ON MEANING AND MENTAL REPRESENTATION

NEW DIRECTIONS IN MATHEMATICS AND SCIENCE EDUCATION
Volume 26

Scope

Mathematics and science education are in a state of change. Received models of teaching, curriculum, and researching in the two fields are adopting and developing new ways of thinking about how people of all ages know, learn, and develop. The recent literature in both fields includes contributions focusing on issues and using theoretical frames that were unthinkable a decade ago. For example, we see an increase in the use of conceptual and methodological tools from anthropology and semiotics to understand how different forms of knowledge are interconnected, how students learn, how textbooks are written, etcetera. Science and mathematics educators also have turned to issues such as identity and emotion as salient to the way in which people of all ages display and develop knowledge and skills. And they use dialectical or phenomenological approaches to answer ever arising questions about learning and development in science and mathematics.

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On Meaning and Mental Representation

A Pragmatic Approach

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Preface

> Das Verstehen, die Meinung, fällt aus unserer Betrachtung heraus. [Understanding, meaning, drops from our considerations.]
>
> (Wittgenstein 2000: 1)

> *Meaning:* A word so confused that it is best never used at all.
> *Mental:* This word not used by us.
> (Dewey and Bentley 1949: 194)

> Die befindliche Verständlichkeit des In-der-Welt-seins *spricht sich als Rede aus.* Das Bedeutungsganze der Verständlichkeit *kommt zu Wort*. Den Bedeutungen wachsen Worte zu. Nicht aber werden Wörterdinge mit Bedeutungen versehen. [The situated intelligibility of being-in-the-world *expresses itself in language/speech*. The meaningfulness of intelligibility *is put into words*. To significations words accrue. But word-things are not supplied/fitted with significations.]
>
> (Heidegger 1927/1977: 161)

Terms such as «meaning», «understanding», and «mental representation» are core concepts in the Anglo-Saxon scholarship generally and in science, technology, engineering, and mathematics education (STEM) specifically. However, in the opening quotation L. Wittgenstein tells his readers that two of these terms—understanding, meaning—drop from his considerations; he certainly would have dropped the third term, too, as his later work amply testifies. Dewey and Bentley also recommend dropping the terms «meaning» and «mental». That is, in a pragmatic theory of language that constitutes the background to both quotations, there is no use for these concepts. In the third quotation, M. Heidegger turns around the common way of articulating the relation between words and signification.[1] Thus, if anything, words accrue to an always already intelligible world rather than receiving meaning as a property that comes to be attached to them. Cultural-historically, before the dawn of the human form of consciousness, this intelligibility expressed itself in the first sound-words that the animal-in-the-process-of-becoming-human-at-the-time exchanged in and for coping with life. In Heidegger's analysis of language it is the same intelligibility, which arises from an ability of coping in a famil-

[1] The German word *Bedeutung* tends to be translated as meaning, and some scholars do translate the quoted passage substituting "meaning" for signification.

iar world, that expresses itself in words. Thus, it is this familiarity that expresses itself in words; and, thereby, these words come to be integral to the intelligibility of the lifeworlds we inhabit and live in. There is therefore no difference between knowing a language and knowing one's way around the world generally. In child development, too, before children can think of themselves and of their selves as being different from other selves—e.g., have some form of inner speech to maintain an internal monologue about who they are and what they want to do—they already competently navigate their familiar environments: home, garden, nursery school, kindergarten, and other everyday places. It is to this familiar, intelligible, and significant world that words accrue rather than the other way around.

The common discourses in the STEM literature appear to put these insights on their heads. Students are said to *construct* "meanings," "knowledge," "mental representations," and "understanding" when they talk with and about new words that the curriculum introduces into their lives. This way of approaching language is at odds both with cultural-historical evolution of society (phylogeny) and individual development (ontogeny). Language is a latecomer, always finding a place in an already familiar world. When there is no familiar world in which a word could find its habitat, then learners—e.g., foreign language learners, school students asked to learn new words—use them inappropriately. Rather than saying that the words "have no meaning," it might be better to say that the learners are not familiar with the words or with the world in which these are useful for getting things done.

In this book, I deconstruct[2] the ideology that comes with the use of theoretical terms such as «meaning», «mental representation», «conceptions», and «understanding». I place these terms in chevrons to mark their provisional nature (unless these are placed in quotation marks, which I do when citing others using them); the provisional nature allows me, in the final chapters of this book, to propose a new way of hearing and using the terms. As currently used and what these imply, the terms misguide us and are of little value to those who are asked to teach science, technology, engineering, and mathematics. These terms are of little value because teachers have little time to wonder about what might be in their students' heads. Instead, I propose an alternative according to which everything required for understanding language-in-use is out in the open, on the surface, accessible to students and teachers alike. We therefore do not need «meaning» or «mental representation» in the way these terms are currently used. The approach to language I articulate and advocate here is consistent with, and developed on the basis of, the works of scholars such as L. Wittgenstein, M. Heidegger, and M. M. Bakhtin (together with his collaborators). Words and language do not point to something else, things or phenomena in a metaphysical world. Rather, we speak (or write) in the way we walk or use our hands without having to cogitate «meanings», reflecting about or applying «mental representations», or manipulating «conceptions». None of these traditionally conceived actions allows us to appreciate language as a societal or individual phenomenon.

I intend this book to be a call for the critical interrogation of «meaning» and the associated theoretical terms of «mental representations» and «conceptions». I

[2] I use the term in the sense of *Abbau* (literally "unbuilding") the systematic undoing of a structure for the purpose of becoming familiar with its composition rather than in the sense of destruction.

intend to initiate a reconstruction of the terms and lead to new categories more consistent (a) with the evolution of humanity and human forms of speaking and thinking and (b) with a post-constructivist understanding of how language works when students learn science, technology, engineering, and mathematics.

Chapters 3 and 5 were developed from texts originally published in *Cultural Studies in Science Education*; chapter 4 evolved from a text originally published in *Educational Studies in Mathematics*. The transcripts and interpretations thereof that appear and are critiqued in chapter 8 are from the notes and records of a research team that I was part of in 1995 while doing research on knowing and learning in a German tenth-grade physics class studying chaos theory. The notes and records and subsequently appeared or were taken up in a variety of presentations and papers, both in English and German. Some of the data featured in this book have been collected with the support of research grants from the Social Sciences and Humanities Research Council of Canada (Roth, chapters 4, 5, 6, 7; Radford, chapter 6 and from the Natural Sciences and Engineering Research Council of Canada (Roth, chapter 6). A grant from the *Deutscher Akademischer Austauschdienst* supported the collection of the data that appear in chapter 8

In this text, I draw in some instances on the originals of books that are also translated into English, French, or German. In the case of Russian, I often reference the original; but in every case, I compared my translation with the one published (which in the cases of particular important concepts make inappropriate, ideologically based decisions of word choice). When I quote from French or German texts, the translations are mine; in this case, the original book or article is listed with the title translated as per the latest APA guidelines. A related issue is the spelling of author names, which differs between languages. In the present text, I always use the English spelling (e.g., Vygotsky, Leont'ev). In the in-text and end-of-text references, I spell the name as given on the book cover or, in the case of Russian, use the standard transcription rules used for scholarly purposes (e.g., Vygotskij [Russian, German], Leontjew [German]). When I note a foreign word in an alphabet other than the Latin one, I also provide a rendering following standard scholarly transcription rules. For phonetic purposes, I sometimes use the transcription rules of the International Phonetics Association that orients us toward the sound itself.

Victoria, BC
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Die Produktion der Ideen, Vorstellungen, des Bewußtseins ist zunächst unmittelbar verflochten in die materielle Tätigkeit und den materiellen Verkehr der Menschen, Sprache des wirklichen Lebens. Das Vorstellen, Denken, der geistige Verkehr der Menschen erscheinen hier noch als direkter Ausfluß ihres materiellen Verhaltens. Von der geistigen Produktion, wie sie in der Sprache der Politik, der Gesetze, der Moral, der Religion, Metaphysik usw. eines Volkes sich darstellt, gilt dasselbe. Die Menschen sind die Produzenten ihrer Vorstellungen, Ideen pp., aber die wirklichen, wirkenden Menschen, wie sie bedingt sind durch eine bestimmte Entwicklung ihrer Produktivkräfte und des denselben entsprechenden Verkehrs bis zu seinen weitesten Formationen hinauf. Das Bewußtsein kann nie etwas Andres sein als das bewußte Sein, und das Sein der Menschen ist ihr wirklicher Lebensprozeß. Wenn in der ganzen Ideologie die Menschen und ihre Verhältnisse wie in einer Camera obscura auf den Kopf gestellt erscheinen, so geht dies Phänomen ebensosehr aus ihrem historischen Lebensprozeß hervor, wie die Umdrehung der Gegenstände auf der Netzhaut aus ihrem unmittelbar physischen.

(Marx/Engels 1846/1958: 26)

(The production of ideas, of conceptions, of consciousness, initially is directly interwoven with the material activity and the material intercourse of humans, language of real life. Conceiving, thinking, the mental intercourse of men appear here as the direct outflow of their material behavior. The same holds for mental production, as represented in the language of politics, laws, morality, religion, metaphysics, etc. of a people. Humans are the producers of their conceptions, ideas, etc., but the real, active humans, as they are conditioned by a definite development of their productive forces and by the intercourse corresponding to these, up to its [intercourse] furthest formations. Consciousness [*Bewußtsein*] never can be anything else than conscious Being [*bewußtes Sein*], and the Being of humans is their actual life-process. If in all of ideology humans and their circumstances appear upside-down, as in a camera obscura, then this phenomenon arises just as much from their historical life-process as the inversion of objects on the retina does from their physical life-process.)

1 Language, «meaning», «mental representation», and «conceptions» in STEM research

This book is about language in STEM research and about how it is thought about and theorized: as something that somehow refers to something else not directly accessible. This something else often is named «meaning», «mental representation», or «conception». These underlying, explicit and implicit (folk) theories of language, as considered in current STEM discourse, are out of joint. These theories constitute a problematic way of thinking about language; and they are inconsistent with the *pragmatic* approaches that we have become familiar with through the works of K. Marx, L. S. Vygotsky, M. M. Bakhtin, V. N. Vološinov, L. Wittgenstein, F. Mikhailov, J. Dewey, R. Rorty, and J. Derrida, to name but a few. All of these scholars, in one or another way, articulate a critique of a view of language that has been developed in a metaphysical approach from Plato through Kant and modern constructivism; this view of language, which already was an outmoded view for Wittgenstein in the middle of the last century, continues to be alive today and dominates the way language is thought about and theorized. However, the consensus of the mentioned scholars is that there is nothing *behind* language—no «meaning», «mental representation», or «conception» in the closets of language. There is but language itself. Such a view should be of interest to STEM educators, because they no longer have to think about «ideas», «meanings», «conceptions», or «mental representations» that might be inaccessibly *behind* the students' words and how to work with them. Rather, the objectively available language constitutes the very ground, topic, resource, and tool with and about which (societal) intercourse is conducted and produced. In fact, it is this quadruple role of language as ground, topic, resource, and tool that has remained untheorized because STEM educators focused exclusively on the representational role of language.

For several years now, I have either not used the term «meaning» or only used it within quotation marks. Similarly, after having returned from doing my PhD into the classroom, I found the talk about «mental representations» useless in the face of what I had to do as a teacher: listen to students, engage with students, and foster them to express themselves in ways that STEM educators consider competent scientific or mathematical discourse. After having conducted years of research and close analyses of body and language in classrooms and the workplace, as well as

having done extensive readings in the philosophy of language and incarnation as the basis for all forms of knowing, I have come to this conclusion: these concepts and what they entail are inconsistent with my epistemological commitments that are directed toward overcoming the metaphysical ideas underlying the constructivist position that I had staunchly defended for much of the 1990s. I abandoned these metaphysical ideas about knowing and learning because they got into my way of understanding classroom science learning both as a practicing teacher and as a researcher. In the course of time, I have come to realize that «meaning» and «mental representation» are part of the set of pre-constructed concepts that social scientists have taken up from the everyday world without having subjected them to categorical analysis. Critical psychologists and sociologists alike have warned us—and continue to do so—of the dangers that come with the pre-constructed concepts that beleaguer the social scientist everywhere. When social scientists use concepts, they in fact take up entire ideologies; in general, the sciences tend to reify everyday concepts.

