries of power relationships in the classroom are accepted and teachers' claims are assumed to be univocal and unchallengeable.

Another aspect of science classroom discourse that reinforces this positioning of students in the role of listener is the "overall picture" teachers try to create, a picture related to the planned curriculum. Teachers provide hints about this picture to students through overviews, metacomments, and so forth. In fact, however, students rarely get the overall picture. Instead, they understand only partial, though increasingly comprehensive, aspects of it. From the teacher's point of view, this overall picture provides direction to the process of meaning making. Because students do not have an overarching model of the puzzle they are trying to solve, it is unlikely that they will be able to have a real speaker role in the classroom, and this limits the possible contracts of intersubjectivity.

As Rommetveit (1979a) noted, "What is made known at any particular stage is thus not only made part of an expanded shared social reality, but serves at the same time as a prerequisite for making proper sense of what is said next" (p. 99). Where this whole process of meaning making in the science classroom is headed, nevertheless, is something that only the teacher knows. This is an important aspect of discourse in this setting, and perhaps it is a paradox for those concerned with designing curriculum if we believe that the students should perform as an authentic speaker.

Another important characteristic of science classrooms is that the teacher is usually trying to move from the here and now of everyday phenomena and ways of speaking about them to more abstract levels of discourse framed in speech genres having to do with the second reality of abstract objects and relations. In doing so teachers shift from the phenomena themselves to things that are not in the here and now. Instead, they are abstract entities that only have meaning within

the context of more general models and theories. This shift in the ontological categories that are referred to in the discourse is accompanied by a shift from everyday language and its genres to the more sophisticated genres of science.

According to Halliday (1993), scientific discourse has its own peculiar grammar in which verbs and nouns function differently than in everyday language. In many cases, processes that would require an entire textual segment to be expressed in the everyday language are nominalized in scientific language. Verbs function in clauses as a causal link between these nouns–processes. By means of such grammatical metaphors, processes are put into relationship in the construction of a scientific argument (Halliday, 1993). The language of science is, therefore, a way of talking about the world that is different from everyday language, even in its grammar.

Normally, science teachers go from phenomena to explanation and generalization, from everyday language to scientific discourse, quite unconsciously and automatically. In many cases, however, these shifts are not followed by the students. As has been demonstrated by several studies on the use of particulate model of matter (e.g., Ben-Zvi, Eylon, & Silberstein, 1986; Brook, Briggs, & Driver, 1984; Garnett, Garnett, & Hackling, 1995; Griffiths & Preston, 1992; Hesse & Anderson, 1992; Mortimer, 1998; Reström, 1987), students have great difficulty in distinguishing or making transitions between these levels. A very common finding of these studies is that students attribute macroscopic properties, such as color or fusibility, to microscopic particles. In Rommetveitian terms, one could say that, in doing this, the students do not share the rules of categorization and attribution of the teacher, resulting in failures of attaining intersubjectivity.

EMPIRICAL ILLUSTRATIONS FROM THE CLASSROOM

The data we analyze in this article come from a Brazilian eighth-grade science classroom (students ages 14–15) in which the particulate model of matter was taught in connection with physical states of matter. The entire class as well as a subgroup were videotaped, and the tapes were transcribed. The episodes to be analyzed belong to a sequence of 12 lessons that lasted over 3 weeks. Videotaping had begun 2 months prior to the interaction to be analyzed here occurred, and the students seemed to be quite unaware of the camera. All the classroom talk produced during the 12 lessons was transcribed. In this article two episodes from these 12 lessons are analyzed.

The lessons were based on small-group discussion, which alternated with whole-class discussion. In the initial lessons students had to discuss and then select one of the models the teacher had selected from their own suggestions in earlier sessions. In these earlier sessions the students had been invited to draw models for a system, both before and after transformation, related to the following phenomena: compression of air in a plugged syringe, expansion of air heated in a test tube with a balloon over its neck, the release of a vacuum in a flask connected to a large syringe, the diffusion of gas odor in the kitchen as it escapes from its container, dilatation by means of heating with the hand of the alcohol (or mercury) column of a thermometer, and melting and vaporization of naphthalene heated in a test tube.

