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## **Culturing Conceptions: From First Principles**

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Running Head: CULTURING CONCEPTIONS

## **Culturing Conceptions: From First Principles**

### **Abstract**

Over the past three decades, science educators have accumulated a vast amount of information on conceptions—variously defined as beliefs, ontologies, cognitive structures, mental models, or frameworks—that generally (at least initially) have been derived from interviews about certain topics. During the same time period, cultural studies has emerged as a field in which everyday social practices are interrogated with the objective to understand culture in all its complexity. Science educators have however yet to ask themselves what it would mean to consider the possession of conceptions as well as conceptual change from the perspective of cultural studies. The purpose of this article is thus to articulate in and through the analysis of an interview about natural phenomenon the first principles of such a cultural approach to scientific conceptions. Our bottom-up approach in fact leads us to develop the kind of analyses and theories that have become widespread in cultural studies. This promises to generate less presupposing and more parsimonious explanations of this core issue within science education than if conceptions are supposed to be structures inhabiting the human mind.

Keywords: activity · learning science · conversation analysis · conceptual change · praxis



Fig. 1. An “interviewer” (left) and Mary (right) talk about day, night, sun, and earth.

**Fragment 1**

- 61 I: so do you think `why we have day an:: night.<sup>1</sup>  
 62 (0.42)  
 63 M: because of t-the movement of the sen (0.68) and uh in the evening  
 we couldnt a get the sunshine <<dim>so thats the reason we have  
 that>  
 64 I: yea: but ↑`why we didnt have the sunshine.  
 65 (1.18)  
 66 M: because we are at ah (0.22) i heard (0.14) i think because of  
 (0.62) the other half of the earth (0.14) have the sunshine.

We find ourselves in the middle of an “interview” in which Mary is queried about the sun, earth, day, and night for the purpose of understanding the (mis-, alternative, naïve, etc.) “conceptions” that might be articulated in the course of talking about the causes of day and night (the segment on which we draw here can be found in its entirety in the appendix). We use the term *interview* provisionally, because in its etymological origins it literally means to see each other; we use the term *conception* provisionally to mean the ensemble of ways of talking about some entity. Experienced science educators will have no difficulty pointing to a particular stretch of the talk transcribed in the fragment and say that this is evidence of a “misconception,” as Mary apparently “thinks” that the earth is stationary and the sun moves around it giving day and night.<sup>2</sup> Following the utterance of the interviewer (turn 61), there is a brief pause before Mary takes a turn suggesting that

because of the movement of the sun, we cannot get sunshine in the evening. With a fading voice intensity, she elaborates, “so that’s the reason why we have that,” which the “interviewer” then follows up without noticeable pause, “Yea, but why we didn’t have the sunshine” (turn 64). There is a considerable moment of silence now before Mary speaks again, opening with another “because.” She then articulates what is to come as having heard about this idea and then reformulates it by saying that “the other half of the earth has the sunshine.”

As the drawing (Fig. 1) shows, at the moment they are talking, their faces are turned toward each other. They evidently are *oriented* toward one another not only physically but also in the way they take turns, which appears to be very orderly. There are pauses and sometimes these pauses within the turns (e.g., 63, 68) are longer than those between turns (turn 61–63, 63–64). There are also speech patterns between the turns. For example, the interviewer repeatedly utters “why,” which is followed by Mary’s response of “because.” Overall, there is order in the way turns are taken and in the way in which one person “responds” to the other. If therefore, the two are not independently producing noises and orienting their gazes toward each other as random acts, then there certainly are presuppositions that underlie their ability to relate to one another in talk so that it becomes an orderly event. This patterned turn taking is of a higher order than mere individual production of random noises.

In fact, if the interviewer is producing an utterance and Mary notes and understands the sense being rendered, then what the interviewer says is not so singular (solipsist) after all. The interviewer produces sounds that are intelligible *as words and interjections*, and this intelligibility is shared; there is no need to address Mary if she did not already understand the sense marked and exposed by what the interviewer said. What the latter says and what Mary does with language, in fact, are manifestations of a higher order which we shall call *culture*—language is one of its forms—in which not only Mary but others too can co-participate. For example, we, the analysts, can view the videotape and

hear the interviewer “ask questions” to which Mary “responds.” That is, at a minimum, besides Mary, there are also the three authors of this paper who see the individuals on the videotape transact and hear them ask questions and produce responses—where we use the term *transact* to denote that what the individuals do is not independent and reserve the term *interact* for those situations for which it can be shown that speakers are acting completely independent one from the other. We, the analysts, notice the sense marked and exposed in the doing of what is done and said on the tape—if it were not thus, the very possibility of conducting research would be denied.

As researchers, our noticing of the sense goes as far as involving those utterances that express what some science educators and psychologists might call *misconceptions*. The prefix *mis-* indicates “bad,” “wrong,” “erroneous,” and “misdirected” and therein constitutes the negation of a conception (idea, notion). That is, both the interviewer, who requests Mary to elaborate by providing a reason (turn 64), and the authors understand the sense that is marked and exposed by what Mary has said in turn 63, although it may be the *negation* of an conventional scientific idea or concept—and the sense we make may be, in the extreme, in terms of the non-sense (thus the expression, “this is non-sense,” where something makes sense *as* non-sense) of an utterance. However, in this case, we would really be in a contradictory situation because during communicative situations, no individual intentionally produces non-sense. This becomes clearer when viewed from the position of the interviewee from whose stance this non-sense precisely makes sense. Hence, in *understanding* an utterance *as* misconception, we recognize and accept it as one possible form of talk; we understand it; and we recognize and *accept* its cultural (i.e., collective) reality. We ask why we should not acknowledge it in a positive manner, in and for itself, rather than judging it negatively, with respect to something else outside of the activity in which it makes sense? After all, established scientific “truths” do change, even in the case of apparently settled issues such as the number of planets in the solar system during the weeks that we are writing this text (August 2006).

Our analysis quickly leads us deeper into the tacit operating conditions of communication that is at play in fragment 1 specifically and in the entire recorded session more generally. We already note above that Mary and the authors typically expect the interviewer to ask a question and Mary to provide an answer; in fact, the nature of the interviewer's utterance *as* question depends on Mary's utterance *as* answer. If Mary were to say, for example, "you're insulting me!" then the interviewer's utterance would have been completed *as* an insult. That is, the cross-turn why–because sequences show us that the first speaker is *setting up* an orderly sequence that is normally completed by the second speaker; and it is *completed* in this recognizably mundane way because the speaker utters these rather than other possible word sequences.

We are now at a point where we have to recognize that although the interviewer sets out to ask something that Mary has no foreknowledge about (i.e., what she will be asked), the latter effortlessly understands the sense exposed by the preceding utterances as a co-participant. Mary further responds to it in a way that the interviewer apparently finds satisfactory, for the latter has sufficient reasons to ask additional questions in greater depth. That is, the interviewer's turn 64 sustains the topic, and in this, marks the topic of what Mary has said as something relevant to their shared situation at hand. As unremarkable as it may seem, this short excerpt, as well as the rest of the recorded session, camouflages how expertly both participants are carefully orienting to each other in terms of their conversational trajectory. This then means that there is more to such an interview than the spilling of Mary's mind in the verbal articulation of its content.

The purpose of this article is to derive and articulate a framework for the cultural analysis and theorization of conversations about the topics of interest to scientists and science educators (i.e., "scientific phenomena," "scientific concepts"). We begin the analysis as ordinary, everyday folk, drawing on the mutual understandings that we are presupposed to master for participating in situations such as that depicted in fragment 1. We use commonsense and past experiences to interrogate the very conditions and

presuppositions that allow us to engage in such conversations and to understand what is said and the nature of activity that is occurring (e.g., an “interview”). We show that the identification of conceptions as well as misconceptions presupposes the intelligibility of talk in the first instance; this intelligibility of “misconceptions” undermines any attempt to completely “eradicate” them by means of instruction. We proceed in the most rigorous way by asking a series of questions designed to query even our own method of analysis employed here. We ask, what are the minimum assumptions for such conversations about phenomena that are of interest to scientists and science educators? What are the minimum models we need to understand and explain such conversations? What are the assumptions made by researchers who, in contrast to our analysis, assume that individual turns can be analyzed as if there had been no utterance preceding or following it? What are the assumptions analysts make when conceptions are reduced to something that is solely determined by structures in the mind? In so doing, we expose and mark the possibilities in and of a cultural approach to “conceptions.”

The bottom-up analysis of the interview data leads us to open issues from the following aspects of the talk. First, talk generates the very context that makes its cultural activity possible in the first instance. Second, talk relies on non-verbal means for generating, marking, and exposing sense as well. Third, even if someone discussed topics he or she never has encountered before, the sense inherent within talk sustains the overall conversation as a mundane, transactional phenomenon. Fourth, sense from talk simultaneously caters for non-sense whenever the latter is identified as such by experts such as science educators. As we produce our explanations, our language begins to slide from an everyday register, drawing on everyday experiences and knowledge to a form and content of language (e.g., using references to the literature) recognizable by members of a community that uses the term “science education” to reflexively refer to itself. The attentive reader will note that this sliding of the language is precisely the same phenomenon that allows forms of talk to be constructed as synonymous, homonymous,

heteronymous, or antonymous expressions. We then summarize our argument in the final section and describe some implications for conceptions as one of the pressing concerns in the discipline of science education.