When the concepts we use in our scholarly community are not interrogated as to the historical baggage that comes with them, even a critical feminist sociologist not only might find herself at the receiving end of societal processes but also contribute to the reproduction of these processes. An example of this is when the life of a female sociology professor with her child comes to be determined if it is conceived in terms of "single parent family" (Smith 2000). That is, the set of societal (ruling) relations that are sedimented in and inextricably associated with the use of terms have real consequences to our lives. Thus, by understanding herself and her situation in terms of a "single parent family," D. E. Smith, despite and perhaps because being a sociologist, actually reproduced the societal preconception that single-parent families provide less than ideal contexts for the learning and development of their children. It is only when the very ruling relations—those that are embedded in and come with the use of the concepts and the associated ideologies—are interrogated that a transformation of the relations between the mother and the school and other societal institutions can be transformed. That is, when we do not interrogate the history of the concepts we use, we may contribute to the reproduction of the very ruling relations that need to be transformed to improve our life conditions. The problem with the pre-constructed classificatory notions such as «meaning» or «mental representation» is that STEM educators are attempting to understand their subject, learning, of which they themselves are a product; the use of such concepts makes us reproduce the very epistemology that we (some of us at least) want to overcome. The danger with using everyday concepts comes from their self-evident character, which "arises from the fit between objective structures and subjective structures which shields them from questioning" (Bourdieu 1992: 235). From this results something like a science that is only partially scholarly because, Bourdieu continues to argue, it "*borrows its problems, its concepts, and its instruments of knowledge from the social world.*" This science, in turn, "records as datum . . . facts, representations or institutions which are the *product of a prior stage of science*" (ibid: 236, original emphasis).

The upshot of a critical position therefore is to question the categories we use in our work as STEM researchers and teachers to think about and change what we do. There are serious consequences if we do not engage in such critical investiga-

tions. The most important consequence perhaps is that we cannot bring about lasting change in STEM education, because the very problem arises from, but is hidden behind, the ways in which we articulate issues. If this articulation occurs by means of categories that stand outside of the question, then we are unable to deal with the way in which these determine what we articulate and how we articulate it. Not knowing our categories, their origin, and their function leads to the noted fact that we do not really know what we are doing when we say we conduct research.

A scientific practice that fails to question itself . . .

> A scientific practice that fails to question itself does not, properly speaking, know what it does. Embedded in, or taken by, the object that it takes as its object, it reveals something of the object, but something which is not really objectivized since it consists of the very principles of apprehension of the object. (Bourdieu 1992: 236)

Science, technology, engineering, and mathematics education, as any other (social) science, requires categories and concepts to establish the theories for their phenomena of interest. However, fairly little if any work appears to be done in our field concerning the fundamental categories and concepts that are in current use. In our field—as in psychology, philosophy, or sociology—researchers by and large operate with commonsense concepts that have been elevated to philosophical and scientific concepts through some refinement and operational definition. This take up of commonsense concepts leads to the fact that *"the preconstructed is everywhere*" (Bourdieu 1992: 235, original emphasis) not only in the everyday world but also in the (social) sciences. Yet to practice a truly scientific endeavor, STEM education researchers, in the same way sociologists and their relatively older science, have to guard against the reification of common sense. This is why STEM educators and researchers, just as other social scientists, have to develop their *own* language: here, "the terminological problem, which requires a complex analysis, takes the lion's share of a science" (Vygotsky 1927/1997: 289). This should be one of the grand challenges of STEM education, especially in a globalized world where the validity of terms, theories, concepts, and metaphors across languages becomes an issue. Therefore, the

> construction of a scientific object requires first and foremost a break with common sense, that is, with the representations shared by all, whether they be the mere common places of ordinary existence or official representations, often inscribed in institutions and thus present both in the objectivity of social organizations and in the minds of their participants. (Bourdieu 1992: 235)

The problem is to know, without assumed presuppositions and prejudices, the object of research of which researchers are the product. If STEM education as a practice does not interrogate and bracket its categories and concepts one by one, that is, if it fails to question itself, it literally does not know what it is doing, as Bourdieu suggests in the introductory quotation to this section. This means that we really ought to bracket even our most cherished concepts and categories.

Bracketing here does not mean that the concepts and categories are denied or made to disappear: their existence is acknowledged without giving these any place in explaining phenomena. In psychology, there are a few attempts to reconstruct the human psyche bottom up based on functional historical analysis of the psyche generally and of motivation more specifically while avoiding the preconstructions common in our culture. More recently, a step toward such an approach to the teaching of science exists in Germany, where researchers have developed the "model of didactic reconstruction," whereby the development of curriculum is made a function of learning research rather than based on the basis of disciplinary considerations. But that approach still falls short of the present proposal to engage in a *categorical* reconstruction of the basic concepts. In this book, I use triangular brackets (chevrons) "« . . . »" around a concept word (i.e., «meaning») to emphasize (a) the provisional character of the terms to be reconstructed in this manner and (b) the need, consistent with the argument for a pragmatic approach to language, to look at the work that is being done by and with the deployment of this term. (I place terms in quotation marks when these refer to the use in the texts analyzed.)

One of the core notions of STEM education constitutes «meaning», which, as shown in the next paragraph, appears with high frequency in the science and mathematics education literature. Students, teachers, and researchers are said "to construct/make 'meaning'" without a clarification of the work that the term «meaning» does or lends itself to do—as I show, it tends to reinforce a mentalist approach to STEM learning. Yet, even more so than with the concept of "scientific literacy," which seemingly resists definition or is subject to continuous redefinition, there exists a conceptual mayhem when it comes to the notion of «meaning». But unlike in the case of scientific literacy, STEM educators do not work on a categorical construction of such notions as «meaning», «conception», and «mental representation». Without some categorical reconstruction in the context of empirical studies, we may be/remain a "half-scholarly science [that] *borrows its problems, its concepts, and its instruments of knowledge from the social world"* (Bourdieu 1992: 236, original emphasis). Being a product of this world, STEM scientists use, as Bourdieu says, "facts, representations or institutions which are the *product of a prior stage of [their] science*."

Despite the exhortations of specialists in semiotics and language concerning the problems with the theoretical notion of «meaning», the term and its variations as verb, adjective, adverb, and gerund may be among the most-used in the STEM education literature. For example, a count of the occurrences in the 49 articles from the 2011 volume of the *Journal of Research in Science Teaching*—which I subject to an extended analysis in chapter 2—reveals 281 uses of the noun *meaning* or its plural form, 104 uses of the adjective meaningful and the associated adverb and 4 uses of its negation meaningless, and 241 appearances of the verb "to mean" (mean, means, meant). The term "meaning" and its plural version also figures prevalently in mathematics education, for example, 111 times in *Mathematics Education and Subjectivity* (Brown 2011), a book from which I take many quotations in chapter 4 as examples of the current STEM ideology concerning «meaning» and the «subject». An alien ethnographer trying to understand the discourse element «meaning» and its variations (verb, adjective, present participle, gerund,

adverb) would find a bewildering array of uses, functions, and modifications. The ethnographer may even use the term "conceptual mayhem" to describe the observations related to the practical uses of the term and its grammatical variations. Not surprisingly, perhaps, Wittgenstein drops the term, as much as that of *understanding*, from his considerations of language and knowledge (see first quotation in the *Preface*).

To deal with the intrusion of the commonsense world into the science(s) of STEM education, it has therefore been recommended to *bracket* common sense and the concepts of existing scientific research simultaneously, whether the research concerns consciousness or the order social actors produce and encounter in the social world. Bracketing denotes the action of putting out of functioning of the very concepts that we have the habit of using in a particular context. That is, we are asked to exercise radical doubt with respect to the very discourses and concepts that have become common place. In his own field, sociology, Bourdieu suggests that research "bypasses the radical questioning of its own operations and of its own instruments of thinking" (Bourdieu 1992: 236). In fact, he suggests that in that field many members would consider radical doubt—i.e., the work of engaging in a *reflexive intention*—"the relic of a philosophic mentality, and thus a survival from a prescientific age." But in the course of doing so, the field of sociology avoids getting to know the instruments of its constructions, and, therefore, he suggests, it "is thoroughly suffused with the object it claims to know, and which it cannot really know, because it does not know itself." In and with this book, I intend to contribute to a similar endeavor in the science(s) concerned with STEM education by critically interrogating the concepts of «meaning» and «mental representation».

Toward a pragmatic theory

The construction of theoretical categories is necessary to understand the theoretical implications and entailments that these bring with them. Thus, for example, once we draw on «meaning» in the ways STEM researchers commonly do, we also require "shared «meanings»" and "shared «understandings»" to understand language use, as evident in the following excerpts from the 2011 volume of the *Journal of Research in Science Teaching* (JRST).[1]

> This framework may again appear at first glance to contradict our earlier stated position that there is no single version of the science student role and that each individual may have a personal understanding of the role that exists within a culture of *shared meanings and symbols*. (JRST: 386, emphasis added)
>
> [P]ractice is constituted by a patterned set of actions, typically performed by members of a group based on common purposes and expectations, with *shared cultural values, tools, and meanings.* (JRST: 463, emphasis added)
>
> Based on *shared understanding*, members use joint intellectual efforts and resources to investigate and resolve issues, problems, or questions and to actu-

[1] Because I am concerned with *discourse*, inherently a social phenomenon characterizing a community of practice, I refer to the journal page. In this way, the use of the discourse as a whole and of a particular phrase is indexed to the readers and author/s rather than to the latter alone.

> alize their understanding and meanings. (JRST: 684, emphasis added)

In the first quotation, the individual and the culture constitute opposite poles, whose "personal understanding" is opposed to the "shared meanings and symbols." Such a description is inconsistent with Vygotsky's notion of words, language, and consciousness as impossibility for the individual but always already implying the multiplicity of society and its culture. In the second quotation, the term "meaning" is modified by the adjective "shared," which implies that there are other forms of «meaning», for example, «personal meaning». Returning to Vygotsky, consciousness is impossible for one individual—already the etymology of the word, from Lat. *co[m]n–*, together, with + *sciēre*, to know, suggests that consciousness *always* is being conscious and *knowing together* (Vygotskij 2005). The third quotation again uses the adjective "shared" to modify "understanding," thereby denoting that there are forms of understanding that are not shared. This flies in the face of the very definition of language as something that we use to modify the behavior of others and ourselves.

In a pragmatic approach, however, we do not need shared «understandings» and «meanings» that are somehow behind the language people actually use in interview or classroom talk. Language use is irreducibly tied to and meshed with situations; and these situations are managed locally ("endogenously"). The initial analysis of the uses of «meaning» presented above shows that it is consistent with, and contributes to producing, a metaphysical theory of knowing and learning. The theory is metaphysical in nature because whatever the term «meaning» denotes is not directly accessible: the words-in-use only point to «meaning», which itself continuously escapes. The very use of the term thereby precludes other ways of researching and theorizing what happens in classrooms, such as when researchers do not seek recourse to anything other than what members to a setting make available to each other. Analyzing and using in explanations only what people *accountably* make available to each other—i.e., we can all point to what they are saying and doing, which is not the case when we *attribute* «intentions» or «meanings»—is a fundamentally pragmatic approach to knowing generally. In this section, I explicate a pragmatic alternative that arises when we conduct the analysis as proposed in the preceding section: we stick to language as it is used and to the social order attended to and made available for everyone else participating in a situation. It is an approach to human life forms that does not require recourse to «meanings», «(taken-as-) *shared* understandings», and «negotiations». I begin by articulating philosophical considerations, move on to situate the theoretical aspects in a concrete example, and then sketch how the research policies of ethnomethodology fully realize the pragmatic approach to practical action.

Language philosophical considerations

> Any higher psychological function was external; this means that it was social; before becoming a function, it was the social relation between two people. (Vygotskij 2005: 1021)

Pragmatist philosophers of language agree that to understand social situations we do not need to seek recourse to some mental stuff—e.g., meaning, ideas, or concepts—and conceptual frameworks behind words. Wittgenstein is quite explicit about dropping meaning, as understanding, from his considerations of language, its use, and its functioning in social transaction: "Understanding, meaning, drops from our considerations" (Wittgenstein 2000: 1).[2] Even cultural-historical psychologists do not need to seek recourse to mental stuff that is behind the words we use, for, as Vygotsky states in the introductory quotation to this section, any higher psychological function is (at some time) external, is a social relation between two people. Moreover, for any child learning something new, these are the social relations of its first experiences *in the present*. That is, these social relations that are subsequently ascribed to higher psychological functions always already are co-present with the latter. Actual, concrete, physical relations in society are the very stuff that subsequently is ascribed to individuals and their higher functions. That is, the dichotomy opposing the inner and the outer is an artificial dichotomy: "There is nothing *other* for us from the outset that would not be our *own*" (Mikhailov 1991: 20). Anything like mind is the result of "a single process" of the mutual generation of what is self and what is other (social).