The activities and lessons planned for teaching atomism as a model to explain the physical states of matter began with a discussion in which students expressed ideas through their own models. In this sense, these lessons can be said to represent a different contract of intersubjectivity, set up with the implicit admission that multiple voices, which could even be in conflict, should be taken into account as part of this only partially shared world populated by different ways of cate-

gorizing matter. Nevertheless, the pressure toward univocal meanings that characterizes classrooms as institutional settings works against this new contract of intersubjectivity, as we see in the data presented here.

Episode 1: "Draw a Ridiculous Square and Put the Model Inside"

Episode 1 shows how the lack of a shared rule of categorization and attribution between teacher and students misled the students when they were trying to perform a task of drawing a general model for matter in the gaseous state. This episode tends to confirm that "mutual understanding or intersubjectivity is something that you can only assess negatively. It is impossible to get a positive measure of perfect mutual understanding. You can only pinpoint or empirically assess misunderstandings" (Rommetveit as cited in Josephs, 1998, p. 191).

The episode occurred in the fifth lesson of the sequence when, after discussing the models for all situations involving gases, the students were asked to draw a model for any gas. This movement from the here and now of the phenomena involving actual gases to a general category of matter (i.e., gas) presupposes a shift in intersubjectivity. Specifically, it involves a shift from using models to talk about everyday real phenomena to using models that deal with an abstract referent, gas, now considered as a general category of matter rather than as a concrete particular. The difficulties that arose from the interference of the students' everyday voices, in which the word *gas* refers to a concrete prototype, namely kitchen gas, show that despite the students' effort to share the univocal world of the teacher, they were still operating in "a multifaceted, only partially shared, and only fragmentarily known world" (Rommetveit, 1979a, p. 102). Here is Episode 1:

1. Edw: It has to be a model for all ... .
2. (Parallel talk, inaudible.)
3. Car: What does a model for gas have to have? What characteristics does it have to have?
4. Edw: First, being gaseous.
5. Car: No, material?
6. Ale: No, (it has to) have [i.e., contain] the gas.
7. Car: Yes, to have the gas.
8. Ale: It has to be compact, of course. You can't put a gas ... , no, because the gas in the butane bottle (*botijão*[1]) ... .
9. Car: Is liquid.
10. Ale: It is liquid, but ... .
11. Edw: For instance, you can't put (it) in a plastic container, of course. It has to be something ... .
12. Ale: But, you can't put the gas ... how can you transform it into its liquid state.
13. Gla: Put it in a container ... . (Inaudible.)
14. Car: Hey people! Then it must be a butane bottle.
15. Edw: How can I say it ... a container ... . I forget the word ... . it has to be a container (Edw gesticulates with her hands, indicating something closed.) (The group calls the teacher, who is working with another group.)
16. Car: Gee! Seriously, I have no idea.
17. Edw: No, we have an idea, we don't know how to explain it ... .
18. Car: No, it has to have more ... .

[1] A *botijão* is a metal container of gas used for kitchen cooking in Brazil. All the students were thoroughly familiar with these containers.

19. Edw: A supposition ... it has to be a vacuum .... supposing, it is only an example, one way is to put the gas there, inside ... .
20. Ale: (to the teacher, who comes over to the group). Teacher, all gases can be transformed into a liquid state?
21. T.: Yes, all can be transformed, but some have to be in perfect condition; otherwise they can blow up.
22. Ale: Sort of ... ?
23. T.: Like methane, natural gas. What do they do with natural gas? (The teacher explains why natural gas must be transported through pipelines and cannot be stored in containers like butane and propane.)
24. Edw: See, now it changes completely .... to put (the gas) in a pipeline or inside a butane bottle ....
25. T.: Hey, pay attention: What should you do in this question, now? You have proposed a model for each one of the previous situations. This model now, the final model, isn't it the same model for all the situations? Then, what is this? It is to generalize. Which is that model? What model is it?
26. Ale: It is a compact model, isn't it?
27. T.: No, it is not this. Forget the butane bottle! It is constituted by ... .
28. Car: Particles ... .
29. T.: By particles, it this. All the gases, then ... .
30. Ale: Particles!
31. T.: Particles. And what are the characteristics of the particles? Then, what you should discuss is this. Particles and what else? .... How the particles ... what happens to them .... how do they behave? (The teacher leaves, going to another group.)
32. Ale: If they undergo modification ... I'm not understanding ... .
33. Car: Nether do I (All laugh.) ... .
34. Ale: The thing is: it has to be made a characteristic of a gas. Of gases ... .
35. Edw: We were talking about that, totally wrong! Here it doesn't say anything about a container ....
36. Car: But here it is asking to describe the model.
37. Edw: Then, the model .... (Inaudible.)
38. Car: Yeah ... .
39. Edw: Maybe he said it this way: draw a ridiculous square there and put the model inside the square.
40. Car: Yes, then it is this. (They begin to draw.)
41. Car: The particles of a gas are the same as the particles of the air?