### **Talk Makes (Cultural) Activity**

We begin the previous section by stating—following fragment 1—that the conversation transcribed derives from an “interview,” a part of which is presented in textual form accompanied by a drawing perceptually situating and relating the two participants. In fact, *commonsense* (sense that is *common to* and therefore *shared by* members of a group, culture, and this commonality and shared nature precedes the talk itself), everyday experience says that it is (virtually) impossible to understand the sense a conversation articulates, unless one is provided with contextual information. What aspects of the social world are these participants in the process of achieving? We have already denoted the situation by the term “interview.” The talk transcribed therefore derives the sense ascribed to it from the fact that it is part of interview talk; the talk first and foremost produces an interview event, and second, it does so by highlighting and sustaining certain information supposedly held by one (Mary) but not the other, interested party (“interviewer”). In fact, the two participants denoted here as “interviewer” and “Mary” have known each other prior to this situation but have never had a conversation like this or about *this* topic; and, as we (authors) know, the conversations they normally enjoy do not follow the turn-taking pattern observed in fragment 1 specifically and in the interview as a whole more generally. Thus, throughout the transcription we can see typical formations of turns, whereby the use of interrogatives (“why,” “which,” “do you think”) is exclusive to one person (“interviewer”), whereas the other provides “responses,” frequently involving the connective “because.” That is, the two manage to have *this* conversation, which follows what we may recognize as a protocol for a science educator’s conceptual change interview, although they have not conducted such a type of

transaction before, and although Mary has never participated in an interview that solicits explanations of everyday phenomena of interest to scientists and science educators. Because of the mutual dependence of the utterances and the particular distribution across material bodies, the term *transaction* for what occurs appears to us more appropriate than *interaction* of two independent individuals producing talk only in and for themselves.

In addition to the use of “questions” for opening a topic, one person (“interviewer”) queries statements that the other makes, but the reverse is not the case here. This is apparent in fragment 2, where the “interviewer” questions statements Mary has made.

**Fragment 2**

- 07 M: so the sun is in the position of thata sky ((hand gesture))  
     ↑<sub>position</sub> ((looks at interviewer, makes eye contact))  
     (0.18)
- 08 I: yea (0.86) a:nd which? direction. (0.30) maybe east? or north?  
     <sub>o:r</sub>  
     (0.33)
- 09 M: <sub>o:h::</sub> ((hand moves up to the chin, eyes move upward, pensive))  
     (0.26) in the morning it should be in the east
- 10 M: (0.17)
- 11 I: yea:. why?

After Mary suggests that the sun is in the sky because of its position, the interviewer asks her about the direction it travels and offers a few alternatives, east and north (turn 08); and when Mary states that in the morning the sun is in the east, the interviewer asks “why?” (turn 12). In each such case, the interviewer not only asks a question but also, in asking, co-articulates (frames) that the response to the initial question has *not* yet been answered sufficiently. There is no reason to ask another person to elaborate if a topic has already been treated exhaustively. This is evident when we compare the patterns available in this interview with the nature of questions heard in everyday contexts. It would indeed be strange if the response “five o’clock” to the question, “What time is it?”

was followed by another question “Why?” or “In the morning or afternoon?” The latter response would be uncalled for *unless* we know that the two speakers find themselves in different parts of the world and communicate on the phone or via iCHAT software and are confused about the time delays.

If someone on the street asked us, “What time is it?” we would not find it exceptional; but if the same person asked us, “Why do we have day and night?” (turn 61) we would find it unusual; so too would our neighbors if we walked across the street asking them the latter “question.” Under what conditions would questions such as those posed by the interviewer not sound peculiar? Based on mundane, everyday experience, it would strike us odd to find ourselves in a question and answer sequence such as that found in Fragment 1—*unless* we are students asked by a teacher who wants to find out if we understood the lesson, *unless* we are participants in a project researching conceptions and conceptual change, or *unless* (possibly) we are visitors to a science museum where docents engage us in asking something about day and night. That is, because in these situations we know the kind of cultural activity we participate in, we immediately recognize what someone else articulates and makes salient in a situation as sense; we do not have to ask, “Why are you telling me this?” or “Why are you asking me this?” The interviewer and Mary proceed in this ready manner *because* they “do an interview,” and everything they say is said *to produce the interview as event*. In the process, the talk that makes the conversation also produces its topic: the reasons for having day and night.

The interviewer and Mary know that they participate in an interview even if they do not verbalize it during the transcribed part of their face-to-face encounter. But the very fact that there is a particular order produced points us into the direction that they draw on a variety of resources for reproducing a type of event in which one person asks questions and another responds. If this turn-taking routine changed, that is, if, for example, Mary were to begin asking questions about the tilt of the earth or the distance between sun and earth and then the interviewer responded, we would certainly find ourselves in a different

kind of activity, say a discussion or a tutoring event. There therefore exists simultaneously a mutual constitution and delimitation to phenomena in which two or more people are involved: We need to know the nature of *this* activity to participate meaningfully in it, and yet it is only through our actions that *this* activity develops its shape. Even the undergraduate students in our universities who participate in psychological research studies know that by entering the laboratory they are contributing as research participants and therefore they orient themselves to *produce and reproduce* psychological research. They do not behave in a random way but collude with the experimenter to make *this* (in each case) event a recognizable one—objective and objectivizing data collection. And yet, there are colleagues at our universities (as elsewhere) who proceed as if these students' responses were applicable to other situations as well without that our colleagues make an effort of empirically showing that such generalizations are in fact the case. There is therefore a mutual constitution of the data collecting events *as a kind of event*; the collusion of all parties is required to achieve it in a satisfactory way, because even first-time research participants contribute to successful data collection events. The same is true here, in the case of Mary and other participants in our database.

At another level, there is a second type of mutual constitution. We know that in most conversations, we do not prefigure our talk before actually talking. We have a general inarticulate and unelaborated sense, which comes to be ex-scribed and exposed *in and in the course of* our saying; we do not, however, choose the words, which appear to emerge from our mouths. Any stretch of the transcribed interview features mumbles, stumbles, and pauses; ingrammaticisms; starts, false starts, and restarts; and inchoate ideas. Therefore, there is a general sense that comes to be concretely realized during each observable performance; but the specific and exposed sense only exists through that very performance.



The production of interjections (“uh,” “hm”) on the part of the current listener is necessary for conducting the activity but “grooming gestures” apparently are not salient resources in the conduct of the session. Thus, whereas the back-and-forth movement of the hand (depicted in Fig. 2) subsequently comes to be reproduced in the drawing Mary makes on her thighs, therefore constituting resources for subsequent discursive action, the interviewer’s hand movement to her glasses pushing them closer to the forehead (Fig. 3) is not picked up later in the conversation or used in the production of the interview in some other way. Thus Mary uses some but not other productions on the part of the interviewer in her own contributions to the content and process of the interview. Nor would we, the analysts, drawing on our ordinary competence as members of society, consider them as important to the ongoing topic, whereas we do consider relevant the hand movement. That is, we already bring to the situation particular competencies that allow us to select some material productions (body movements, sounds) as relevant and distinguish them from others that we consider as irrelevant. Yet is precisely this competence that makes anything like an “interview” possible in the first place; whatever topic ultimately emerges from a session *presupposes* forms of competence that allow us to categorize vastly different productions into those that are pertinent and others that are not. We share this cultural competence with the interviewer and interviewee, who similarly attend to some productions and disattend to other productions. We, the analysts, therefore are competent only to the extent that we have competencies *in common* with the individuals on the videotape; and it is based on this *common* sense that we can be analysts.



Fig. 3. Some hand/arm movements such as pushing the glasses closer to the forehead (“grooming gestures”) are recognized as having no or little relevance to the conversation.

### Communicative Resources are Situationally Produced and Coordinated in Real Time

The participants in this and other interviews in our database produce, reproduce, and use other modalities for articulating questions and responses. These modalities include gestures, material configurations, spatial orientations, material entities, and artifacts in the setting, and so forth. For example, in the following fragment, the interviewer and Mary together produce an ephemeral configuration using their hands and, in the process, build a demonstrable, inspectable, reportable model of sun, earth, and day and night. Just prior to the episode that makes fragment 4, Mary has come to a temporary endpoint when, and already overlapping her, the interviewer harks back to find out what Mary *really* means in saying what she has said. As she holds up first her left hand and then the right hand overlapping with the words “earth” and “sun,” the interviewer holds her fists up in the air right in front of her (turn 105). Mary grumbles the interjections “uh hm,” which—as shown in the interviewer’s continuation that reiterates the designation and positioning of the “sun” (turn 107)—are positive acknowledgments.

#### Fragment 4

105 I: [S:O:: ] so you mean (0.16) earth is here an::: (0.32)  
 sun is he[re] ((holds up left hand with “earth” and right hand  
 with “sun”))

- 106 M: [uh] hm=  
 107 I: =so when sun is ~here=  
 108 M: =anda this part of the earth can have the sunshin[e; bu]:t  
 ((points from "sun" to "earth" [Fig. 4])  
 109 I: [yea ]  
 110 M: the other part (0.24) [did]nt.