Pragmatist philosophers of language take issue with the traditional conception of language, which seeks recourse in «meaning» to explain its use: "In the old mode of expression we can say: the essential of a word is its meaning" (Wittgenstein 2000: 8). The traditional conception of language is the core issue deconstructed in *Philosophical Investigations* (Wittgenstein 1953/1997). In the opening paragraphs of the book, the author presents a quotation from St. Augustine's *Confessions*, and then suggests that the text provides us with a particular way of understanding human language. Augustine says this about the way in which language is learned:

> I was no longer a speechless infant, but a speaking boy. This I remember; and have since observed how I learned to speak. It was not that my elders taught me words (as, soon after, other learning) in any set method; but I, longing by cries and broken accents and various motions of my limbs to express my thoughts, that so I might have my will, and yet unable to express all I willed, or to whom I willed, did myself, by the understanding which Thou, my God, gavest me, practise the sounds in my memory. When they named anything, and as they spoke turned towards it, I saw and remembered that they called what they would point out, by the name they uttered. And that they meant this thing and no other, was plain from the motion of their body, the natural language, as it were, of all nations, expressed by the countenance, glances of the eye, gestures of the limbs, and tones of the voice, indicating the affections of the mind, as it pursues, possesses, rejects, or shuns. And thus by constantly hearing words, as they occurred in various sentences, I collected gradually for what they stood; and having broken in my mouth to these signs, I thereby gave utterance to my will. (Augustine 1860: 11–12 [§8.13])

[2] I elaborate on the difference between *inter*action and *trans*action in chapter 5 (p. 111). In interaction, independently existing "elements" come to relate as part of a whole (e.g., molecule); in transaction, the parts become parts only in their relation to the whole. What a part is can be specified only as a function of the whole, not independently of it (see Dewey and Bentley 1999).

Here, Augustine articulates a theory where a word stands for something else: something that the elders meant (to say) without actually saying so. Augustine also points out that what is meant but is not directly available is expressed in other ways, "from the motion of their body," which he calls the natural language shared across "all nations." He lists a variety of body movements that even today many academics and non-academics alike list among features of "body language," even though, because of the lack of a clear semantics and syntax, the word "language" in "body language" is actually a misnomer. Augustine also describes how he "collected" what the words that occur in various sentences stood for. That is, he describes a process that others, such as B. Russell, have theorized as inference through abstraction.

> There are two ways of getting to know what a word means: one is by a definition in terms of other words, which is called verbal definition, the other is by frequently hearing the word when the object which it denotes is present, which is called *ostensive* definition. It is obvious that ostensive definition is alone possible in the beginning, since verbal definition presupposes a knowledge of the words used in the definitions. You can learn by a verbal definition that a pentagon is a plane figure with five sides, but a child does not learn in this way the meaning of everyday words such as "rain," "sun," "dinner," or "bed." These are taught by using the appropriate word emphatically while the child is noticing the object concerned. Consequently the meaning that the child comes *to attach to the word* is a product of his personal experience, and varies according to his circumstances and his sensorium. A child who frequently experiences a mild drizzle will attach a different idea to the word "rain" from that formed by a child who has only experienced tropical torrents. (Russell 1948/2009: 10, emphasis added)

As Augustine, Russell here articulates a way of learning "the meaning of everyday words." «Meaning», in this approach, is referential: A word «means» what it can be identified as denoting, that is, when the child consistently hears the sound /reɪn/[3] while there is "stuff" coming from the sky. Because this stuff or the way it arrives is never the same, the child, so Russell, abstracts from all of these experiences the «meaning» of the sound /reɪn/, which we transcribe as the word "rain." Russell also discusses where the different «meanings» that different individuals "attach" to words have their origin: in the differences of the circumstances and sensorium of the *individual*. Thus, a child who only experiences drizzle—typical for London or the Canadian Northwest coast—will "attach" or associate very different «meaning» to the sound /reɪn/ than the child growing up in Darwin (Australia) or Singapore, who experiences tropical downpours. The philosopher writes of words being "infected with subjectivity" (Russell 1948/2009: 22). In Russell's definition of language learning, we also note that «meaning» is something that

[3] This is a representation of the sound that we tend to hear as "rain" as per the conventions of the International Phonetics Association. These conventions allow speakers of all languages to know and produce the sound independently of the particular sounding rules that other, language-specific transcription rules specify. Thus, Webster's II New Riverside University Dictionary transcribes a particular sound as /rān/, where the "ā" is to be sounded as the "ay" in p**ay**, which we thereby hear as the word "rain."

comes to be "attached" to words. These words constitute material bodies, signs as it were, to which something ephemeral is attached or attaches itself. That is, there is something else that comes into play when human beings use language; and this something else is attached to but not visible or directly denoted. As a result, "the common world in which we believe ourselves to live is a construction, partly scientific, partly pre-scientific" (ibid: 12). The whole course of individual development, therefore, constitutes a journey that has "one constant purpose: to eliminate the subjectivity of sensation, and substitute a kind of knowledge which can be the same for all percipients" (ibid: 12). In all of this, the one big mistake Russell makes lies in the opposition he draws "between individual and societal consciousness" (Mikhailov 1976: 131).

Augustine, as Russell, presents the essence of language in this way: "Every word has a meaning. This meaning is correlated with the word. It is the word for which the object stands" (Wittgenstein 1953/1997: 2]). From a pragmatic and post-constructivist perspective, this way of considering language requires deconstruction and revision, for the associated "philosophical concept of meaning has its place in a primitive idea of the way language functions" (ibid: 3). The philosopher continues to say that such an idea is that of a language more primitive of the one that he denotes as "ours." Wittgenstein extends this argument to the word understanding: "The word 'understanding,' the expression 'to understand a sentence,' also is not meta-logical, but an expression as *any* other of language. One could say: Why bother with understanding? We have to understand the sentence, that it is for us a sentence" (ibid: 1). From a cultural-historical, dialectical materialist perspective, there is an additional problem with this traditional way of approaching language: it forces a wedge, and creates an unbridgeable gulf, between the world of culture, external to the individual, and the individual. This creates the problem already recognized in the constructivist literature: words, «meanings», «conceptions», or «mental representations» are not shared but can only be taken-as-shared. The very use of these theoretical categories—and Kant's analysis thereof—leads us into the discourse that is centered on the individual, caught up within its ruminations. But no individual could have an inner dialogue, thought, or consciousness if it were not for language, which is the result of living in a collectivity. Any inner monologue or dialogue is the result and reflection of the outer dialogues that a child has participated in (Vološinov 1930; Vygotskij 2005). The very notion of language implies the societal nature of thought and consciousness, as Vygotsky points out in many of his texts, and, therefore, the impossibility of individuals who create worlds from within themselves and for themselves. Already K. Marx points out that such a way of thinking about thinking and consciousness constitutes a Robinsonade: an impossibility. Cultural-historical scholars reject the idea that the human "individual contains the cause of self-development within himself. This Robinsonade . . . will not be considered further" (Zuckerman 2007: 47–48).[4] Thus, such issues are due to constructivist epistemology rather than problems of epistemology more broadly. There are ways to language that do not presuppose the split between the individual and societal consciousness, of which language (word) is concrete embodiment, but where each instance of language

[4] The Robinson Crusoe of the literature is already a cultural-historical product.

(word) use is a document of culture as a whole. Each individual statement, therefore, can be understood as a concrete instance of the (generally) possible and, therefore, there is unity in the specific and general, concrete and abstract, individual and collective (societal).

As soon as we deepen the analysis of «meaning», we rapidly realize that it leads us to a circularity from which there is no escape: "The meaning of a word is what the explanation of meaning explains" (Wittgenstein 2000: 34). Elsewhere this statement is explicated by saying that if "we want to understand the use of the word 'meaning,'" we have to look up what is called "'explain the meaning'" (Wittgenstein 1953/1997: 149). Thus, the mobilization of «meaning» already requires an understanding of «meaning», or, in constructivist terms, it requires the construction of «the meaning of «meaning»». But to know that we have constructed the «meaning» of ««meaning»», we already need to know the «meaning» of «meaning», for otherwise we cannot make a decision that my construction is actually that of ««meaning»» rather than of something else. This attempt to invoke something else that is attached to and belongs to a word, therefore, leads us to an infinite regress. Wittgenstein discusses this problematic in the context of asking for the "meaning of the word 'thinking'" (ibid: 104). If we watch ourselves during the process of thinking, "it would be as if without knowing how to play chess, I were trying to make out what the word 'mate' meant by means of keen observation of the last move in a game of chess" (ibid: 104).

We do not need to draw on «meaning» to explain the experience of thinking: "When I think in language, there are no 'meanings' that occur to me in addition to the verbal expression; rather, the language is itself the vehicle of thinking" (Wittgenstein 1953/1997: 107 [§329], my translation). This situation is an analogue to other practices, such as walking: We do not have or require «meanings» in our head when we walk: we simply walk. When we greet our neighbor on a sunny Saturday morning in front of our homes saying "Nice day today, a bit chilly though," there are no «meanings» floating in our minds or between the neighbor and us in addition to the language that somehow are constructed and accompany. Moreover, the neighbor does not have to engage in an interpretation to construct «meaning» in his/her head or construct what «[personal] meaning» might be in my head when I say "Nice day today, a bit chilly though."[5]

The problem of «meaning» is exacerbated in translations of scholarly works in the philosophy of language, which makes the construction of a theory valid across languages next to impossible. For example, the translator of Wittgenstein does not consistently translate the German *Bedeutung* into English, by and large rendering it as "meaning," but also translating it by the term "sense" (e.g., Wittgenstein 1953/1997: 48). But *Sinn* (sense) and *Bedeutung* (reference, signification) are

[5] This issue has been dealt with extensively in Zen Buddhism. For example, in one koan (riddle), where the decision about the abbot of a future monastery hinged upon the response to the question "This must not be called a pitcher. What do you call it?" while the questioner points to a water pitcher. One of the many reported replies of the head monk was "It cannot be called it a piece of wood." One of the cooks arrived at the scene and simply kicked the pitcher, spilling all the water. He was named the abbot of the new monastery. One lesson is that naming does not get at the essence of the pitcher. (A deeper, more advanced lesson for Zen practitioners is that even the cook was caught by a fallacy, as his kick has missed the essence—i.e., [negation of the] «meaning»—of the pitcher.)

radically different terms, for there are many sentences for which one can determine their sense but where the reference (signification) is doubtful or does not exist (Frege 1892).

In another situation, the translator uses "sense" to translate the German *Sinn*. The translators of *Being and Time* (Heidegger 1927/1977), whose position is often said to be equivalent to that of the later Wittgenstein, sometimes use "meaning" and sometimes "signification" to render the German *Bedeutung*. Thus, reading an English text on the philosophy of language, we would not know whether the German version used the radically different terms *Bedeutung* or *Sinn*, and, simultaneously, we would not know whether a translator would choose "meaning" or "sense" when the German features the word *Bedeutung*." These variations in the translations are ascribed to the different «meanings» of *Bedeutung*, so that we end up in the situation of pure circularity described above.[6] The problems become even greater when the uptake of theoretical work in another language is translated back into the source language. Thus, Bakhtin and Vološinov read and actively reacted to the work of the Franco-Swiss linguist F. de Saussure (1916/1995), who uses the French terms *sens* (sense) and *signification* (signification), clearly distinguishing the two. Here, sense is to the word what signified is to the signifier; signification is the *relation* between the two terms of each pair. In their critique of this work, Bakhtin and Vološinov used the Russian "смысл [smysl]" and "значение [značenie]" as equivalents for the terms de Saussure uses (Vološinov 1930). The French translation of their book (Bakhtine [Volochinov] 1977) returns the terms de Saussure used, whereas the English version (Vološinov 1973) vacillates between "sense," "meaning," and "signification." That is, the very distinction de Saussure established has disappeared in the English version of Vološinov. Relative to our STEM community of practice, we might ask how native French-, German-, or Russian-speaking science educators might write in English what they have thought in terms of their native tongues?

Pragmatic approach to data analysis

Consistent with Bakhtin and Vološinov, there is a difference for Wittgenstein between different uses of an expression such as "he comes." For Bakhtin and Vološinov, the different uses are associated, for example, with different forms of intonations and different forms of social evaluation. Thus, some of the different forms of use are associated with writing the expression alternatively as "He comes." "He comes?" "He comes!" "*He* comes." "*He* comes?" "*He* comes!" "He *comes*." "He *comes*?" or "He *comes!*" Although the two words of the nine phrases are identical, the implications for producing these words with the associated intonations and emphases are different. For example, we might observe the following sequences of turns at talk involving two speakers A and B.

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[6] The very problem is highlighted in the translation of the original title of G. Frege's essay, where *Bedeutung* is rendered in the English translation that appeared 50 years later as "reference." If *Bedeutung* is sometimes translated as "signification," sometimes as "sense," sometimes as "meaning," and sometimes as "reference" by appealing that we know what the German author «meant» to say we are already caught up in an infinite regress.

Fragment 1	**Fragment 2**	**Fragment 3**
A: He *comes*?	A: *He* comes?	A: He comes.
B: He *goes*!	B: *He* comes.	B: He *comes*?
		A: He *comes*.