In the first five utterances of this episode, the dialogue between Car and Edw suggests that they were interpreting the task from the teacher's perspective. Edw referred to a model in Turn 1, and Car adds a question consistent with the teacher's perspective as reflected in Turns 27 and 29. In Turn 6, however, Ale begins to diverge from this perspective by introducing the notion of a container for gas. Ale was continuing to use terms introduced by Car and Edw, but it seems that he was thinking about a specific gas—cooking gas widely used in kitchens—whereas Car and Edw apparently began the episode dealing with gases in general.

At this point in the discussion, the perspective introduced by Ale prevailed, and the students went on to discuss how to draw the gas container, something that was clearly framed by the prototypes of gas they were using, butane gas for cooking (Turns 6 to 19). The question they posed to the teacher in Turn 20 is grounded in this perspective ("Can all the gases be transformed into a liquid state?"). From the previous dialogue, we can infer that this question could be restated as "Can all gases be transformed into a liquid state just as butane can be?" After answering their question, the teacher was able to perceive, from Edw's comment in Turn 24, that they were formulating things from a different perspective, namely, one concerned

with the characteristics of a container in which to put a gas instead of the characteristics of gases in general.

In Turn 27, the teacher starts with the directive "Forget the butane bottle!" and then follows this with an invitation to the students to think of gases from a more general perspective ("It is constituted by ... "). This suggests that the teacher was performing his role of "controlling the criteria by which comprehension and intersubjectivity are evaluated" (Rommetveit, 1979b, p. 170). The interventions of Ale in Turn 34, using the word *gas* in the plural, and of Edw in Turn 35, evaluating their lack of the shared meaning presupposed to solve the task ("We were talking about that, totally wrong! Here it doesn't say anything about container ... "), suggest that the teacher succeeded in moving them to the perspective he desired, thereby reestablishing a state of intersubjectivity on terms he deemed appropriate for the discourse.

Edw's evaluation of their performance in Turn 39 ("Maybe he said it this way: draw a ridiculous square there and put the model inside the square") and the question from Car in Turn 41 ("The particles of a gas are the same as the particles of the air?") suggest, nevertheless, that the task of drawing a general model for all gases still did not make sense to them. It sounds as if the students were trying to answer a question they would never ask themselves (Rommetveit, 1979b).

It is interesting to note that this happens precisely when the teacher tried to move the discussion toward theoretical discourse involving abstract categorization. When he was asking the students to use a scientific model to explain everyday phenomena for which they already had their own explanation, the students apparently were able to consider the teacher's questions as authentic and make them their own. They were also able to use general features of a particulate model. Nevertheless, when the teacher explicitly suggested that they could leave behind their everyday phenomena to think about a general category of matter, the students experienced much more difficulty in considering the task as something meaningful for them. In the end, they resisted participating in the speech genre proposed by the teacher, a speech genre concerned with the second reality of abstract objects.

Episode 2: "If I'm in the Street, I Won't Use Particles to Define Glass"

The second episode that we examine comes from the same sequence of lessons but closer to the end. In this case students are trying to classify materials as solid, liquid, or gas based on three criteria: (a) a perceptual–sensory one, which they have proposed in an activity at the beginning of the sequence (a solid is hard, we can hold it; a liquid is wet, we cannot hold it; etc.); (b) an empirical one, which was learned in a previous grade and states that solids have constant volume and definite shape, liquids have constant volume but take the shape of a container, and gases have neither constant volume nor definite shape; and (c) a criterion based on the particulate model of matter, which states, among other things, that solids have particles geometrically arranged in crystals and that in liquids and gases the particles are disorganized.