Fig. 4. The interviewer (left) and Mary articulate one for the other and for themselves the relation of “earth” and “sun” and, thereby constitute a publicly debatable model for why and where it is day and night.

Mary then involves herself in the public articulation of the gestural model relating “earth” and “sun”: as she begins, Mary leans over toward the interviewer, first points to the latter’s right hand then moves along an invisible straight line toward the interviewer’s left hand (Fig. 4) while uttering “this part of the earth can have the sunshine” (turn 108). Overlapping her, the interviewer interjects a particle of acknowledgment and Mary completes (as articulated in the falling pitch within the turn; see “.” at the end of turn 110) the repeated description of the other part of the earth that cannot have sunshine.

In this situation, the interviewer and Mary produce a hand/arm configuration for one another and together. Inherently, as with the sounds that they hear as words, each participant has to assume that her production necessarily exposes sense, that is, *sense for the other*, too. As a speaker, I say what I say because it makes sense to me; but in saying what I say *I must assume* that what I mark and expose qua sense constitutes recognizable sense for the other, too. Because this sense is available to us (researchers), sense itself is a general possibility. Therefore, each marking and exposition of sense is both particular, a concrete articulation of sense in this instance, and general, a possibility of sense for

participants in a community. If this were not the case, it would *make no sense to attempt to speak at all*, for we would for ever be caught in our private worlds.

We may next ask how the sounds (words), body movements, and body positions are related. To investigate this problematic, we provide a more fine-grained description of turn 105 in Fig. 5. As the interviewer formulates what is to come as yet another way of saying what it is that Mary means (“you mean” [Fig. 5a]), she begins to reorient her body, straightens it out, pulls the left hand out of her lap, raises it up above the shoulder level and then “sets” it with a slight downward movement while uttering “here” (Fig. 5b). During an elongated “an:.” and the pause that follows, the right hand moves from the lap upward above the shoulder position (Fig. 5c) and then moves sharply downward to its final position Fig. 5d while uttering “sun.”



Fig. 5. As the interviewer prepares for re-articulating the sense of what Mary just has said, she turns her body to first set the left hand in space while uttering “earth is here” and then sets the right hand precisely with the utterance of “sun.”

The two are producing the model *for* each other. The production is evidently satisfactory (intelligible), which is expressed in two ways (see the transcript in Appendix). First, Mary says “yea” (turn 116), adds and thereby completes the verbal articulation of the model (turns 120, 123) where the *left hand stands for* the earth and the right hand *stands for* the sun (but not the reverse). Second, after repeated interjections “uh hm,” the interviewer enters the word “summer” (turn 124) into the conversation and thereby moves on to, at least temporarily, what turns out to be a new though interrelated

scientific topic. In moving on, she co-articulates that what has been said to that point is satisfactory with respect to the purposes of the activity (interview) as a whole and that she now—after repeatedly asking Mary to further elaborate, explicate, or explain—is ready to move on. This therefore signals that the production of *this* conception has been completed for the interviewer.

Given the expert coordination described above, it is tempting to argue that there is some underlying mechanism (in the mind of the person) that drives both speech and gestures (body positions). But is this the minimum unit of analysis for the situation? If there were a unified model presupposed for speech and gesture production, then it would not be necessary for the interviewer to actually look at her hands while talking. But she does look at them in this situation, as well as at other moments when she uses her hand(s); and Mary does the same when she “draws” figures on her thighs and knees. A more parsimonious account is that the production of these communicative resources happens right then and there, in real time. Talk and movement are coordinated, in part, by lengthening phonemes and pauses in speaking. That is, we perceive (hear, see) the resources that the current speaker uses to tightly coordinate these two different modalities.

The interviewer’s precise dance of gesture and speech is not just for herself but also and precisely *for* Mary. In fact, if it were unambiguously apparent that the words and the gesture expose the *same* sense, then exact coordination would not be necessary. It is precisely when two radically different matter/form configurations are to point to the *same* (concept, idea, topic) that the need for coordination is mandatory. This coordination inherently is *for* the (generalized) other, who therefore may agree that the radically different communicative forms point to something that is the same. Because this is the first time that the two are talking about this topic—there are many pieces of evidence: this “interview” is unnecessary if they had talked about the issues before; in turn 14 “I never think about that”; and turn 66, where Mary says “I heard” prior to “I think”—the

interviewer and Mary cannot know whether something they articulate makes sense to the other unless they can assume what they articulate is a realization of sense generally. That is, they each have to presuppose that what they utter is intelligible generally rather than merely by the respective other specifically.

The coordination leads us to a *one*, something that speech and gesture have in common despite their radical difference—sound in the former instance made available to the aural sense and hand movements in the latter instance made available to the visual sense. The interviewer produces these two communicative resources with different parts of her body and she produces them for the different senses of Mary (and therefore also of the researchers): eyes and ears. Rather than thinking these resources as produced from the same underlying model, we may take the same approach also used above. The two are different concrete realizations of a *general possibility* (idea), which always only is available through any one of its multiple, potentially innumerable concrete realizations. That is, the general and particular always are given at one and the same moment, where the concrete realization always constitutes a singular and therefore one-sided expressive means. Both the general and the particular are equally concrete, because the former is the ensemble (set) of possible pre-existing ways of concrete realizations—sense is constituted by the concrete plurality of all possible concrete singular expressions that are deemed to belong together. Because there is no end to the coordination of different expressive matter/form combinations, an “idea,” “concept,” or “notion” certainly exceeds what any individual can produce at some point in time. The “idea,” “concept,” or “notion” is a collective possibility of expressions that mark out and expose sense, which any individual concretely expresses in only a limited number of ways. Even if we accepted that an individual had an internal model (concept, framework), then it would always only *one* concrete realization rather than the full range of expressions of the idea, concept, or notion as such. Any singular expression therefore, in a metonymic (*partes*

extra partes) way activates many other possible singular expressions so that an idea, concept, or notion never is a transcendental but always a concrete universal.

Thinking along this line opens up the possibility for understanding change and learning without positing that (cognitive) frameworks have to be deconstructed, abandoned, and reconstructed. This is because the same individual can concretely realize the general/universal (idea, concept, notion) in a number of different ways; and these different ways may exist in the same expressive mode, such as sound (words). But two expressions (utterances) are not identical—even the modulation of sound changes. This non-identity among realized possibilities constitutes a shift, a difference at the heart of the presupposed sameness. With this shift and difference, the idea (concept, notion) itself shifts ever so slightly sometimes thus allowing a presumable identity (sense) of two ways of talking to be actually different sense. Precisely *because* two expressions are inherently different, members in a community can consider (constitute, construct) them to be different or spend some effort and make them the same, that is, to constitute a different expression as a synonym, homonym, heteronym, or antonym as the case may be.

In this fragment, the interviewer jointly works with the interviewee on a model that relates earth and sun in a particular way and, in this, *explains* why the sun is perceived on one half of the earth but not on the other. The model exists in and through the position of their hands and arms. It is in this way available to each participant, who produces what she does *for* the other (public articulation rather than private cogitation) as much as for herself (eyes oriented toward the position). The model therefore exists in the arm/hand configurations, and therefore materially. Because each person also talks, the model is distributed across the bodies, concretely realized in different ways by each participant. The model is embodied in the sense that it takes the production of sound and sensorimotor movements to produce it. But it also is distributed in space, across the material bodies of both individuals, each of whom realizes only part of the model generally (idea). The sense of the model therefore exceeds the two, existing in

(ephemerally) produced and marked out ways and thereby also becomes available to the researchers who, in listening and watching, realize sense in additional but alternative forms (especially because we do not see each other as we collaborate on this article located in three different countries). The model, in being produced in and by a one-for-the-other mode, also is accessible, inspectable, and arguable by participants, researchers, and any other socially competent person watching the videotapes.

Which model is more parsimonious in terms of the demands that it makes on the brain of the person interviewed and in terms of the description? In a mental model approach, the figural productions using hands and arms and the “drawings” on the leg and knee would have some equivalent in the head of the speaker. That which is made visible in the production has a corresponding image somewhere in the brain. In our (cultural, dialectical) approach, *the production itself of the concept in public space is the thing to be modeled*. Do we need the former? Which case is more general? In the latter case, the participants generate a presentation; in the former, a re-presentation has to precede the production of the presentation. The now familiar instant when James Watson and Francis Crick were said to have discovered the DNA structure exemplifies that the playing around with material shapes presented potential configurations to the eye and one for the other that really preceded any re-presentation that might have existed in their minds concerning the actual molecule. That is, Mary and the interviewer may produce a constellation *for the first time* without having had a prior mental image of or about it, which segues us into the next section.

### **We can Speak about Topics We have Never Talked or Thought about Before**

Individuals participate in conversations generally and interviews specifically about topics that they have not even talked about before. What they say therefore is a real-life ongoing construction of sense that surely cannot be preceded by a model in their mind,

because the latter impossibly requires possession of a re-presentation when there never has been a presentation in the first place. People can talk about *new* topics, even though later the topic is repeated in different forms (re-presentations). Nevertheless, we do participate almost daily in conversations about topics that we have not yet and never before talked about and that we have never considered in the privacy of our thoughts. In this interview, Mary also participates in talk about a topic that she says she has not yet thought about (turn 14). In such cases, we know from everyday experiences that persons will often formulate (co-articulate) the very fact that they have not talked (thought) about the issue before. This is also the case with Mary (and other interviewees in our database). In fragment 5 from the interview Mary at least twice provides us with signals that she is thinking through the attendant issues for a first time—aloud, publicly, and therefore already realizing an inherent possibility to be intelligible.