In the analysis of such sequences—which may be observed frequently in science classrooms where students are involved in small-group tasks such as concept mapping or in the one described in the analyses featured in chapters 2–4, and even between teachers and students (e.g., Roth 2009b)—we do not have to worry about any «meaning» as operating somehow behind the words but just focus on what is happening as an irreducible social phenomenon. Thus, in Fragment 1, we have a question|reply turn pair, where the reply part emphatically offers a contrasting verb for describing what the talk is about.[7] In that situation, the issue was a question as to the nature of the word. We might gloss what happened in this way: A asks something like "Is the verb 'comes' the correct one to use?" and B replies by saying something like "No, you need to use 'goes'." We observe such a pattern in situations between teachers and students, when the latter offer some response that they are uncertain about, and the teacher, rather than saying "No," provides the correct term. In Fragment 2, there is also a question|reply sequence; but the issue does not concern the verbs coming or going but the nature of the person in the subject position of the locution "He comes." The reply part asserts that at issue is the particular person currently being the subject of the statement. It could be another person who is coming, or a question whether this person (e.g., a world renowned expert) is coming to some place. In the third case, there are two full turn pairs. The first pair constitutes an assertion|questioning, where the stress is on the coming; the second turn pair is question|assertive reply turn, whereby the process of coming is at issue and comes to be questioned and asserted as being appropriate. To understand how the conversation unfolds, we need to understand its *inner forces*. To understand the inner forces, we have to look at the interdependence of terms that make turn sequences. Thus, who the "he" is and what "coming" and "going" do *in this situation of interest* can be found out only by looking at language *from within* the particular context. Finally, the three fragments are not just about content, about some person coming or going; the very same language actually produces and maintains the relation between the speakers. It is a soci(et)al relation that subsequently comes to be attributed to the individuals as the higher psychological functions of which Vygotsky speaks in the introductory quotation of this section. Without this relation, there would be no exchange. Relation and verbal exchange presuppose each other.

[7] I use the Sheffer stroke "|" to construct dialectical notions. The words on the two sides are ways in which the phenomenon denoted by a notion comes to manifest itself. But the phenomenon is not the addition, interaction, or synthesis of the two manifestations. There are two consequences to this. First, the expression encompasses an inner contradiction, because it asserts both mutually exclusive manifestations simultaneously. Second, the expression as a whole is true if and only if at least one of the manifestations is false. Thus, an utterance is not inherently a question. It is a question only when there is a corresponding reply. That is, the question presupposes and is conditioned by what it is not. The expression question|reply makes salient the mutual dependence of question and reply.

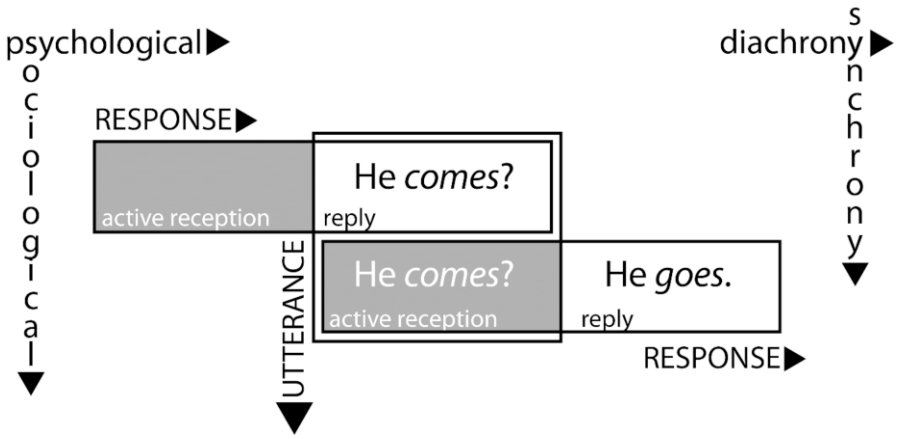

Figure 1.1 This model of *con*versation has psychological and sociological, diachronic and synchronic dimensions. A phrase is said and heard so that any utterance, such as "He *comes*?," belongs to speaker (black) and listener (white); this involves the sociological and synchronic dimensions of talk. The *response* on the part of the listener includes (is spread over) active reception and reply, and thereby covers psychological and diachronic dimensions.

When we look up in the dictionary, the same dictionary senses will be listed if we enter "he" today or tomorrow; and these dictionary senses will change only slowly over time. (See, for example, the use of etymology and the changes words undergo in their use.) Similarly, the dictionary senses of "to come" are relatively stable. But dictionary sense is actually not at issue, for it is only the material with which the transaction in each of the three fragments is done.[8] For example, in one instance this might be a conversation about a situation where it is unclear whether a person is coming or going, or where it is unclear who of two persons under consideration is coming. But we hear the conversation very differently when we know it to be between two teenagers talking about a sexually explicit movie they are just watching. When both of these senses are known to exist simultaneously while only one of this is the sanctioned, then we have connotation (e.g., an "in-joke"). Thus, recognizing *what* a person says is equivalent to recognizing *how* a person is speaking, for example, in saying "He comes": literally, metaphorically, emphatically, jokingly, connotatively, and so on. The *how* of the speaking may be available from other, often very different aspects of a person's voice or behavior—e.g., a grin, an air quote, a hand gesture, or a body movement. The different dimensions of talk can be understood in terms of the model presented in Figure 1.1.

[8] The term *transaction* here denotes the fact that in the category question|reply the two manifestations, question and reply, are interdependent. The question is a question only because there is a reply, and the reply is a reply only because there is a question. The nature of a locution cannot be derived from itself but requires the nature of another locution.

In this model, speaker A says "He *comes*?" with a prosodically achieved emphasis on the verb "comes." But this statement does not belong to A, for B, to be able to reply, has to actively listen to the words. That is, the phrase belongs both to A (who speaks) and B (who listens). When Vološinov or Bakhtin use what has been translated as "utterance," they name this double belonging of a phrase to speaker and listener. The utterance *simultaneously* belongs to all participants; this is the sociological dimension of conversational talk. Figure 1.1 also shows that the *response* has to moments: active listening and reply (what B actually says). These two moments cannot be understood independent of each other. The response therefore includes parts of B and A, to whom the reply is oriented in turn; it also is spread out in time not only because the words in each part unfold in time but also because active listening and reply occur at different times. The response is diastatic, that is, shifted with respect to itself: it is non-self-identical, being spread out in time and space ([speaker] positions). The figure as a whole represents our unit of analysis, which therefore includes sociological and psychological as well as synchronic and diachronic dimensions. But none of these dimensions can be considered on its own because each implicates all the other.

Up to this point, we do not know what work the statements actually do. From the pragmatic perspective, this requires the context, which determines the "theme" [*tema*] of a statement (Vološinov 1930). The theme would be different for each of the three fragments even if these were to be repeated in identical ways. This is so because, at a minimum, the repetition occurs against a background that no contains the first appearance. The fragments would no longer be the same because they can be recognized as repetitions and therefore raise new questions—e.g., why speakers repeated what they had said. The theme is the relation between the statement (word, phrase) and the historical situation, which, because it is never repeatable and "once-occurrent," leads to the fact that the theme associated with, or function of, each statement of "he comes" changes. This change is both local, here *within* each fragment, and global, the recurrence of the same fragment in historical time. Thus, even if the same two people were to have the same exchange at another point in time, the theme would be different. This is the case although the dictionary senses of the words "he" and "comes" will not have changed—unless the distance in historical time becomes very large. The theme, therefore, is the continually changing function of expressions always tied to the immediate contexts of word use. This context *never* is the same, as every "event of Being" is only "once-occurrent" (Bakhtin 1993: 2).

Words are used to manage events (situations), which in turn assist in managing the use of words. And events are experienced in terms of a practical understanding of the (life-) world, which is given to us prior to any "conception"—an infant does not have to have any conception of crawling or pointing to crawl and point. Vološinov's formulation of the theme, therefore, returns us to the pragmatist position, which suggests that there is "no learnable common core of consistent behavior, no shared grammar or rules, no portable interpreting machine to grind out the meaning of an arbitrary utterance" (Davidson 1986: 445). Any boundary between knowing and language and knowing one's way around the world more generally is thereby erased. This is the very point that an analysis of the nature of commonsense understanding of the role of words therein has shown. Thus,

"word-things are not provided with significations/meanings" (Heidegger 1927/1977: 161); instead, "words accrue to significations/meanings" (ibid: 161). Thus, it is not merely the use rather than some «meaning» that exhibits the nature of language, but linguistics expressions "must mesh with *my own* life" (Wittgenstein 1977: 66). As a consequence, there is "no such thing as a language, not if a language is anything like what many philosophers and linguists have supposed" (Davidson 1986: 446). The philosopher continues to say that we must give up the idea of a clearly defined shared structure that language-users acquire and then apply to cases. Instead, anything that is done with language is a situated coping with the current conditions, continually adapted to the purposes and needs at hand.

From a psychological perspective, we understand others based on the presupposition that what they say is rational, purposeful, planned, and coherent. In and with their saying, they provide the resources for understanding a locution literally, metaphorically, emphatically, jokingly, connotatively, and so on. That is, the rule for understanding unfolding talk is provided in the manner of talking itself: the rule does not exist behind, underneath, or in some other place. Thus, for a recipient to hear a statement as a double entendre, the resources for such hearing have to be available in the here and now of the situation. "*'Shared agreement'* [then] *refers to various social methods for accomplishing the member's recognition that something was said-according-to-a-rule and not the demonstrable matching of substantive matters*" (Garfinkel 1967: 30, original emphasis). As a result, "*the appropriate image of a common understanding*" no longer is that of "*a common intersection of overlapping sets*" (ibid: 30). A better image is that of an operation, where there is no longer a distinction between the word and its meaning. The locution itself provides us with the rule for how to hear it. Thus, in Fragment 2, for example, the exchange "*He* comes?" "*He* comes." shows that the first locution can be heard (a) as *a question* and (b) as a question about the nature of the person: it is *he* rather than someone else. A more definite hearing may depend on the next turn not reproduced here, for the second turn itself is a first turn in a turn pair. That is, whereas the statement "*He* comes." completes a turn pair, thereby contributing to the closure of its nature (e.g., as a question|reply pair), its own nature depends on the turn that follows. Therefore, saying here that it is a "reply" actually presupposes our hearing of the turn that follows but is not reproduced here.

Readers may ask, "How can people communicate without a 'shared understanding'?" From the pragmatic perspective, real-time interlocutors and authors/readers in everyday exchanges pragmatically resolve issues pertaining to the words and other expressive signs they use. After discussing the example of someone being sent to buy "five red apples," Wittgenstein elaborates on the question of the meaning of the word "five": "What is the meaning of the word 'five'? No such thing was in question here, only how the word five was used" (Wittgenstein 1953/1997: 3). We know this to be the case, for nobody in North America will have trouble appropriately reading a roadside sign "firewood 4 sale." No resident in the community will wonder about "the meaning of '4'." Nor would they have to wonder about the «meaning» of "Xmas" (as in "Xmas sale"), "Xing" (at a pedestrian crossing), and "X-ing" (as in "X-ing" a day in the calendar) and give the difference between the Xs that appear in each of these three contexts. Ethnomethodology

generally and conversation analysis specifically specialize in describing and explicating the work of *how* people communicate and get things done without seeking recourse to «meanings», «(taken-as-) shared understandings», or «negotiations». The "theme," too, though making use of the stable feature of word-sense, precisely because it is ever changing, is subject to the local, indexical, and endogenous practices that produce the orderliness of soci(et)al events. Precisely because it is ever changing, there cannot be general rules for deriving local use of specific words and language. This is so especially because new communicative forms may spontaneously emerge that have no prior history of being «constructed» or «negotiated» and «having been agreed upon». Even though new words spring up suddenly, they may be, and usually are, immediately understood.[9] As the example of "He comes" shows, what is being done across situations using the same words will differ; and the *how* of the doing is managed in ways appropriate to and taking into account all local contingencies. In fact, the particular approach to the analysis employed in the example of the different versions of "He comes" and the featured excerpt—i.e., a version of conversation analysis—is included and integral part of ethnomethodology (Garfinkel 1988). The collective conversational management practices cannot be reduced to the individuals but always already are something that constitutes a *joint* accomplishment, which, inherently, cannot be reduced to any one of the individuals present. This *joint* accomplishment is *inherently* social and cannot be reduced to individual accomplishments.

There is one field where the pragmatic approach is implemented in a radical way: ethnomethodology. In this approach, which concerns the way in which members to a setting produce and exhibit for one another accountable social structure, three main assumptions made leading to the dropping of metaphysical positions: (a) "that . . . we must at the outset know what the substantive common understandings consist of" (Garfinkel 1967: 28); (b) the "accompanying theory of signs, according to which a 'sign' and 'referent' are respectively properties of something said and something talked about" (ibid: 28); and (c) "the possibility that an invoked shared agreement on substantive matters explains usage" (ibid: 28). Thus, a point also made by Davidson and Rorty, shared meanings in the psychological (constructivist) sense are not required for people to engage in *sympractical*[10] activities and to collaborate. If the notions «shared understanding» and «shared meaning» are dropped then *what* the parties to a conversation talk about cannot be distinguished from *how* the parties are speaking. An explanation of

[9] I know this to be the case, because my wife Sylvie and I often make up new words and yet immediately understand them. Thus, shortly after the beta version of Google had become available, I used the verb "to google" prior to ever having heard it. Sylvie immediately knew—without having to "interpret" my words or "constructing meaning" thereof—that I suggested looking up something on the Internet using the Google browser.