This episode of discourse reveals two striking tendencies on the part of the students. First, they demonstrate a resistance to adopting a flexible view of the world that would allow heterogeneity and plurality of conceptualization. They seem to take it for granted that the discourse of science is univocal, that it represents in a direct and transparent way a "real" and unique world. As stated previously, this seems to be part of the implicit contract of intersubjectivity in science classrooms. Students are uneasy about using more than one criterion to classify matter because they seem to

assume that only a single second reality and a single accurate way of describing it can exist. As Raq says in Turn 4, "It should be only one classification, only one criterion, otherwise there is no way."

Second, the students seem to refuse to "buy" the abstract view that glass can be thought of as a liquid because its particles are disorganized. Ale clearly states in Turn 9 that he sees this criterion as something strange and artificial, which cannot be used "in the street" ("Here, just between you and me, here below [He speaks more softly so as to avoid having his speech recorded by the camera], I think that glass is a solid. If I'm in the street, there's no way I would use particles to define it"). Car agrees with him in Turn 10, and Raq summarizes their view in Turn 11 ("Solid outside, in the laboratory I use particles"). Ale completes her statement in Turn 12 ("Because he [referring to the teacher] asks for it"), making clear that he is able to use this perspective but will only do so in classroom contexts because the teacher asks for it. In Rommetveit's words, Ale admits to using it only because the contract of intersubjectivity in the classroom is established from the point of view of the teacher. Here is Episode 2:

1. Car: What happens is that fog doesn't have definite shape and can't be held in the hand.
2. Raq: Do you see, it will be in contradiction, do you know why? It means kind of ... the criterion: If we can hold it, how are the particles (organized), so .... Then, look at the example of glass, amorphous material, it doesn't have a geometrical arrangement of particles, its particles are disorganized. If the particles are disorganized, they are liquids.
3. Edw: If you say that we can hold it, then it is a solid ... .
4. Raq: There should be only one classification, only one criterion, otherwise there is no way.
5. Ale: Just because it is solid doesn't mean that the particles are organized.
6. Raq: Then they are disorganized, but in truth it is a solid.
7. Edw: It depends on the criterion you use for a solid.
8. Raq: Even at a glance, you will see that it is a solid.
9. Ale: Here, just between you and me, here below (He lowers his voice to avoid being recorded by the camera), I think that glass is a solid. If I'm in the street, there's no way I would use particles to define it.
10. Car: Neither do I.
11. Raq: Solid outside, in the laboratory I use particles.
12. Ale: Because he (referring to the teacher) asks for it. Now, it is a liquid when it makes something wet.
13. Car: Hold on folks, come here. The glass ... it's useless to say it is a liquid, it is a solid, it is an exception to the rule, all rules have exceptions.
14. Edw: We can hold the solid ... .
15. Car: No, no, the capacity to think that glass is a liquid, I mean ... , I have this capacity because I know that the particles are disorganized, but it doesn't go inside my head.

As in the first episode, the problem of adopting an abstract view of the world emerges here. The third criterion for classifying materials as solid, liquid, or gases, outlined earlier, is quite removed from experience when compared with the first two. Similar expressions are used in different ways, becoming progressively detached from immediate experience as one moves from the first to the third criterion.

The students' dialogue in this episode reveals that they seemed to have no problem understanding the words and concepts being proposed by the teacher. They seemed to be capable of using the words associated with all three criteria for distinguishing materials. This suggests,

then, that the problem is not a lack of understanding in some kind of basic cognitive sense. Instead, the students seemed to have a lack of willingness to buy the more abstract view, something clearly stated by Car in Turn 15 ("No, no, the capacity to think that glass is liquid, I mean ... , I have this capacity because I know that the particles are disorganized, but it doesn't go inside my head"). There also seems to be a feeling of discomfort with the multiplicity of meanings that a single word can carry, a discomfort with the notion of a "word's *meaning potential*, the range of meaning-mediating possibilities it offers us as shareholders in a common language" (Rommetveit, this issue).