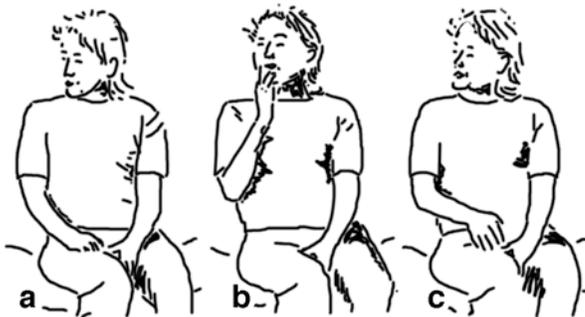


Fig. 6. Formulating “thinking.” a. Mary has eye contact with the interviewer. . Mary raises gaze toward ceiling, brings hand up to the mouth (“pensive”). She finally orients again toward the interviewer, brings hand back into the lap.

#### Fragment 5

- 07 M: so the sun is in the position of thata sky ((hand gesture))  
 ↑position ((looks at interviewer, makes eye contact Fig. 6a))  
 (0.18)
- 08 I: yea (0.86) a:nd which? direction. (0.30) maybe east? or north?  
 ˘o:r
- 09 (0.33)

- 10 M: `o:h:: ((Fig. 6b)) (0.26) in the morning ((Fig. 6c)) it should be  
in the east
- 11 (0.17)
- 12 I: yea:. why?
- 13 (1.06)
- 14 M: <<pp>uh> why::? (1.70) <<p>uh: i never think about that.> () i  
^thi:nk (0.33) i:ts=a becau:se (0.24) of the movement of the  
↑`sun.

First, while talking about the position of the sun and while being asked about the direction, Mary gazes at the face of the interviewer (turns 07, 08; Fig. 6). Following the interjection “oh,” which, given the descending movement of the pitch and the elongated phoneme “o” and the extended expulsion of air (transcribed by “h:.”), can be heard as surprise. That is, the content of question comes as a surprise. That it likely is surprise, we can see from the gesture that follows (Fig. 6b), whereby Mary, while uttering “in the morning” (turn 10) moves her gaze toward some spot at the ceiling, her right hand moves from the lap toward the mouth. Culturally competent listeners and analysts see this movement as *formulating* “thinking,” that is, Mary expresses that she now is thinking about a situationally appropriate answer to whatever the current question is. That is, following the expression of surprise, Mary not only thinks but also expresses that what she is doing is thinking. In fact, Mary provides one more formulation that she has been thinking for the first time about the answer to the question concerning the directions of the sun. In turn 14, she explicitly states, “I never think about that.” That is, Mary has described the position of the sun as being “in the east” “in the morning,” but when the interviewer asks her about the reason for stating this, admits to *never* having thought about this. That is, *the fact that we do say things even though we have never thought about it dismisses claims that mental models of something must predate or coincide with talk about this something.*

At this moment, thinking about this problem has occurred for a first time; and it has occurred publicly (aloud). Given the brevity of the moment and even with the pause of 0.26 seconds, there is insufficient time for her to have figured out in private a model for how the sun moves and in which direction and only *then* to have articulated it for the interviewer and the camera to hear. But in providing her answer, Mary also articulates its tentative nature: she says, “it [sun] should be in the east” rather than saying, “it is in the east” or “it is somewhere near east, depending on the season.” She employs the conditional “should,” which, as competent speakers of English we know, would allow her to change her mind without losing face. Nevertheless, despite never having thought about this, Mary provides an answer. She provides a response even though she has not had the time to think about it, as she formulates to have done when the interviewer asks her about the reasons (“why”).

Given the above, we ask, what makes it possible for Mary to produce an answer? We ask this question especially because private cogitation—always in terms of language and images that we can share with and have appropriate from others, as the next section shows—has become the model of choice for everyday *and* professional ways of theorizing talk. We also ask, do we have to presuppose a mental model or conceptual framework as the ground (reason, cause) for people to talk about phenomena and terms that are of interest to scientists and science educators? We further ask, can we ever know that someone has pondered *precisely* the question an interviewer or teacher might ask a student? Or would it not be more parsimonious to assume that participants in conversations, including interviews about conceptions and science classroom talk, say what they say *about* the issues and *for* the purposes of the activity at hand, drawing on the resources available in the situation and embedded in the language that they speak? Is not what participants make available to each other always the only resource available? And would it not be more reasonable if teachers were to think about instruction in terms of the forms of talk their students exhibit in collaboration with them rather than in terms of

possession (and absence) of mental models and conceptions, to which they never can have complete access?

### **Borrowed (Mis-) Conceptions For/From the Other**

We do not own the language that we speak, so that each speech act is a concrete realization of possibilities already available to all knowledgeable speakers of the language. (This is why even the physicists at our universities, among the staunchest defenders of the “right conceptions” that students are to “get” or “construct,” can talk about the beauty of *sunrises* and *sunsets*.) In this interview, the interviewer and Mary articulate words (use language) and forms of talk that are not theirs; they also gesture, make drawings, and engage in other forms of action that are not theirs but have pre-existed not only in this situation, but also predate their lives. In this, each person in this interview concretely realizes one language, English; but she does not own it, as each has received the language from others in the Anglo-Saxon speech community, and each now returns this language to the other. The more competent a speaker is in and with a language, the more she experiences its possibilities *and* the less its constraints. More so, because in everyday conversation—in contrast to writing—we do not think about and select the words and sentences we assemble, they spring forth and become speech. There is therefore an essentially passive component to speaking: language, here English, speaks (means) through us. We do not need to know grammar to express ourselves grammatically, and we do not know science to express figures of speech and produce everyday dictions (“I don’t have a lot of *energy* today.” “A beautiful *sunset!*” or “Whatever goes up comes down.”). If there are such things as misconceptions, these are already possible in the language we *receive from* the other and which we *produce for* the other.



Fig. 8. All the sounds (words) Mary uses and the drawing of the compass she produces on her leg are already possible for articulating sense in the culture and English language; her conception is borrowed from the culture, is hers and not hers simultaneously

Mary begins to answer the question about the direction of movement by rapidly answering “from east to west,” but then begins to hesitate: there is a pause. The interviewer interjects an “uh hu:,” by means of which she does not express anything but indicates that she is attending without taking the turn away from Mary. Mary raises her hand to point toward the sky, makes a movement as if following the sun as she utters “east ta” (Fig. 7), but then hesitates; she returns her arm/hand her right thigh to *visibly* produce an invisible and ephemeral drawing. She draws what we recognize as a horizontal line from left to right with an arrow at the tip (Fig. 8); crossing this line she draws another one beginning at a position away from her but then adds another arrow head that points away. She then points to top and bottom of the vertical line, then to the right-most point of the horizontal line at which point she grunts an long and drawn out “u:m::” She then begins at the right arrow head, moves to the point on the cross away from her, the point on her left, and ends with the point closest to her. At the four cardinal points, she utters “east,” “north,” “the west,” “and the south,” and “the east again.”

On what basis does Mary produce her description? A first proposal to this can already be found in our description and in what our description presupposes. Thus, although we have little to go by to impute anything other than making a diagram, Mary’s subsequent articulations of the cardinal points provide the context in which the prior drawing—the memory for which still has not left us—comes to be a compass. She then reads off this compass the movement of the sun, “from east to north (up) to west to south and to east again.” Here, she begins by reproducing the drawing of a compass, understood as such at least once she begins to articulate the cardinal points of a compass. Mary then reads the directions of the compass, which constitute a movement from east to west, just as she has uttered before (turn 23). She uses language generally and the order of the compass points

in particular that are prefigured in the language. Thus, although she may find herself having never thought about the direction in which the sun moves in the course of the day (see the expression of surprise when asked in turn 10), she constructs an answer with the resources at hand, including language and the image of the mariner's compass, which she reconstructs for the interviewer (and therefore for us, the analysts) right in the *here* and *now* of this situation. The language, which she has inherited from those who spoke English before her, the sequencing of the cardinal points when following a compass in counterclockwise direction (which may be in the same way that children correctly seriate number words even before understanding numbers), and an ephemeral compass drawn for herself as much as for the interviewer, provide the resources to construct an answer to the present question.

Here, Mary uses local resources (language, ephemeral diagram of a mariner's compass) to produce an answer. Under what conditions can she use these resources as part of a communicative act? She can do so because neither the English language nor the compass exclusively are her own to use; they have come to her as components of the community in which she participates as she appropriates its language (appropriation and membership are mutually constitutive). More so, she does not appear to have thought about this question and its answer beforehand. All evidence that she produces in the course of the recorded event (which we denote by "interview") indicates that she produces an answer in real time, which, because she uses the resources others provided her with, is again not (entirely) her own. Of course, it is *her* answer in the sense that she is physically producing it using her vocal cords, hands, and other body parts; but because her answer is designed for the interlocutor, the resources she rallies are inherently common property just as their sense is presupposed. If she could not presuppose the sense of what she says, then it clearly makes no sense to say anything at all! The fact that she does say something presupposes that it is something that inherently is possible as a way of marking and exposing sense.