[10] The adjective *sympractical* refers to the fact that activities require *joint* action. However, joint action here is understood from a *sociological* perspective that does not reduce *social* phenomena to the individuals involved. Thus, although A and B participate in the three fragments analyzed above, the unit of a turn pair such as question|reply cannot be reduced to one or the other person. There is not just an interaction between two independent utterances that A and B produce. Rather, there is a *trans*action where the *whole* determines the nature of each part; and this whole is a collective consisting of A and B. Thus, each part, question or reply, is a function of *A and B* simultaneously. The part cannot be reduced to A *or* B. (See also Figure 1.1.)

what the parties are talking about then consists entirely of describing *how* the parties have been speaking. This, therefore, says the same about talk that Wittgenstein says about thought in terms of verbal thinking. What we think can be described entirely in terms of the words used; it is unnecessary and deceiving to invoke «meanings» that somehow are behind or underneath the speaking and thinking at issue. We therefore abandon the distinction between words and «meaning», that is, we abandon distinguishing "*what* was said and *what* was talked about" (ibid: 29). Instead, we make another, more appropriate distinction "between a language-community member's recognition that a person is saying something, i.e., that he was *speaking*, on the one hand, and *how* he was speaking on the other" (ibid: 29).

For a re/construction of «meaning» and «mental representation»

In the STEM research literature we frequently find encouragements for students to "refine their meanings" so that these better correspond to the "standard meanings" of science. In this book, I suggest that such recommendations should apply to the work of STEM educators as well. If we do not re/construct our fundamental concept and category words after bracketing their everyday use but use them in the differing, even antithetical ways that have historically emerged, we end up with a discourse that is only half scientific (Bourdieu 1992). The purpose of this book is to make a case for the need to bracket the fundamental concepts and categories that we use in the STEM literature and to reconstruct these in a truly scientific approach. The case is argued by means of an analysis of the uses of «meaning» and «mental representation» and by an articulation of a pragmatic approach that makes the problematic concept unnecessary. Because each "word, like the sun in a drop of water, *fully* reflects the processes and tendencies in the development of a science" (Vygotsky 1927/1997: 288), the categorical re/construction of «meaning» and «mental representation» likely will affect STEM education as a whole. Moreover, because the pragmatic approach does not require the postulation of a metaphysical domain in which «meaning» exists but solely focuses on how participants use language and other sign forms to produce order and orderly conduct, many of the traditional dichotomies fall to the wayside. These include the dichotomous splits between body and mind, personal and shared knowledge and application, knowing-that and knowing-how, and knowing a language and knowing one's way around the world.

The intent here is not to critique the uses of «meaning», «mental representation», «mis/conception» and the likes, especially when these uses appear to be contradictory within the same text. Throughout this book I present analyses that show that the way in which «meaning» and associated terms tend to be used presupposes a particular epistemology; also throughout this book I present alternative analyses of transcripts that sketch an approach where the classical use of «meaning» is dropped from consideration. Instead, I propose a different use, where «meaning» and «mental representation» (or, rather, «social representation») are families of ways of speaking that can stand in for each other. Such an approach, as intimated, also is consistent with the cultural-historical approach, according to which any higher psychological function *is* a societal relation.

Categorical reconstructions—e.g., of «meaning»—will certainly require considerable individual (book-length) and collective efforts, where critique of particular uses may indeed have an important role. A considerable part of this interrogation consists in the archeology of the field and its discourse. This analysis has two tasks with respect to the fundamental epistemological figures (rational elements) that are used: "to determine the manner in which they are arranged in the *episteme* in which they have their roots; and to show, also, in what respect their configuration is radically different from that of the sciences in the strict sense" (Foucault 1966: 377). It is precisely in the negative that our theoretical "language emerges in all its nudity, yet at the same time eludes all signification as if it were a vast and empty despotic system" (ibid: 386). Thus, for example, when a text uses descriptions such as "meaningful use of technology as a research tool" or "meaningfully deploying the technology as a teaching and learning implement" (JRST 2011: 65), we might legitimately ask about the nature of the work done by the term «meaning». We do so by asking a question about the negative: What is a meaningless use of technology? Thus, we might ask the question in an analogical situation: "What is a «meaningful» 'use of a hammer'?" or "What is the «meaningless» 'use of a hammer?'"—if we are interested in an authentic situation where someone intends to drive a nail into a wall? What do we say and hear when using an expression such as "«meaningful» inclusion," and what might be a "«meaningless» inclusion" on the opposite end? If a "debate" is modified by the adjective «meaningful», we might legitimately seek clarification by looking for concrete cases in our databases where a debate is «meaningless», for whom, how participants make the problem available to each other as social order. It might turn out that the very fact that people debate an issue should be taken as the point of entry into the analysis, and those who participate in the debate would not do so if there were no pertinence to what they are doing. So what might be a real, concrete debate between people that is «meaningless»? It is through the madness of the negative that the tenuousness of concepts shines through the cracks of a system that wants to be infallible. If we do not engage in such work of constructing our categories by bracketing their common and scientific uses, then, as Bourdieu suggests, we literally do not know what we are doing. But we can do better than that—if we begin by bracketing and reconstructing the fundamental concepts and categories of our field. In the chapters that follow, I do precisely that. I bracket the use of «meaning» for the purpose of reconstructing how (and when) this term and all associated terms might suitably be used.

2 «Meaning» in science education

> The meaning of meaning is a semiotic labyrinth both on theoretical and on terminological grounds. . . . No fewer than twenty-three meanings of meaning were distinguished by Ogden & Richards. (Nöth 1990: 92)

The purpose of this chapter is to make a case for the need to spend more effort on the reconstruction of the main categories employed in the field of STEM education by taking a closer look at the concept of «meaning». The notion is problematic, for it—as the survey of its use in the 2011 volume of the *Journal of Research in Science Teaching* presented below shows—embodies a metaphysical position on knowing and learning in science. This position inherently separates and produces the splits between body and mind, individual and collective knowing, knowledge and application, knowing-that and knowing-how, and so on. In this chapter, I draw on the documentary method, whereby the individual case—here «meaning»—indexes the general; every individual case falling under the same general could be used to illustrate the general in and through its concrete articulation (Mannheim 1921–22/2004). It is precisely in this way that only one piece of one art form was needed—with two additional pieces for analogical purposes—to derive the psychology of art in general (Vygotsky 1922/1971). But rather than using a generic statement to present and represent the general need to reconstruct the fundamental categories and concepts of the field—which makes it difficult if not impossible to learn how a term is to be used and recognized—my suggestion is to think of «meaning» in terms of the concrete deployment of any actual case of the use of a word. That is, the «meaning» of a word is constituted by the ensemble of all concrete ways of using the word in different settings and contexts, and any individual use of the word is a manifestation of the whole. The «meaning» of a word then is as concrete and this-worldly as any single use of the word, which in fact stands for all the (contradictory) uses and non-uses of the word.

Use of "meaning" in science education research discourse

Reading a volume of the *Journal of Research in Science Teaching* might leave the unexpecting (Martian) ethnographer of the field with the impression of a bewildering array of uses. The review of the uses of «meaning» articulated below shows that there is not just one kind of «meaning» but there are in fact many kinds. Thus, "meaning" is modified by a wide variety of adjectives including "theoretical," "ra-

cial," "social," "static," "explicit," "implicit," "alternative," "context-dependent," "personal," "deep," "rich," "short-lived," "cultural," "significant," "possible," "narrower," "broader," "refined," "consistent," "scientific," "[historically] enduring," "historically constructed," "[differently] accessible," "culturally produced" "locally produced," "transnational," "overwhelming," "multiple," "particular," "shared," "exact," "tentative," "everyday," "conventional," "colloquial," "stipulative," "approximately the same," "intended," "basic," and "expressed." In addition, as shown below, there are very different ways in which «meaning» is used and, therefore, what it «means». This multiplication (proliferation) of the "«meaning» of «meaning»" is achieved by means of adjectival modifiers. It is in fact a way of establishing a category system typical of Western thought generally and Western science more specifically. Native peoples might have many words to make distinctions between different states of snow (Inuit, Saami) or reindeer (Saami)[1]; they tend to make classifications based on rule. Western classifications are of the adjectival type, which is based on similarity of members within a class: There is hard snow, soft snow, powder snow, and artificial snow. Thus, simply because there can be «exact meaning» and «tentative meaning», there is both similarity and difference expressed. The adjectivally modified «meanings» are concrete instantiations of the more inclusive and therefore higher-order category «meaning». However, as part of the program of a categorical reconstruction of «meaning» one needs to ask whether these members of the superordinate class «meaning» thereby produced are in fact based on similarity or whether some uses preclude the uses of others. If there were to be a «scientific meaning» associated with some word or concept, then every individual scientist would have to "have the same «meaning»," which may well be inconsistent with «meaning» as something «personal» and tied to the context. What is a «theoretical «meaning»» and how is it distinguished from other types of «meaning», for example, «non-theoretical «meaning»», «scientific «meaning»», «personal «meaning»», or simply «meaning» (i.e., when it is unmodified by an adjective)?

What may bewilder the ethnographer is the fact that «meaning» comes in so many guises and sometimes is used in quite unexpected ways such as when it is synonymous with «perspective»: "Argumentation can be defined in terms of both an individual or structural meaning as well as a social or dialogic meaning. . . . The dialogic or social perspective on argumentation focuses on," JRST: 795).[2] It is bewildering that «perspective» is the same as «meaning». What may be even more

[1] The Saami peoples of northern Norway, Sweden, and Finland have over 1,000 individual terms for reindeer that take into account differences in (a) sex and age, (b) body size, body shape, and condition, (c) color, (d) nature of the coat, (e) head characteristics, (f) antler characteristics, (g) feet, (h) personality, functionality, and habits, (i) circumstantial facts such as who trained the animal, and (j) ear marks (Magga 2006). The Saami also have 175–180 basic stems on snow and ice leading them to have something like 1,000 lexemes relating to snow, ice, and the associated processes of freezing and melting.

[2] In this chapter, I reference quotations not in terms of the authors who signed an article but by denoting the page number in the entire 2011 volume of *JRST*. I do so because I analyze *discourse*, which is never the discourse of an individual or group but, in addressing itself to and being produced for the benefit of an audience, constitutes a collective entity. That is, each quotation from *JRST* is an example of *JRST* discourse specifically and, to some extent, of science education discourse more generally.

bewildering than that is the proliferation of «meanings»: ''with any topic in science, students' understandings will change as they seek to clarify relationships between their intended meanings, key conceptual meanings within the subject matter, their referents to the world, and ways to express these meanings'' (JRST: 991). Yet this situation in science education may therefore reflect a more general indeterminacy with respect to the use of the term: the introductory quotation refers to C. K. Ogden and I. A. Richards, who noted such a bewildering array of the "meaning of 'meaning'" already in the early part of the 20th century. But when the term «meaning» is used in so many ways, the question is therefore what precisely are students making when they are said to "«make»/«construct» «meaning»"? In what does the «making» or «constructing» consist given that the verb "to make" refers to very different processes in the phrase "making bread" and "making pudding." Moreover, if «meaning» is used synonymously with intelligibility and the intelligibility is fixed by culture—as given in a dictionary—then the question becomes even more salient about the nature of the thing that students are «constructing».

In the following I sketch in broad outlines the ways in which the noun *meaning* and its cognate verb (*to mean, means, meant*), adjective (*meaningful, meaningless*), adverb (*meaningfully*), present participle (*meaning*), and gerund (*meaning*) are used in science education discourse. This review shows that the use tends to ground itself in a metaphysical epistemology, whereby the talk of research participants becomes an index (sign) of «meaning» that itself is not available in the talk. That is, whatever research participants say only indexes something but does not immediately render it for the hearing. In their publications, STEM researchers only gesture obliquely towards this «meaning» that exists in some other realm.