The analysis of empirical versus theoretical explanations as different modes of speaking and thinking (Scribner, 1977) can be profitably used to interpret these patterns in the students' answers. Specifically, a difference similar to the one Scribner outlined between types of responses can be used to understand the flow of discourse that reflects the competition between students' common sense and the way of thinking required in science classroom tasks. Hence, difficulties in using a theoretical speech genre that contradicts everyday experience are not unique to nonliterate people from traditional cultures. They also characterize the apparently homogeneous cultural setting of schooling, where they underlie the dynamics of science classroom discourse.

From this perspective, what interfered with the students' efforts in the first episode was their *empirical bias*, defined as "the subtle effects of problem content which 'seduces' the reasoner from the formal task" (Scribner, 1977, p. 490). This bias operated as a distractor for the students. The prototypical categorization of "gas" as kitchen gas, something that is grounded in everyday experience and discourse, seduced the students away from the formal task of finding general features of gas as a state of matter. By the end of the episode the students understood that they were formulating things in the wrong way from the point of view of the theoretical speech genre required in the school task, but they continued to resist this task definition and did not seem to attribute high value to the more abstract, "arbitrary" problem.

In the second episode the students' discourse clearly reflected an awareness of a conceptual profile of states of matter (Mortimer, 1995). In this case again, however, they were not at ease with the theoretical speech genre required in the setting. They seemed to be able to operate with different concepts of solid, liquid, and gas and to use the different genres associated with this profile of concepts, but they also refused to use the more abstract one that contradicted their everyday experience. Clearly, the particulate model of matter was viewed as one item in a "cultural tool kit" (Wertsch 1991) that does not replace other cultural tools or mediational means, but instead adds more heterogeneity (Tulviste, 1991) to this tool kit. The fact that the students were aware of the appropriateness of using empirical–sensory concepts of solid, liquid, and gas in talking "in the street" shows that as far as different options of genres and modes of thinking are concerned, to be more abstract does not necessarily mean to be more powerful in a broader cultural sense. The students regarded the more abstract criteria for understanding matter as an alien and not very convincing way of speaking of a world already populated with everyday meanings and genres.

CONCLUSION

The episodes of discourse we have examined pose important questions for science education. It seems to be impossible to teach science without invoking what we have termed *theoretical speech*

genres. These forms of speech posit a second reality of very general and abstract entities whose meaning is strongly rooted in a theory. Such theory-laden referring expressions are quite different from those used by students—and virtually everyone else—in everyday life. This is not to say that generalization and abstraction are not part of everyday discourse mediated by "practical" speech genres. However, the specific form that the generalization takes in the two cases is quite different.

All of this leaves us with questions such as: How can one make scientific explanations meaningful for students? And how can one turn the questions of science into real questions for them? We have approached these issues from the perspective of the analysis of intersubjectivity provided by Rommetveit. In his view a basic question to be posed when trying to understand human communication is "in what sense and under what conditions [can] two persons who engage in a dialogue ... transcend their different private worlds"? (1979d, p. 7). As our illustrations have demonstrated, the private world students bring to science instruction is often not the same as that introduced by the teacher.

We have also argued that transcending the gaps between these private worlds is not simply a matter of cognition and learning. The negotiation over which speech genre to use when speaking and thinking in settings of science instruction is also shaped by inherent and unavoidable differences in cultural preferences. To teach science will always involve a clash between theoretical forms of categorization and attribution used by science and the ones used in everyday life, in which prototypes and specific phenomena and objects play important roles. As a result, to teach science as something that can be meaningful for everyday life will always imply addressing these contradictions between different genres and degrees of intersubjectivity.

What our illustrations have suggested is that even when students can demonstrate an ability to view objects from the perspective of the theoretical speech genre proposed by teachers, they may not demonstrate a willingness to do so. In this sense, the dynamics of teacher–student dialogue may echo those of experimenter–subject dialogue reported by Luria (1976) and Scribner (1977) in more ways that we have recognized. In order to address these issues, it will be necessary to expand our understanding of how intersubjectivity is attained by accounting for ways in which interlocutors may resist, rather than accept, the perspective proposed by speakers. In the end, this amounts to creating a new, richer level of intersubjectivity within the perspective that Ragnar Rommetveit has been pursuing for several decades.

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