Language (here English) constitutes a virtually infinite set of resources that speakers use to describe and explain the phenomena of interest to scientists and science educators. Competent speakers employ ways of talking rather than mechanically assemble words into series; and ways of talking embody resources for making inferences. Thus, most of us have admired and described the poetic nature of a “sunrise” and “sunset” or talked about the sun as moving east to west. In each case, agency is conferred to the sun, which moves relative to the earth. If therefore Mary speaks about the movement of the sun in the sky, all she needs is a certain familiarity with non-technical language, which exhibits relations, descriptions, and implicit theories. A child too has the capacity to infer that the sun moves given that the adults around her speak about sunrises and sunsets. In this, the moon is little different from the sun viewed from a phenomenological perspective (both rise and set), whereas from a scientific perspective, the relation of earth and celestial body movement is reversed.

A North American and European<sup>3</sup> scientist or science educator may quickly jump to the conclusion that Mary produces non-sense, because in their experience, the sun moves from somewhere around the east to the south to set some point somewhere around the west (depending on the season). The interview was conducted in Canada, and so the temptation would be great to attribute a sense that does not conform to the ways of making sense of the movement of the sun that experts have agreed upon. The answer, even if we were to assume that it is non-sense, still would be an answer about the sun and its movement. It is an answer that to characterize at all as a misconception about the sun and its movement as marked out on a compass presupposes that it is a misconception about a common object. But if the existence of a misconception about a common object is intelligible, the misconception (or rather the language used as a starting point to construct the misconception) has to be intelligible as well. It is intelligible not only to the researcher but especially to the person interviewed. More so, in its very intelligibility it is

a possible way of marking and exposing sense, inherently shared within a culture as such, including those researchers who would call it a misconception.

### **From Situated Talk for the *Other* to Conceptions for the *Self*: Reductions Irreducible**

In and with this section, we now slide into the talk of science educators, that is, to the ways in which many science educators talk about “non-scientific” ways of talking about natural entities. That is, we address the massive body of literature that identifies itself as making a contribution to “conceptions” and “conceptual change,” and in so doing, we presuppose the familiarity and membership of readers in this form of talk. Consistent with our form of analysis, we understand our talk to slide between the foregoing sections and the one in this and subsequent sections. From the beginning, our analysis shows that talk makes no sense unless sense is presupposed to be *out there* and *for* the other: it is a recipient-designed feature of talk. Conceptions and conceptual change research across the globe, however, accepts conceptions as a peculiar though shared feature of an individual: conceptions are presupposed to be in and for the Self. Under what (methodical) conditions can we say that conceptions are contents or structures of an *individual* mind? To adequately respond to this important issue, we first require some definitions of what concepts actually are.

The recent science education literature presupposes its readers to know what conceptions, and to find a definition we had to return to texts published over twenty years ago. Concepts are taken to be cognitive entities, pieces of furniture of the conscious mind that are unlike signs (Pines 1985). They are human inventions that “once labeled become communicable through the use of language” (p. 108); the term conceptions refers to the way in which individual humans conceive of concepts. Conceptions in this very prevalent view are thus mental/cognitive regularities that are made available to others by verbal means. They are “employed in thought and communication” for they are “conceptual

handle[s], enabling one to hold on to the concept and to manipulate it” (p. 108).

Depending on the particulars of the study, conceptual change may refer to the process of change or outcome of the change process; in any event, the process is of a psychological (cognitive) nature, though tools, artifacts, and social configurations may mediate the change process (e.g., Roschelle 1992).

Concept maps, semantic networks, or node-link diagrams are routine diagrammatic forms illustrating “concepts” and the “conceptual relations” in which they are involved and are used widely to promote metacognition in science learning. These relations are expressed in propositions that may be communicated in the form of sentences. Thus, for example, node-link diagrams (concept maps) have been used to show the differences between radical and non-radical (simple, slight) conceptual change, corresponding to conceptual change across and within ontological categories (Chi 1992). Using this framework and based on our own extensive familiarity with concept mapping research and teaching practice, Mary’s “conceptions” of the sun, its positions and movement, the earth, and day and night can be represented as in Fig. 9 below. Our problem now becomes, “Under what conditions and which presuppositions are at work in our cultural account of the production of the interview, interview text, and the conceptions attributable solely to Mary?”

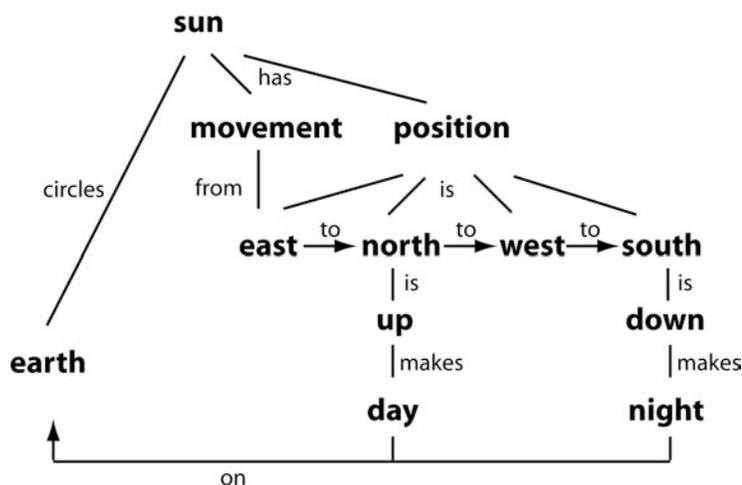


Fig. 9. A conceptual change researcher may depict what Mary has said in the form of a concept map, said to depict her conception or conceptual framework.

In the early part of this text, we suggest that a conversation is a unique, once-occurring event that cannot be fully captured by whatever means. Any form of recording, or any form of making the conversation present again, constitutes a reduction or abstraction. This includes our own transcription, even though it includes indications of the change in pitch and speech intensity and all the pauses. To go from a conversation—produced in real time as re-presented with high but not exact fidelity in our transcript—to conceptions represented in textual or diagrammatic form (Fig. 9), a series of reductions have to be accomplished. Whatever conceptions are attributable to individuals in the conceptual change literature, the viability of these reductions has to be granted. In the following, we articulate and discuss some of these possible reductions and abstractions that are often assumed by science educators.

### *From Praxis to Recording and Transcription*

A first reduction leads from a once-occurrent event—from which there is no time out, which cannot be replayed, and in which each performance is final—to a physical recording, which in the present case has been captured on videotape. Whereas the videotape can be replayed over and over again and whereas the analyst knows the entire trajectory that the conversation has taken, the participants, including the interviewer with the most rigorous guidelines for producing the interview, cannot ever know beforehand what exactly will be said, how it will be said, and what the process is by means of which the interview becomes what it ultimately will be. Whereas we can never return to the original moment when the interview happened and was recorded, one way of approaching the inherently temporal nature of an interview is to engage in an analysis that takes the *first-time-through* as a paradigm, which means, the researcher takes as illegitimate any move to consider what is being said *outside* of the temporality. That is,

from a first-time-through perspective, the discursive resources are viewed as historical and as being augmented in and through *this* interview talk rather than as the atemporal expression of relations in Fig. 9.

### *Abstracting from Time and Contingency*

Our approach articulated in the course of analyzing the videotape and its transcript is dialectical, which inherently leads us to constitute the talk in its historical (temporal) and contingent characteristics. Each turn, we note above, is for the other, with the language that is not the speaker's own, and preceded and therefore conditioned by the talk of the other speaker. Talk *only* is attributable to an individual if all those links and mutual contributions apparent to participants and researchers are removed. Our analysis shows the conversation as contingent, and this contingency also marks its product, talk as recorded on tape. A concept map (e.g., Fig. 9) however expresses the said of a conversation in an atemporal fashion, as if the said had been prefigured, the outcome of some underlying cause that is not affected by time (e.g., a stable underlying conceptual framework). Going from the conversation as a temporal event to a stable framework, what is said thereby becomes *merely* the external expression of a framework (conception) already in place. This makes it difficult to explain change from a so-called misconception to a scientific conception, because that which is beyond (mis-) conceptions, the kind of talk between the misconception and a conception has not been theorized; the in-between forms of talk, which neither can be due to a misconception nor to a conception are beyond the capability of a conceptual change approach. These transitory moments between the different forms of sense (misconception to conception) cannot be theorized in and for themselves, because even the notion of non-sense still is theorized in terms of sense.

A historical approach, however, is required in situations where participants talk about topics that they have not talked about before or have not considered before. In a very

strong sense, speakers cannot have a conceptual framework for something they have not thought (talked about) before. Because in this situation, as we show in and through our previous analysis, the talk about a phenomenon, drawing on available (linguistic, paralinguistic, and extralinguistic) resources necessarily is contingent, mediated by whatever has been said and done (e.g., drawing, gestures) so far and by whatever means they find in the social setting (configuration that make possible orientations, artifacts, materials). It thus seems reasonable to claim that a conception such as the one depicted in Fig. 9 is articulated *in* and *through* the process of talk rather than *driving* the talk. Indeed, to go from talk to that conceptual framework, we have to abstract the talk from the activity itself similar to how we abstract from the fact that participants use talk to make the activity first and foremost, which frames the possibility of sense. They make the topic in the process, for the purpose of realizing the activity. Thus, what (content) and how (process) participants say is produced and reproduced in an interview, which also has a topic.