Establishment of corpus and categorization of instances

For the purpose of this demonstration, I selected the entire volume 48 (2011) of the *Journal of Research in Science Teaching* as the data corpus. Three major reasons underlay this choice: (a) it had the highest 2011 impact factor of all science education journals[3], which is indicative of the fact that the audience actually reads and peruses the articles; (b) it has a high number of annual submissions and a low acceptance rate, which is indicative of the "desirability" of publishing in the journal; and (c) it has a relatively high number of researchers with English as the native language. In the following analysis, the articles are taken as representative of a discourse. Thus, I do not analyze the use of "meaning" and its variations for particular author/s, but take the texts as concrete samples of a collective discourse, an ideology that—by means of language—is shared among authors and audience. Precisely because these articles are for the audience, returning the language—its genres, topics, ideas, and words—to the community from which it has been borrowed, the texts are representative of the community at large rather than of the

[3] The impact factor (IF) is an index of the number of times a particular journal has been cited. It is calculated in the following way.

$$IF_{\text{Year X+1}} = \frac{\text{Number of citations}_{\text{Year X}} \text{ to journal issues}_{\text{Year (X-1) and Year (X-2)}}}{\text{Number of articles}_{\text{Year (X-1) and Year (X-2)}}}.$$

individual author/s. The following tentative categorization of the use of the term "meaning" and the related verb, adjective, adverb, present participle, and gerund is grounded in the documentary method (Mannheim 1921–22/2004), where each case is taken as a concrete realization of the general usage. Similar uses were grouped in a first round of analysis. The results were compared with an existing classification of "meaning" (i.e., Nöth 1990), which led to the stratified grouping of the first-level results.

«Meaning» as sense

In the corpus (*JRST* 2011), the term "meaning" frequently is used to cover either or both "sense" and "reference." The sense of a word refers to the different ways that it can be used according to standard dictionaries. Reference is what a word refers us to. For example, a name refers to a specific person. If I were to say "Sylvie is coming today," my family, friends, and acquaintances know that my wife is arriving on whatever day I have uttered or written the sentence. The person in flesh and blood is the referent of the name Sylvie. Used in this way, «meaning» may be "an idea, a concept, an object, or a thing" (Nöth 1990: 93). The *sense* of "meaning" denotes the different uses of the word legitimized by standard dictionaries of a language—for example, such as the Merriam-Webster Collegiate Dictionary that the publication manual of the American Psychological Association endorses.[4] *Reference* covers those cases where a word is correlated with a thing, for example, by means of pointing—e.g., the speaker points to a tree and produces the sound /tri:/ (tree) and thereby makes the former the referent of the latter.

Semantic realism of sense

When "meaning" is used to denote some entity "behind" and separate from the (arbitrary) sign user, we observe a case of *semantic realism* typical of Platonism. This is the approach that Kant has elevated to its pinnacle in his constructivist theory of the mind. This theory has shaped not only the work of B. Russell discussed in chapter 1 but also (social, radical) constructivist and other current (individualistic) ideologies of knowing that use the verb "to construct" in their theoretical repertoire (whatever adjectives they use to characterize themselves: sociological, cultural, feminist, post-modern, post-structural, or socio-historical). The following two quotations employ "meaning" to refer to something that lies behind a scientific criterion and permutation of a dimension.

> Although the outcome of IT fluency in our study was also the development of scientific inquiry abilities, it is likely that more can be achieved if teachers intentionally help students become more cognizant of the meaning behind each scientific inquiry criterion. (JRST: 110, underline added)

[4] The Merriam Webster (2012) online dictionary lists the following senses of the term "meaning": 1a the thing one intends to convey especially by language PURPORT; 1b the thing that is conveyed especially by language: IMPORT; 2 something meant or intended AIM; 3: significant quality, implication of a hidden or special significance; 4a the logical connotation of a word or phrase; 4b the logical denotation or extension of a word or phrase.

> Intersectionality helps us understand: (1) all of the various dimensions related to structures of power, privilege, and oppression (for instance, race, class, gender, sexual orientation, gender expression), (2) the dynamic interplay between each of the dimensions, the meaning behind each permutation of these dimensions. (JRST: 343, underline added)

In this type of use, words denote ideas that are independent of our soul/minds (Lat. *anima*, Gr. *psykhe*). Ideas are metaphysical, members of a spiritual world independent of the concrete world of human experience. The ideas stand for things. These things are distinguished from sense. But both are correlates of the «meaning» of a word. We even find uses where "meaning" is said to be "attached" to a word or concept "[a]s if meaning were a hazy cloud accompanying the word and carries with it into every kind of use/application" (Wittgenstein 1953/1997: 48). This is quite apparent in the following quote.

> In our study we found significant meaning attached to the concept of role and the students easily understood what we were asking of them—discussing the idea of role and of generalized expectations placed on them by school science seemed to be fairly natural to them. (JRST: 391, underline added)

In this form of use, «meaning», though not directly available in words, may be conveyed: "Teachers' science questions convey rich meaning about the nature of teacher authority over questions and appropriate answers, confounding scientific talk in classrooms" (JRST: 16). The senses of the verb "to convey" include "to channel," "to transmit," "to communicate," and "to express." That is, the teacher questions are said to do something other than asking questions. They constitute a carrier, a tunnel, a medium for something else that is transported to others. Moreover, the "meaning" is *about* the nature rather than the nature itself. Typical of this use also is that researchers distinguish between deep structure or reality, the ideas, concepts, and surficial aspects of talking. What the researchers identify may be more abstract concepts or "deeper realities" as in this quotation: "She calls it la facultad: 'La facultad is the capacity to see in surface phenomena the meaning of deeper realities, to see the deep structure below the surface'" (JRST: 361). The surface phenomenon, the way in which people talk, then becomes the «meaning» of the deeper structure. Because the ideas, concepts, or things are independent of the sign and its user, different words—e.g., "Different authors tend to use different terms for approximately the same meaning" (JRST: 665)—or sign forms—"Examples of modes for expressing meaning include writing, diagrams, graphs, gestures, music, layout, images (still and moving), 2D and 3D models as well as voice" (JRST: 986)—may then be used to refer to the «meanings» hidden below the visible surface. Because «meanings» in this way are part of the deep or conceptual structure, they then can be used to explain surficial descriptions and observations: "even elementary students can move beyond simply observing and describing to negotiate and debate meanings and explanations" (JRST: 794).

Mentalist theory of meaning

"Meaning" is used to denote something "behind" the word or phrase but which is

something in the mind rather than something floating somewhere out there independently of the user. In this use, «meaning» is deeply rooted in its Proto-Indo-European root *men–*, to think, the mind, spiritual activity that has made its way into thinking-, mind-, and memory-related words of many languages. A second root, *mei-no-*, wish, intention, opinion is also given as the possible origin of the Old English *mǣnan*, which later develops into "to mean" and into the German equivalent "meinen." Perhaps the most salient expression of this way of using "meaning"—to refer to something behind the word, e.g., in the mind—is articulated in the following quotation:

> Peirce . . . identified three terms that help explain how meaning is made when a sign represents an object . . . and (iii) the meaning generated from the sign is called an "interpretant." . . . The sign . . . addresses somebody, that is, creates in the mind of that person an equivalent sign, or perhaps a more developed sign. (JRST: 990, underline added)

In the mentalist approach to «meaning», the phrase "to make meaning" tends to be synonymous with learning. It is said to be the result of constructions and making. As such, «meaning» is the result of processes in the individual mind: "The socially constructed knowledge claim was well suited to this study because of the research focus on participants' meaning making through personal experiences and how those constructions influenced reconciliation of perceived conflicts between evolution and personal religious beliefs" (JRST: 1029). Various social processes, such as "discussions" or "negotiations" may be invoked as instances that precede individual construction: "Explicit meaning-making discussion should likely be centered on primary and secondary criteria that are less established in students' repertoires" (JRST: 501). Here, «meaning» is actively made in discussions; that is, there is more to a discussion than the discussion itself, because something emerges as the result other than that which the *Saying* has said. Teachers or students may learn something without having made «meaning», which they then have to construct on their own. For example, after engaging teachers in "cognitive apprenticeship" where they have learned to teach, "teachers still need room to construct their own meanings" (JRST: 143). That is, the teachers do something in the cognitive apprenticeship that does not yet exist, and this additional stuff is the result of a construction. They make this additional thing themselves and therefore own it: "meaning." Texts may directly point readers to cognitive or constructivist theories to theorize how «meaning» may be constructed, such as when "cognitive theory" is said to have "been influential in understanding how analogy functions to generate meaning" (JRST: 773). The result, «meaning», is something different then the tools and materials—e.g., "signs," "language," "stories," "(material, symbolic] cultural resources," or "analogies"—that are employed to produce it: "Lemke refers to a social activity of making meaning with symbols and language within particular settings" (JRST: 774).

The Platonic heritage of the mentalist approach to «meaning» is clearly evident in those cases where researchers allow it to be constructed by individuals all the while postulating the existence of normative/intended «meanings». In the following quotation, what students interpret/construct in their minds is different from

"intended meanings": "There is a belief among many policymakers that greater specification gives educational leaders greater control over student learning because it reduces variability and minimizes misinterpretation of intended meanings" (JRST: 577, underline added). A concrete example would be the case when researchers investigate students' «meanings» of the term "velocity" and compare these to the normative uses in Aristotle and modern science.

Substitutional equivalence theories of meaning

The term "meaning" may be used to refer to instances where words and expressions are replaced or substituted by other words and expressions, such as when "turn-taking" is said to "best summarize the overwhelming meaning of 'sharing ideas and tools' in Mrs. Sparrow's class" (JRST: 468). Standard lexicography and the everyday use of expressions such as "What do you mean by . . .?" mark that a translation is requested or occurring. In this approach, the actual verbal expressions are taken as vehicles of something else: "What is needed are statements of science knowledge and skill that can be illustrated using a variety of cases and instances, but which convey the same basic meaning to all who read them" (JRST: 588, underline added). That is, the knowledge and skill do not stand on their own and for themselves; what is important in the quoted phrase is the fact that knowledge and skill convey something else. What this is we do not find out other than by the label "meaning." The different statements all are taken to convey the same «meaning», so that they are equivalent. This type of use, therefore, amounts to grafting one sign/referent relation onto another. This grafting process can be continued with ever-new sign/referent relations grafted on all those that precede the latest one, giving us the "infinite semiosis" in Peircean semiotics or an infinite chain of signifiers in Lacan's (1966) reframing of de Saussurian semiology. In both semiotics and semiology, there is a "vertical" relation between a material sign/signifier and its metaphysical referent/signified, on the one hand, and a "horizontal" relation between the different signs/signifiers that can be substituted to denote the same referent. When students are said to produce discourses that hybridize the root discourses of science and the vernacular that they speak at home, we also have a case where different words are used as equivalents of the same: "Wallace indicated that this student's use of authoritative language such as pressure is hybridized with the student's own meaning(s) such as pickling and push out" (JRST: 776). The students are using different words, those from their familiar language, to talk about the same idea. They use different words/expression to mark the same sense. (In this example, it is actually not a different «meaning».)

The substitutional equivalent use of "meaning" is especially marked by the deployment of the verb form, its present participle, and its conjugations (i.e., mean, meaning, means, meant). For example, a text might state that "students took up the promoted practices of science so that 'doing science' in this class meant, in part, working with, sharing ideas with, asking questions of, and listening to a partner or group mates" (JRST: 473, underline added); "By 'weighed more,' did the student mean 'had more mass' or 'was pulled harder downward?' (JRST: 1119, underline added); or "The general consistency of these results (with the above

noted exceptions) should not be taken to mean that every single student (even students of the same gender or from the same school) expressed the exact same views" (JRST: 382, underline added). In these examples, the verb "to mean" is used to flag an alternative expression that could be substituted and employed instead of what a student has said. In the second example, we actually observe equivalence and mentalist/semantic realist uses at work, as the researchers wonder which of two alternatives is the equivalent of "weighed more." In this way of using the term, "to mean" also may be employed synonymously with "to intend," such as when a text states that "by describing physics as 'cold'," researchers "only mean to suggest that students likely do not view the physics topics explored here as controversial relative to topics like evolution and climate change" (JRST: 914).

Substitutional equivalent use of "meaning" inherently involves translation, which may occur (a) within language, between different expressive modes including "images, gestures, language, prosody, mathematical expressions, and other sign forms (writing, diagrams, graphs, gestures, music, layout, images (still and moving), 2D and 3D models as well as voice," JRST: 986) or (b) between two languages ("using a positivistic set of variables (and measures thereof) that have transnational meaning," JRST: 902). Here, the third person singular form of the verb "to mean" flags a translation into another way of saying. This is so because this use may be expanded to read "by which he means to say." Thus, for example, in the following quotation, we observe such a transition between two expressions: "'cancer stage' of capitalism" → "like a malignancy, some members of a community . . . have 'mutated' to the point . . ."

> Indeed . . . we are in the ''cancer stage'' of capitalism, by which he means that, like a malignancy, some members of a community (perhaps international financiers) have ''mutated'' (although still resembling others) to the point of focusing strictly on their own self-interests while, in the process, destroying their neighbors. (JRST: 650, underline added)

The very idea of having trans-national tests is grounded in the idea of «meaning» as the constant phenomenon that can be translated and rendered by equivalent expressions in the different national languages. There are indications, however, that such translation is not inherently possible when science educators, while "producing summaries in their native languages," "need to utilize English in some instances" (JRST: 614) because "the need to translate English into their first language may result in losing particular meanings of words during the translation" (JRST: 614). Translatability may actually be taken to be equivalent to positivism such as when "the national educational contexts in which science education takes place" are "simplistically compared, using a positivistic set of variables (and measures thereof) that have transnational meaning" (JRST: 702). Additional questions have to be raised about the nature of «meaning» if it can be translated. If it is the case that it can be translated, it has to be available as language, in which case the "meaning of a word" is but an articulation of sense "in other words." When the possibility of "accurately translating the meaning of words, concepts and metaphors into English" (JRST: 704) is at issue, additional questions about the «meaning» of a concept arise, for a concept is already something on an ideal plane that is

only denoted by some concrete instance but not accessible in itself.

Contextual theories of meaning

In some uses, "meaning" is said to be dependent on or relative to the context; «meaning» may then be synonymous to "relevance" or "significance" (see Merriam-Webster definitions in footnote 3). This context dependence expresses itself when participants can identify something in a specific context where they are asked for instances of some item, such as "teacher effectiveness":

> As a means to further clarify students' meaning we examined key phrases for counter instances. As an example, we defined teacher effectiveness from instances when students could point directly to a facet of a lesson that where they had learned or applied a specific concept and confidently retold their role and impact on learning. (JRST: 42)

In such use, «meaning» may be consistent with a network of signification characterized by our familiarity with situations and the connections of the things and people within them (Heidegger 1927/1977). It is to these networks of signification that words accrue. Significations (*Bedeutungen*) in this sense are relations among the things that make the lifeworld of the person, including the words that are used to get everyday things done without having to reflect (cogitate) about them. Researchers would then investigate and explore with students the «meaning» of terms such as "science" or "science students" in concrete settings: "In the context of the science classroom, approaching social structure through the study of role provides a framework for examining the enduring and historically constructed meanings associated with science and school science" (JRST: 371). Consistent with such use, «meaning» may be explicit, when apparent in the words, or implicit: "These conjectures arose from our understanding of both implicit and explicit meanings of words and actions of our participants" (JRST: 631). In this case, «meaning» is used synonymously with "connotation," when in addition to a literal use, an expression also may be used metaphorically, jokingly, analogically, and so on.[5] When researchers are "concerned about the negative everyday meanings around the term argument that students could bring to the classroom'' (JRST: 796), they are really concerned with the connotations of a term. In this use, the specific context determines relevance or significance, such as when students are said to "be essentializing species-level properties and thus failing to recognize the meaning and significance of within-species variation" (JRST: 253).

The role of context allows the modification of «meaning», which may be of one kind in some context and of a different kind in another context. Thus, for example, disciplinary knowledge, as represented in disciplinary sign systems, are said to derive its «meaning» from the (social) context in which it is used: "Hyperspecialization . . . disconnects disciplinary knowledge from the larger context in which it exists; and from which it derives meaning" (JRST: 312). In this particular case, it even appears that the disciplinary knowledge may not have «meaning»

[5] Researchers generally fail to show how members to a setting mark for each other whether a statement has to be heard as metaphor, joke, analogy, or critique.

when disconnected from a larger (social) context. «Meaning» here is something that is attached to or goes with knowledge that has some meaning that it derives from something else.

Some uses make salient the relevance some word, concept, or idea has to participants, especially to their everyday lives: "Learners must understand the nature of the variables and apply ideas in the discipline in order to design informative experiments and draw conclusions that have meaning in their lives" (JRST: 747). "Meaning" and relevance are co-articulated in the following sample text in the corpus:

> Criterion 1: ''Define a scientific problem based on personal or societal relevance with need and/or source'' means that students ought to identify and accurately define a community-based problem that is meaningful to them. The problem must HAVE personal or societal relevance. (JRST: 102)

In this particular case, the relation to context is emphasized, because the verb "means" also is used to mark a translation, where one English phrase is rendered by another one: "Define a scientific problem based on personal or societal relevance with need and/or source" → "students ought to identify and accurately define a community-based problem." The phrase continues by stating that the problem "is meaningful to them," where the next sentence may be read as a translation of this final part, that is, "meaningful" → "has personal or societal relevance."

Contextual relations are especially apparent when the adjective "meaningful" and its negation "meaningless" are employed. The adjectival modification is further enhanced when used together with "integration" or the making of connections: "MBLs still are not commonplace in science classrooms or meaningfully integrated into teaching and learning in classrooms where they are commonly used" (JRST: 48) or "development of meaningful personal connections in socioscientific contexts" (JRST: 431).

Meaning and participant expressions

«Meaning» tends to be unrelated to what the participants have said. On the one hand, the term may be used to denote (a) participants' talk about some concept or idea that may or may not be presented to the participants as something to be talked about or (b) some unspecified other thing or idea that the participants do not themselves speak about.

Meaning as relation between a researcher's concept word and participants' expressions

Sometimes "meaning" is used in contexts where researchers offer participants a particular expression and ask them to talk about it. What the participants are saying is then taken as the «(personal) meaning» of the expression or concept thereby denoted. For example, researchers may note that "the subscales accurately represented the full range of meanings associated with the second-level themes and to allow the possibility of exploring different factor explanations"

(JRST: 383). In this situation, the themes are what the researchers constructed, such as *asking question* being an action versus being an attribute of a person. "Asking question" is the researcher concept summarizing different participant articulations. These different articulations are referred to as the different «meanings» students have, when in fact the concept is that of the researcher summarizing different types of student discourse. It is for the researchers that the different senses exist rather than for the students, who talk in ways familiar to them. This form of «meaning» is clearly evident in the following example, which is described as a case where "Category 2 examines the meaning participants gave to science and religion in their lives" (p. 1034).

> Category: 2. Participants' perspectives on the domains of science and religion
> 2.1. Participants trusted and valued science as a way of knowing
> 2.2. Participants trusted and were committed to their personal religious beliefs
> 2.3. Participants desired a positive relationship between science and religious beliefs in their worldview.
>
> (JRST: 1034)

The same operationalization of «meaning» is evident in the following excerpt, where "meaning" is used to denote what participants are saying about a researcher category:

> As a means to further clarify students' meaning we examined key phrases for counter instances. As an example, we defined teacher effectiveness from instances when students could point directly to a facet of a lesson that where they had learned or applied a specific concept and confidently retold their role and impact on learning. (JRST: 19)

A similar use of the term is observable when student inquiry is described. Here, "constructing meaning" "involves" making a link between "observations" and "broader disciplinary knowledge." The disciplinary knowledge constitutes a more abstract statement to which a concrete expression comes to be linked. Thus, a text might state that "constructing meaning within a laboratory task requires more than observing outcomes instead involving the linking of observations to broader disciplinary knowledge" (JRST: 1012) or "students were able to iteratively make meaning out of the laboratory experience by relating ideas among concepts and with what they observed" (JRST: 1012–1013).

Meaning as a generic other than what participants say in so many words

In many instances, research articles present excerpts from interviews or transcriptions from classroom video, and then denote by the term "meaning" what participants have made. But this «meaning» is different then what the participants say in so many words. That is, in this instance, «meaning» is a generic researcher concept rather than something grounded in the lifeworld of the participants. For example, in the following quotation, the teacher is talking about learning in situations where he "doesn't know the answers" and therefore is "just going by the seat of [his] pants." But the reporting context describes the situation as one in which

«meaning» is constructed:

> In year 1, through his work in the TPD program and an emphasis on the evolving nature of knowledge, he understood that he would be constructing meaning together with his students as they engaged in inquiry investigations, as he explained: "So, that kind of thing . . . I'm just going by the seat of my pants really, and I don't know the answer to the solution. So I am going to be learning with them." (JRST: 189)

We may therefore ask whether "learning" and "making meaning" are synonymous? Ought we take the content of the two processes, learning and meaning, as the same?

> Many participants expressed the notion that science brought meaning to their lives, as demonstrated by Tiffany, Participant 11: "Science . . . helps me to ask questions about the way things are and . . . that brings joy to my life, to be able to notice something and to maybe wonder about it and then to be able to . . . figure it out." (JRST: 1036)

In this excerpt, «meaning» is something that is brought to the lives of people. That is, the term denotes something that has the quality of a commodity that may or may not be present and that can be brought to a person by means of a vehicle such as science. We note that whatever it is that is brought to the lives of participants, it is something separate from what they actually say. We also note that the participant does not talk about «meaning» but about the joy that has been brought into her life by the ability to ask questions.

From the «meaning» of words to language-in-use

> For a large class of cases—though not for all—in which we employ the word "meaning" it can be defined thus: the meaning of a word is its use in the language. (Wittgenstein 1953/1997: 20 [§43])

The preceding coarse classification shows that in all cases, «meaning» denotes something that is not actually given. It is always deferred to something else, much in the way that the (Peircean) sign never reaches its object (referent), leading to the production of interpretants, new interpretant (sign)/sign relations that are grafted upon the original sign/object relation. This same non-attainability is apparent in the structuralist articulation of the signifier (e.g., a word) that can never reach the signified (e.g., in English often «meaning») but is continually replaced by still other signifiers without ever being able to satisfy the hope to reach the signified to which they all refer (Lacan 1966). In this section, I provide a concrete example from the texts published in the 2011 volume of JRST to exhibit how the term "meaning" is mobilized in the field of science education during an analysis. I then move to a way of analyzing the same data from a perspective that focuses on language-in-use without postulating some «meaning» behind or denoted by it.

One specific example where the "construction of 'meaning'" is discussed derives from a study of chemistry learning, where the text introduces a particular

transcript fragment in this way: "we see the students to-ing and fro-ing between everyday discourse and chemical discourse as students construct meaning about nerve signaling" (Bellocchi and Ritchie 2011: 781). The text suggests that there is a to-ing and fro-ing between the terms of the analogy, key and lock, and the terms from the target domain, GABA and channel.

> 39 Fergie: Yep you're the key I can be the chloride ion a-aaand Liz what do youwanna be?
> 40 Sara: The chloride the channel
> 41 Liz: I wanna be the lock
> 42 Fergie: That's the door
> 43 Sara: Yeah that's the door «the chloride channel»
> 44 Fergie: OK you're the lock
> 45 Sara: Ehehehe
> 46 Liz: Are you the key?
> 47 Sara: Yes I'm the key ehehh
> 48 Fergie: GABA slash key «reads what she is writing»
>
> (Bellocchi and Ritchie 2011: 781)

The transcription is said to describe a process of negotiation at work in the course of which "meaning" is constructed. It suggests that terms have «meanings» without also specifying what this «meaning» is—though in the present excerpt, we may actually make do by replacing the term "meaning" with "sense" or "reference" in the way suggested above. The text provides the following analysis of the classroom episode.

> The words ''lock'' and ''door'' are used interchangeably in the exchange to signify GABA and the chloride-ion channel. This to-ing and fro-ing indicates that in the context of the interactions there was no fixity in the meanings of words. Thus, ''key'' has no unitary meaning as it is also used here to refer to GABA. There is a to-ing and fro-ing between the two discourses in Turns 39–44 where the meaning of the terms remains tacit and fluid. For example, in Turn 40 Sara refers to the chloride channel and in the ensuing turns, key and door are used to represent it. In Turn 48 Fergie shows her understanding of the relational structure of the key and the GABA molecule when she utters, ''GABA slash key'' (i.e., GABA/key). (Bellocchi and Ritchie 2011: 781, emphasis added)

In this analysis, the term "meaning" is used as a synonym of "referent." For example, the text notes that the term "'key' has no unitary meaning, as it is also used to refer to GABA." Thus, "key" is a term that is used in the analogy to stand for and refer to two different concept words in the target domain to be learned. The researchers' narrative further notes that "the meaning of the terms remains tacit and fluid" and provides as example that "Sara refers to the chloride channel and in the ensuing turns, key and door are used to represent it." In both instances, therefore, the term "meaning" is used instead of the semiotic term "referent." In fact, when we look closer, there actually is no evidence in the transcript that in this conversation—rather than in the researchers' interpretation—"key" and "door" are used as equivalents to chloride channel. The participants themselves do not provide to each other resources for understanding this double signification.