### *Abstracting from Linguistic and Paralinguistic Resources*

As our transcript shows, talk is full of uncertainty, pauses, starts and restarts, overlapping talk, unfinished sentences, grammatically incorrect sentences, and sounds run together so that in the transcript, “one” word really is composed of three words (“thereisa” [turn 90]). More so, the pitch does not always follow the customary ways, such as rising toward the end of an utterance when a question is being asked—yet any competent speaker clearly hears the question. This uncertainty itself is used as a resource, for example, as a reason for reformulating what someone has said before (“so you think . . .?” “you say . . .”). Leaving out these aspects abstracts the very resources that people use to make the event into what it is and becomes, and therefore, abstracts “conceptions” their (collective, public, situated, contingent) process of construction *for the other*.

### *Reducing the Nonverbal to the Verbal*

In the literature on conceptions, words are privileged; this is more than evident in the fact that conceptions and conceptual change are represented in semantic networks that are said to change in minor ways (simple, slight conceptual change) or in radical ways that restructure the entire map (Fig. 9) and comes with changes of concepts between ontological categories. To move from our account, which takes into account the visual presentation of gestures, body positions, and other setting particulars and render them in words that can be entered into such a diagram, researcher presuppose that the visual does not present its own features but that all features addressing senses other than the ear—and among the aural features those other than the ones parsed into distinct words—can be translated (from Latin *translatus*, carried from one place to another) and re-presented in verbal form. The visual information, though radically different from the auditory, is assumed to be reducible to the verbal. Yet there is something irreducible in, for example, gestures; and the participants actively articulate this irreducibility when they use gestures rather than saying something in words. There is also something irreducible in pointing to some aspect, such as the configuration of three or more hands, where the aspect to be marked and made salient never is articulated in words so that it is ambiguous just what is being pointed to. Under what conditions is it possible to use words exchangeably for (iconic, deictic) gestural presentation? Are not models that demand *one* underlying conceptual framework more restrictive and require more presuppositions than assuming that the different performances (sound, body movements, orientation, hand/arm movements) are concrete realizations of a universal (the idea) that does not exist other than through its diverse concrete performances? If this is the case, then a concept (idea, notion) does not exist other than in the (infinite) set of concrete possibilities that are said to realize it (an identity that itself requires work). Rather than thinking what different expressions have in common, the intersection of two expressions, we might think of each

expression as a singularity within a plurality (idea, sense). In this situation neither can an expression be reduced to another expression, nor is the plurality as a whole given in any one singular expression. Rather, each expression (modality) one-sidedly and metonymically stands for the idea (concept, notion). There is then no requirement for all expressions to have something in common (which the conceptual approach presupposes as a matter of fact). In this (dialectical) framing, each (synonymous) expression is different, which introduces difference into the idea (concept, notion) itself.

In realizing the event *as* interview through the production not only of the topic but also of the transaction (process), the participants draw on different resources available in the material setting and in the relation to the other. All of these resources contribute to constituting the sense of the said. Some of these resources are made thematic (explicit), others are presupposed—e.g., that the “sky is up,” “the sun is in the sky,” the sun is “((finger pointing toward ceiling)).” Thus, the interviewer utters what we hear as “do you think why the sun is over there” while pointing, upon uttering “there,” in the way she does in Fig. 10. Under what conditions can we articulate in words just where and what this “there” is? What is it that can be found there and that therefore is marked as part of the currently salient sense? And what is the range of error that we commit if we reduce the gesture in the particular direction and orientation is translated into words?



Fig. 10. The interviewer utters, “Do you think why the sun is over there?” while gesturing as seen here.

We outline here that it is the competence of the listener that allows her to attune to the sense articulated; and it is in her subsequent actions that this sense is further articulated. Interpretive errors enter the analysis precisely then when gestures and indexicals are translated into words, literally carried from imagery and body motion into words, thereby necessarily articulating different dimensions of sense; a different sense is articulated even if the re-articulation occurs in the same modality (Italians say, “Traduttore, traditore!”; all translation is treason), such as when something already said is said differently subsequently. Saying something differently clearly is non-identical with what has been said before and therefore already constitutes an interpretation—allowing us to understand that everything is untranslatable although nothing really is untranslatable; translation is the name for the impossible (Derrida 1998). From a cultural perspective, and this is where we have been sliding into, at least by explicitly referencing a cultural theorist, any language shows a great deal of resistance to being translated into all languages, including another form of itself.

Taking all these reductions together, we come to the realization that words and the conceptions being expressed by research participants do not have lives of their own but yet are usually taken at face value by science educators. Rather, talk should be seen as integral part of cultural activity, of utterances performed by flesh-and-blood creatures in real-world contexts and for specific purposes. And because these concepts coordinate and allow people to function in social practices such as during interviewing, they are definitely not confined in the private territory of the human mind.

### **From Observed Talk to a Cultural Approach**

We begin this study with an analysis of a stretch of talk using nothing but our everyday competence of participating in similar talk and repeatedly bringing up the presuppositions concerning the trajectory of the talk. Adhering solely to what the conversation participants make available to one another, we continually ask, “Under what

conditions do participants understand the sense foregrounded in and through the talk of the other and their own talk?" At a second level we asked under what conditions did we, the observers of the videotape on which the original conversation had been recorded, understand the sense participants afforded for each other. That is, we eschewed anything predetermined as science educators but singled out the minimum presuppositions that enabled our understanding of the unfolding social situation. In the course of our text, this form of cultural analyses leads us to a number of interesting results concerning the processes of talk that has as its topic phenomena of interest to scientists and science educators. These results are summarized in the following:

1. Talk is designed to produce the form of societal activity, which simultaneously supplies the context for the topic of the conversation. In the absence of knowing and understanding the nature of the current societal activity, conversation participants lose the nature of the sense being articulated. The communicative act and the activity necessarily presuppose each other, as the latter exists only through concrete acts by participants, which presupposes the nature of *this* activity that is in the very process of being realized.
2. Talk between people makes use of many resources other than words (sounds), which address human senses other than the auditory, and therefore possess very different sense. These resources are distributed *within* and *across* speakers and listeners; they are distributed across setting particulars (e.g., spatially oriented). Each communicative act is concretely realized through *this* sequencing of *these* particular sounds, but the serialized production of sounds again *presupposes* the communicative act as a whole.
3. Turns at talk are interdependent; what the sense of a specific utterance is can be known, from the perspective of the conversation, only from the subsequent turn or turns and not in real time. Each communicative act therefore is spread across a pair of turns. Communicative acts therefore essentially and simultaneously

are agential (has intentional and performative dimensions) and passive (in that the effect is given by the other).

4. In talking, speakers use a language that is not their own; they produce linguistic structures and contents *for* the other. This is another essentially passive aspect to what is being said for what a person says is the concrete realization of a cultural possibility, simultaneously particular and general. Social theorists often argue that language and culture speaks through the person.
5. Talk is inherently underdetermined, full of stumbles, mumbles, malapropisms, alternative pronunciations, inaudible sounds, metaphors, tics, prosodic variations, and pauses. Nevertheless, conversation participants normally understand the sense articulated, because they can draw on non-linguistic resources as mentioned earlier. Therefore, what people say underdetermines sense, they always mean other than is made available in *these* words.
6. All listeners including the analysts bring to a situation a vast array of ordinary competencies as resources for understanding the sense metonymically sketched by the verbal and nonverbal means of communicative acts. This vast array is constitutive of the *process* of the saying as well as the *content* and *structure* of the said.
7. Because it is always possible to rephrase what has been said, using different words, sense inherently is open to development. Culture and sense inherently are open and unlimited because new ways of talking constitute new cultural possibilities available to every member of the culture (linguistic community). Possibilities are dialectical for their concrete realization in the world creates newer possibilities; concrete actions augment general possibilities. This allows us to imagine the situation when some anthropoid uttered the first word (concept) and thereby became human. In uttering the word, he or she already presupposes the intelligibility of the word, and, in a group, the intelligibility on

the part of other individuals. He or she presupposes forms of sense, both at the moment, and developing in time. The origin of conceptions precedes conceptions, precedes even the negation of conceptions (misconceptions), and therefore is constituted beyond any and all conceptions.

The formulation of the position we arrive at in the course of our everyday, mundane analysis of equally mundane talk parallels cultural analyses found within sociology, psychology, and philosophy. For example, cultural sociology is based on an agency | structure dialectic (e.g., Sewell 1999): actions make salient structure both in the setting (resources, constraints) and in the agent (schemas). Thus, agency and structure presuppose each other in the sense that the former make visible and create structure and the latter enables and constrains agency. Cultural (critical) psychologists also recognize the mutual constitution of the individual and collective in the sense that an individual's actions always are concrete realizations of collectively (societally) available possibilities (e.g., Holzkamp 1983). In both approaches, culture exceeds cultural artifacts and observable practices—culture exists in and as the universe of possibilities to act and experience, and these possibilities are continuously expanded in and with every action, leading us to an unstable, dynamic concept of culture.

Similarly, there is always yet another way of rephrasing what a conversation participant has said, leading us to an openness of the possibilities of expression and continuous transformation of ways of talking (concepts, conceptions). This indeterminacy compels us to take a historical perspective since forms of talk change in and over time and therefore are characteristic of moments in time; even our own writing here is characteristic of the historical condition we find ourselves in; and they are characteristic of the biographies of the authors involved. There is no indication that this text would or could have been produced some twenty years ago by the same or different authors; our own biographies brought us to a point where such a text became a possibility, but this is not only our possibility, but also the collective possibility for writing/reading such texts.

Additionally, some philosophers, too, have come to the conclusion that there is a mutually constitutive relation linking individual and collective—being always is being singular plural (e.g., Nancy 2000). For each individual, all other individuals constitute a (cultural) context, so that the individual can be rightfully thought only in and through its relation to all the others. Nothing that can be observed involving human beings and no observation made can be reduced to the individual; anything that articulates sense *inherently* and *always* is shared, intersubjective, and hence cultural.

### **From Conceptions Research to Classroom Practice**

Any new or alternative theoretical framework not only has to be plausible and intelligible but also fruitful, offering to resolve real problems and leading to further avenues. We suggest that because the cultural approach that we articulate here does not deal with conceptions other than in the way they are made available by people in conversation, this model not only is more parsimonious but also provides a way of theorizing students' "conceptions" that is closer to what school teachers experience in their everyday practice. Rather than having to deduce internal models and cognitive frameworks—which, as we show in the previous section, require several levels of abstraction—teachers only deal with "ways of talking" as people get about the serious business of living in the world.

From a cultural perspective, thinking about *a* (scientific) concept, of which individuals *have* a (scientific, alternative) conception makes one suspicious for there are always infinite ways of constituting some topic or phenomenon. Individuals change their ways of talking, and these ways of talking generally change in infinitesimal ways. We find ourselves one day talking differently than we had done some time back. In talking about some topic or (scientific) phenomenon, we are both agential and passive. We are agential in articulating something (idea, sense), but we are passive in the sense that we use a language inherently from the other, which provides not only possibilities but also

constraints, and which constitutes a resource for making inferences that scientists and science educators deem incorrect (from “sunrise” to “the sun is moving”). That is, through us, the possibilities of language are concretely realized and new possibilities are created, which others or we can subsequently propagate or further modify. What teachers have to assist students in, therefore, is developing ways of talking that are contextually appropriate.

There is another advantage in the sense that we no longer have to think in terms of breaking or abandoning conceptual frameworks but in terms of changing forms of talk. Forms of talk, as we show here, may change ever so slightly. For example, articulating in alternative words what someone else or the speaker has said previously constitutes a change of expression. Thus, Mary describes the sun as going from east to north to west to south and back to east again. She makes an ephemeral drawing on her thigh, moving her hand in a circle stopping in four positions as she names the cardinal points. The interviewer re-articulates what has been “said” as “the sun is moving around the earth.” Here, we have some translation and shift with respect to the original communicative act. Such shifts can be thought as taking us, ever so slightly, to ways of talking about and constituting a topic that scientists and science educators find acceptable. Conceptual change no longer has to involve a radical or non-radical mental framework, but occurs in ordinary talk through infinitesimally changing ways of talking. Conceptions are therefore performed as a way of getting around in the social world; and this performance always is public and *for* the other as much as it is a concept *in itself*.

This argument moves us to reinterpret pedagogical practices from a cultural perspective. Now, teachers can be viewed as performing conceptions using available resources and producing new resources as well. The latter include gestures, body movements, spatial orientations, representations, text, other resources in the setting, and talk. That is, what teachers make available consists of more than talk—though predominantly, students only focus on language and whatever is on the chalkboard. If we

view learning science from a cultural perspective, where performances of conceptions is all we ever see and produce, then there are other consequences for teaching science.

Taking language learning as an analogy (we write from experience as for all three of us, English is but one of the languages we speak), we suggest that it is through participating in communicative practice that we learn to communicate rather than by watching others do it. We learn to play a musical instrument by playing it just as we learn to play at ball games by participating in playing ball games rather than by watching others doing it.

Only here we make an even stronger claim that learning science is simply learning to live in the world with other people by using a multitude of cultural tools, not least of which are scientific concepts. In so doing, scientific conceptions assume their position as meaningful, useful, and justifiable tools for/in society and not the abstractions so predominant in school curricular today.

Indeed, science students are too often said to be resistant to (conceptual) change whereas our cultural approach reinterprets this problem as a top-down injunction against talking differently and certain poetic forms of speech that are everyday currency (e.g., “the sun is moving across the sky,” “the sun is setting in the West”). Learners are asked to effect this revolution in speaking without having sustained opportunities for participating in conversations about relevant topics and to experience the need for change, at least, for the purposes at hand in science classrooms. It is no wonder that students with very different backgrounds than that of the dominant class (e.g. aboriginal peoples [Maori, First Nations], African American, dialect speakers, new immigrants, working class) often experience science as (symbolic) violence. Because language is the primary means for exposing sense and because language is both from the other and for the other, speaking, as writing, is an exposition of an inherently *shared* sense, which, in writing, literally is ex-scribed. But exposition and ex-scription occurs out of (*ex-*) a particular *position*, so that the sense inherently is singular and therefore *positioned* (as cultural studies and feminist scholars emphasize) all the while it is universal, inherently

shared. This sharing already existed at the dawn of humanity, when the first word was uttered concretely, presupposing itself in the other to be intelligible; and it exists at the very moment that new words are created in a culture. Every first word and every first way of talking is both a first (concrete realization) *and* a repetition of the possible.

If the teaching of science remains primarily as the eradication of (mis)conceptions, then instruction is perpetually an exasperating chore and one that is doomed to failure. Different ways of talking are inherently useful, and virtually infinite; talk is hybrid, heterogeneous, different within itself—we therefore never speak only one language. This very feature that makes it possible to articulate and re-articulate sense with respect to some phenomenon in ways that scientists and science educators approve also makes it possible to talk about this phenomenon in ways that scientists and science educators reject. Imagining pedagogy narrowly in terms of the eradication of “misconceptions” (ways of talking) means removing the very possibility of conceptions, and therefore living in society as a constitutive member.

### **Theoretical Contribution: The *With* and Passivity**

We could have concluded the text with the previous section. However, we decided to add the present one because it contributes to thinking about conceptions in particular and knowing and learning more generally in a historical perspective that returns to the origins of humanity. To date, most if not all epistemologies are improbable because they *presuppose* the very thing to be explained. Thus, constructivism presupposes the constructor, a conscious being who intentionally pursues knowledge and learning. But who, we might ask, constructed the constructor? How, if consciousness is a function of the language we use, could consciousness arise in the first place? This problem, which takes us to the genesis of (cultural) cognition, has not been resolved in the traditional approaches based, as they were, in Renée Descartes, Immanuel Kant, or Georg W.F. Hegel, or Edmund Husserl. This article provides materials to think about this initial

moment near the birth of consciousness itself, which in turn is able to know (“cogito, ergo sum”) and construct itself in rational (Kant) or dialectical ways (Hegel).

With our analysis, we suggest that in talking/writing, we always presuppose the mutual intelligibility of what we say/write; and we do so even when some of us (poets, journalists, researchers at the cutting edge of their field) invent *new* ways of talking/writing. Intelligibility is also presupposed in talk that researchers might characterize as unscientific; and it is precisely the intelligibility of talk that allows us to make the assessment that some stretch of talk *essentially* differs from other forms of talk, for example, the ones scientists may employ in their teaching. (And this is so although forms of talking change even within the community of those who denote themselves by the terms “scientist” or “science educator” and even on apparently settled conceptions, theories, and other topics.)

In essence, therefore, this presupposition can be taken back to the moment when the first human being to be opened his or her mouth to speak, we, humans, were caught up in the dialectic of community, where the self presupposed the other. Humanity emerged from a pre-essential (pre-ontological) *with*, a relation that, in proximity and touch, begins to differentiate itself into a relation of selves and others. It is only out of such a pre-essential and pre-ontological *with* that we can understand the emergence of *conscious being*, where a first speaker can *presuppose* the shared nature of the (his, her) utterance. In this differentiation, the *with* gives rise to a world and consciousness, self and other, at the moment somebody articulated speech, who cannot be considered the first speaker as her words are presupposed to be intelligible by the other, who had to have preceded her. The dialectic of the *with* underlies all other dialectics in cultural studies, because their discourses are some of the many existing possibilities since the first word was not the original. This first dialectic is our *first principle*, from which all other principles derive, including culture and cultural analysis.

Some time ago, Ken Tobin and Wolff-Michael Roth jokingly referred to the formula “agency | structure” as *the* first principle of cultural sociology (similar to  $F = m a$  in physics). In the articulation and explications of ways of talking (conceptions) during a specific interview, we, the present authors, also have arrived at a more parsimonious first principle for analysis. Our work allows us a re-definition of this core principle within cultural sociology for ours includes a moment of passivity, without which agency could not function theoretically and practically. We speak, but in so doing, realize possibilities that precede their performance; we therefore also constitute the passive means by which language realizes itself. And this was since the beginning of consciousness. At the very heart of agency therefore lies an essential component of passivity—the first human being could not have *chosen* the first word because s/he did not have the consciousness to chose among words. This allows us to rectify the inherent asymmetry in the traditional agency | structure approach, leading us to a triple dialectic expressed in the form

(agency | passivity) || (resources | schema).

A cultural approach therefore allows us to understand that there are active and passive dimensions to ways of talking (“[alternative] conceptions”), because a way of talking always is realized by a person, but the possibilities of language and sense always emerge from the other and are for the other. This redefinition further shows that schemas change not merely through observing someone else in talking (communicating), but that it involves active engagement in the deployment of situational (linguistic, paralinguistic, extralinguistic) resources. Similarly, when we are asked to talk about things such as sun and earth or day and night, especially when we have not talked and thought about them before, language provides us with resources for doing so nevertheless, but this language is not ours. There is an essentially passive component in (mis-, alternative, naïve, pre-scientific, etc.) conceptions that to date has not been theorized in science education.

The same is true such that this way of thinking ultimately returns us to the implications of talking science (conceptions). To knowledgeably overhear a conversation

and subject it to analysis, we require the same competencies that allow others to participate. And we require the same competencies in the production of all those stretches of talk that science educators have come to term as deviations from scientific conceptions. We cannot explicate a stretch of talk unless we are already practically competent at that form of talk (praxis); our explication inherently is preceded, accompanied, and concluded by this praxis. To identify something as a misconception, as the negation of a conception, we have to be knowledgeable not only about the latter but also about the former, and, in this, recognize the former as a legitimate possibility of talk.

## Notes

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<sup>1</sup> The following transcription conventions have been used: ` ' ^ ~ - – falling, rising, rising-falling, falling-rising, and level pitch; ↑ – upward jump in pitch; (0.40) – time in seconds; (.) – noticeable pause of less than 0.10 seconds; ?;,; – punctuation indicates rising, strongly rising, falling, strongly falling pitch movement rather than grammatical structure; <<dim> classifying> – diminuendo, falling speech intensity; <<p>never> – (piano) lower than normal speech volume; <<pp>to> – (pianissimo) very low volume; OH – capitalization marks louder than normal speech; .h – inbreath, each “h” standing for one tenth of a second; e: – colon indicates lengthening of phoneme; = – equal sign marks “latching,” lack of a pause between two speakers; ((hand moves)) – double parentheses surround transcribers comments; [here], [uh hm] – aligned square brackets in consecutive lines indicate overlapping utterances.

<sup>2</sup> By saying this sentence, it immediately presupposes our ready understanding of the field of science education, its discourses and the experiences science educators generally make in the course of their professional and personal lives.

<sup>3</sup> It makes no difference in Asian countries, either, that have everyday languages consistent with English expression of “sunrise” and “sunset.”

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## Appendix: The Interview (Segment)

- 01 I: um (0.48) and do you think why the sun is over there? (0.90) it's  
in the sky?
- 02 (1.12)
- 03 M: why? the sun is in the sky?  
(0.19)
- 04 I: yea:  
(0.65)
- 05 M: because=a its=a ^moving ((hand gesture)) and a its a (0.44) now  
today- (.11) now is (0.13) 'day↑time  
(0.23)
- 06 I: uh hm:
- 07 M: so the sun is in the position of thata sky ((hand gesture))  
↑position- ((looks at interviewer, makes eye contact))  
(0.18)
- 08 I: yea (0.86) a:nd which? direction. (0.30) maybe east? or north?  
o:r-
- 09 (0.33)
- 10 M: ^o:h:: ((hand moves up to the chin, eyes move upward, pensive))  
(0.26) in the morning it should be in the east
- 11 (0.17)
- 12 I: yea:. why?
- 13 (1.06)
- 14 M: <<pp>uh> why::? (1.70) <<p>uh: i never think about that.> () i  
^thi:nk (0.33) i:ts=a becau:se (0.24) of the movement of the  
↑sun.  
(0.42)
- 15 (0.42)
- 16 I: [uh hm:  
17 [((begins to nod))]  
18 (0.40)
- 19 M: the sun is moving ]
- 20 (0.89)
- 21 I: s:o:: which? [direction (0.62) the sun will moving;  
[((hand moves back and forth))  
from; (0.36) you know; (.) where <<pp>to]> where?  
((as in pendulum motion)) ]  
(0.26)
- 22 (0.26)
- 23 M: from east to west.
- 24 (0.33)
- 25 I: uh hu:
- 26 M: ea:st ta ((gesture in the air, to upper legs to make "drawing"))  
27 (2.25)
- 28 u:::m:: (1.41) east north
- 29 (0.14)
- 30 I: [yea]
- 31 M: [in ] the west an
- 32 M: and the [south and [the east again  
[((hand back in "east" position  
33 (0.43)
- 34 I: so you say [east (0.22) and moving [tof;  
35 (0.34)
- 36 M: north=
- 37 I: =north (0.26) a:nd the:n: moving to,  
38 (.)
- 39 M: east
- 40 (.)
- 41 I: east

- 42 (0.22)
- 43 M: =okay (0.26) FROM (0.39) from the east (.) to north and to west  
 ((Just as M turns head to look at I again, the latter begins to  
 nod repeatedly; the nod is recipient designed, too))  
 [(.) and] then to south
- 44 I: [uh hm ]  
 (0.40)  
 to south; (.) an:d-
- 45 (0.36)
- 46 M: [then (0.24) to east again
- 47 (0.51)
- 48 I: [uh hmm
- 49 (0.37)
- 50 M: [i think [this is the movement.  
 [(makes [another circle on the knee
- 51 (0.34)
- 52 I: uh hm=so you think the sun is mo:vi:ng (0.11) around the earth?
- 53 (1.16)
- 54 M: 'ya-
- 55 (0.58)
- 56 I: uh hm
- 57 (0.47)
- 58 M: <<p>i think so->
- 59 (0.28)
- 60 I: uh hm.
- 61 I: so do you think 'why we have day an:: night.
- 62 (0.42)
- 63 M: because of t-the movement of the sen (0.68) and uh in the evening  
 we couldnt a get the sunshine <<dim>so thats the reason we have  
 that>
- 64 I: yea: but ↑`why we didnt have the sunshine
- 65 (1.18)
- 66 M: because we are at ah (0.22) i heard (0.14) i think because of  
 (0.62) the other half of the earth (0.14) have the sunshine
- 67 (0.72)
- 68 I: the other (0.33) half of the earth
- 69 (0.25)
- 70 M: have the
- 71 (0.18)
- 72 I: have the sunshi[:ne]
- 73 M: [yea]; .hhh (0.12) we are (0.27) from t the  
 sou:th:
- 74 I: uh hm=
- 75 M: =we are in the north part right?=  
 76 I: =yea, nor[th]
- 77 M: [th]e south <<dim>part of the earth have the sunshine>  
 (0.96) <<pp>has the sunshine.>
- 78 I: you say when we are in the night-
- 79 M: yea;=  
 80 I: then they will have sunshine.
- 81 M: yea,  
 82 I: so when we:: (0.22) have the (.) day
- 83 (0.12)
- 84 M: they are [in the]
- 85 I: [in the] day::
- 86 M: they are <<dim>in the evening>
- 87 (0.48)

- 88 I: okay; (0.13) then why:- (0.14) why there (.) there is a (0.42)  
you know this kind of; (0.75) uh ^phenomena;
- 89 (1.58)
- 90 M: u:m::: (0.39) (aday?) (0.38) i think because uh (0.68) when  
therisa (0.72) the earth and sun move together?
- 91 (0.24)
- 92 I: uh hm=
- 93 M: ((Looks emptily into the room rather than at interviewer, as if  
looking for something)) =there is the 'point h that=uh (1.53)  
that=u::h (0.17) the s::: (0.34) the earth ((faces  
interviewer)) will face the 'sunshine (0.25) the sun:
- 94 (0.22)
- 95 I: uh [hm::: ]
- 96 M: [and then] again the sunshine a[n the] other half
- 97 I: [uh hm]
- 98 (0.18)
- 99 I: uh hm=
- 100 M: =isa not facing the sunshine
- 101 I: [uh hm ]
- 102 M: [an is not] facing the sun;
- 103 I: uh hm=
- 104 M: =so they <<dim>couldnt get the sunlight> (0.25)  
thats [the reason.]
- 105 I: [S:O:: ] so you mean (0.16) earth is here an::: (0.32)  
sun is he[re]
- 106 M: [uh] hm=
- 107 I: =so when sun is ^here=
- 108 M: =anda this part of the earth can have the sunshin[e bu]:t
- 109 I: [yea ]
- 110 M: the other part (0.24) [did]nt.
- 111 I: [yea]
- 112 (0.21)
- 113 I: and you said the sun will: [moving]
- 114 M: [moving]
- 115 I: around the earth ((circles one hand round the other))
- 116 M: yea
- 117 (0.35)
- 118 I: okay,
- 119 (0.33)
- 120 M: anda then:: (0.78) the vice versa;
- 121 (0.20)
- 122 I: [uh hm:: ]
- 123 M: [the other] way.
- 124 I: [uh hm:: ] uh hm .hh okay so now is summer 'right
- 125 M: uh hm