Moreover, there is no evidence why "the chloride channel" is added as the transcriber's comment to "the door." Did Sara point to the page? Turn 43 is the reception of turn 42 so that we may hear the pair as an assertion|affirmation unit. There is no evidence in the transcript of anything such as «meaning» other than what the students say in the *haecceity* (thisness) of their local situation. There is no additional information that might serve as evidence for this claim. Rather than relying on the researchers' interpretations, we can focus on the ways in which the participants themselves make available to each other the orderly properties of the situation and of their talk. This requires taking turn pairs as the minimal unit, where the second turn exhibits the effect or uptake of a preceding locution or the social evaluation that is implied in and inseparable from any statement. It is for this reason that the statement ("utterance") actually has two sides and belongs to two participants in a conversation: speaker and recipient (see chapter 1). Any statement, or better, any expression goes with a social evaluation that is available in the replique of the recipient (listener).[6]

We first note that although there are speaking turns, these do not appear to be the ordered turn pairs that are commonly analyzed. Thus, for example, in turn 39, Liz is named as the possible next speaker, yet Sara takes the next turn. This turn, however, does not appear to take up, or pair in an apparent manner with, turn 39. Rather, Liz is speaking in turn 41: "I want to be the lock." If we take turn pair 39|41, then we observe the attribution of roles. This is so because the locution offers a question to Liz. There is also a self-attribution of the chloride ion to Fergie, and the "key" to the person addressed as "you," which, in a three-part conversation, can only be Sara. There is therefore a role distribution offered that in fact does not leave a choice to Liz. We do not have sufficient information—e.g., about intonation and prosody—to make a decision about *how* to hear the statement. This is so because turns 39|40 could in fact be heard as a pair, whereof the second part attributes to Liz the channel. Has there been a separation in the articulation of "the chloride" and "the channel"? Is this to be heard as a self-correction? Without information that these speakers make available to each other on *how* to hear the statements that they make, we do not really know *what* they are saying.

If we take Wittgenstein's recommendation that «meaning» is the use of a word in the language at hand—or, alternatively, if we merely look at use rather than postulating, thinking about, and invoking «meaning»—then we only investigate what is available in the open, public to everyone present to the conversation. Moreover, we are not and cannot be interested in individual or personal «meaning» somehow lodged in and produced by the mind, for this would only be an effect of language-in-use generally and of this conversation in particular. On the other hand, Bakhtin's dialogism and conversation analysis/ethnomethodology provide us with tools to go about the analysis of language-in-use that do not draw on «meaning» other than the changing use of an ever-changing language.

Instead of focusing on «meaning»—whether used in lieu of "sense" or "refer-

[6] Bakhtin and Vološinov use the Russian word *vyskazyvanie*, which some translations render as "utterance" but which might be better translated as "statement." Because utterance tends to be confused with locution, the physical act of speaking, the "utterance" therefore comes to be attributed to the physical person. For these language theorists, however, to understand a *con*versation, we have to theorize the word or statement as belonging to both speaker and recipient.

ence" or to denote something from the ephemeral metaphysical realm, like the "meaning of a concept"—we have the option of focusing on "language-games," that is, on the use of language and the rules that appear to be in force. Just as with other games, there is no difference between language-in-use and the game being played: language is an integral part of the game. In fact, the transcript fragment exhibits a game in play: attributing different roles in the game to be played to different people. Here, the words/language used are/is integral to the process of attribution. Once we take such an approach, there no longer is a difference between knowing the language and knowing one's way around this game of attributing roles.

There is in fact a question whether "negotiation" is an appropriate term in the description of the episode. The word etymologically derives from the Latin *negōtiārī*, where it was used as the equivalent of the English "to do business." It subsequently was used in the sense of "to bargain" and "to discuss to reach agreement," where there was an active give and take—a reciprocal exchange of something. This is the way in which J. Piaget used the term to describe the way in which people engage each other. Thus, "negotiation" is produced by "schemas of reciprocal exchange of ideas based on service, value, personal effort, sacrifice, satisfaction, and self-interest" (Radford and Roth 2011: 229). But is there an exchange of ideas observable in the transcript? Is there bargaining occurring? There is not even sufficient evidence in this transcript that there is an active relation of mapping the terms from the two domains. But we do observe something like a game of distribution and attribution of roles in a game; and this game of distribution/attribution itself is a game within the game with a distribution of roles. Language here is an integral aspect of this game and cannot be taken away from its local use without running the risk of losing the very phenomenon we are after in science lessons: changing participation in changing practices. We do not require recourse to «meaning», for once we investigate language-in-use everything required by participants in the game at play is exhibited to all other participants.

In this case, distributing/attributing the roles in a game is inseparable from any content that the language could be said to be about. That is, the same work accomplishes two things simultaneously: "doing [assigning roles]" and "doing [mapping everyday language and scientific language]." Role assignment and mapping are situated achievements of a contingent language-in-use. There is no further requirement for any «meaning». In fact, in presenting his critique of «meaning», Wittgenstein (1953/1997) provides an example that is analogous to this game from the JRST corpus. Thus, in the game of chess that the philosopher discusses, the king has a certain function when the game is played by the official rules. However, in the decision about who plays white and, therefore, who makes the first move in the chess game, one of the two players may take the two kings, one in each hand, mixing up the contents of the hands below the table or behind the back—i.e., hidden from the other player's view—and then hold out the two hands. The second player gets to play the color that the king has in the hand s/he points to; and the color also determines who makes the opening move of the game. Here, in the two parts of the chess game, the kings have a very different function than they have in the game. Yet the very uses of the kings belongs to the game, that is, the assignment of the colors and therefore to the opening move

(which may be decisive for the outcome of the game or the selection of the particular classical strategies).

The JRST text analyzed in this section suggests that what is at issue is the referential relation between the words from the everyday language, serving to establish the source domain for the analogy, and the words in the target domain. The narrative deploys it as part of an argument for the hybridization of everyday language and chemistry language that is said to occur. But we do not require a referential relation at all, as becomes clear in the analyses of a Dostoyevsky narrative, where six artisans walking on a country road each pronounces the same sound-word but with different intonation. Dostoyevsky listed the very different things that the artisans communicated to each other, even though they only used the same word; and he emphasized that the artisans completely understood each other. One analysis of the tale notes:

> All six "speech performances" by the artisans are different, despite the fact that they all consisted of one and the same word. That word, in this instance, was essentially only a vehicle for intonation. The conversation was conducted in intonations expressing the value judgments of the speakers. These value judgments and their corresponding intonations were wholly determined by the immediate social situation of the talk and therefore did not require any referential support. (Vološinov 1930: 106)

Vygotskij (2005) takes the same position on this Dostoyevsky narrative, suggesting that the use of intonation manages the changing significations of words (значения слов [značenija slov]). This is consistent with his presentation of signification to constitute a process, which manifests itself in the continually developing processes of thinking and speaking. That is, in situation, no referential support is required; and there is no evidence in the transcript that the students were actively seeking to establish a referential relation and make this seeking or the relation an explicit topic of the conversation. What we can see playing out is the distribution/attribution of the roles to be taken in their game at play rather than other issues. The students are establishing the relation on which any communication is based. In the course of the fragment from the classroom talk, we find expressions such as "you're the key," "I can be the chloride," "I wanna be the lock," "What do you wanna be?," "Okay, you're the lock," "Are you the key?," and "Yes, I am the key." Anything else is to be speculative about something (i.e., «meaning») that we do not require for understanding the unfolding event and what is being effectuated. Here, this would be the distribution of the roles in a game for which the distribution of the roles is part of the performance—in the exergue, so to speak. In this example, the language is not *about* something (i.e., «meaning»), but the very relation is produced and exists in and as of the language. To date, STEM education research has neglected to give due credit to such function of language-in-use, which is that of creating and entertaining an unfolding, that is, developing relation. Moreover, precisely because language is spoken, it is alive and therefore develops—in contrast to a dead language such as Latin that stays the same precisely because nobody uses it anymore. This dynamic aspect of language gets lost in the focus on «meaning», topic of talk, and semantic stability. This focus is at the heart of a certain kind of linguistics inconsistent with pragmatic and Marxist ap-

proaches to language that focus on what is actually done when language comes to be deployed in concrete situations.

In the featured chemistry classroom, a point is made about the "to-ing and fro-ing," which is said to indicate that "there was no fixity in meanings of words." We do not need to invoke «meaning» at all when we observe such "to-ing and froing." Anyone who has traveled or even migrated between countries using the Celsius scale for measuring temperature versus the Fahrenheit scale has made the experience that a sentence about temperature does not appear to be intelligible. It is but a matter of being used to talk about temperature in terms of degrees Fahrenheit for a statement "It's 68 F" to be saying something specific. As soon as we become familiar with using Fahrenheit and Celsius scales simultaneously—or any other differing scales—we no longer wonder about what has been said and may even provide immediate a corresponding temperature value for someone unfamiliar with one or the other scale. The statement "It's 68 F" or "It's 20 °C" does not have any «meaning», for the expressions do different work in different context. In Queensland, a daytime temperature of 20 °C would be a very unusual situation in January (summer in the southern hemisphere), when the mean temperatures normally would be around 30 °C, whereas during the month of March in Canada, it would be marking an exceptional situation in the other direction, a very high temperature.

The noted flexibility of word-use is always the case and cannot be specified in advance. It is in the local context that such issues have to be resolved. Thus, Wittgenstein provides the example of two statements that employ the auxiliary verb "is": "The rose is red" and "two times two is four" (Wittgenstein 1953/1997: 149 [§558]). In this instance, the same word "is" is used in very different ways, both grammatically correct. However, in the second instance the replacement of "is" with "=" "is permitted" whereas in the former case it is not. And yet, if someone where to use the equal sign, even if not permitted, we still would find it intelligible.[7] This is precisely the rule about the permissibility of the replacement that constitutes a rule. However, many readers will themselves have used, in their notes, "=" as a shorthand notation for "is" in situations not unlike the first. Thus, there is no general rule that forbids the use of the equal sign in cases where Wittgenstein suggests the (mathematical) rule forbids it. In the local situation, participants to a setting will be able to go on without any trouble. That is, the issue about rules has been resolved locally, for the purposes at hand, and without any further wondering about what philosophers or mathematicians consider to be illegitimate. No "negotiation" would be necessary if someone opened my research notebook and found the consecutive entries "perception = passive/passion" and "perception = active/performative" (July 13, 2011). That is, without building a theory, without wondering about «meaning», another person would likely read the statements in the literal ways that these were written. And this would be the case even though there is no other precedent, for all other equal signs (hundreds of them) appear in mathematical and statistical equations.

[7] See also the different uses of "X" provided in chapter 1 to construct expressions: Xmas, Xing, and X-ing,

The *use* of «meaning» in science education

In this chapter, I analyze the ways in which science education discourse employs and deploys the term "meaning" for the purpose of analyzing and theorizing what happens in science classroom. That is, my analysis focuses on the *uses* and *functions* of «meaning» in the language of science education texts more generally. I do not ask the question about the «meaning» of «meaning»—as Ogden and Richards (1923) had done—in science education, which would have been a circular effort, as I would have put into play the very same concept-word that I want to bracket. Rather, I analyze—consistent with Wittgenstein's recommendation to focus on language-in-use—the different ways in which the term "meaning" is brought into play. In this chapter, I classify these uses rather than list the different «meanings» that the term "meaning" might have. These uses include the deployment as synonym for sense or reference and the denotation of something else that is inherently inaccessible and can only be gestured. I conclude that as currently used, «meaning» tends to be consistent with a metaphysical epistemology, where it denotes something that is not directly available in the physical world. We find ourselves in a Platonic situation, where the real, material world that we inhabit is distinguished from another, ideal and otherworldly world of ideas and «meanings» that we never access and of which we only observe the shadows on the wall (i.e., as the words we use). In this book, I suggest to abandon this approach and focus only on the use of words in particular language games that go with the games that we commonly play, including the language games typical of science, technology, engineering, and mathematics education. «Meaning» then comes to be de-mystified and, in fact, becomes an unnecessary concept in the theories of STEM learning. We can then say that students' knowledgeable deployment of language in science and their knowledgeable navigation of the science-related world more generally are indistinguishable. There is one way in which we could redefine «meaning». I present this way in chapter 8, where it denotes the ensemble of alternate (different) ways of saying the same.

3 Hunting the elusive tiger

> To paraphrase Marx: the *psychological* nature of man—a set of societal relations, *shifted to the inner sphere and having become functions of personality and forms of its structure*. (Vygotskij 2005: 1023, underline added)

In this chapter, I take another look at the STEM discourse with and around «meaning» and what the use of this term implies. I discuss in exemplary fashion one article from the field of science education that makes extensive use of the term "meaning" (Krange and Arnseth 2012). This article, as any other article that appears in a science education journal, is a document of the discourse within our field rather than being particular to the authors. This is so because these authors have not invented this language they use: it has come to them from the community of science education researchers. With the article that these authors signed, the language returns to the community for the benefit of which it has been designed. The text addresses an audience so that the language it uses is the language of this *audience*—not only because peer reviewers have vetted it prior to publication but also, and especially, because there are many more readers of the article than there are authors. That is, rather than focusing on a singular text, my analysis concerns the possibilities of the collective discourse concretely realized here in and by this one article.

The article selected for analysis presents an interesting description of how students work in the context of a virtual world, where they design phenomena that they subsequently investigate by analyzing graphical representations. I pick it out for analysis because of my friendly working relations with the authors, which makes it possible to do such an analysis without generating animosity.[1] Their study is aligned with the current canon of science education interested in understanding the inter-psychological and intra-psychological determinants of learning. However, I consider its main focus, «meaning making», a hunt for an elusive tiger with that name. In this chapter, I further articulate the shortcomings inherent in the theoretical notion «meaning», which, in essence, hides rather than reveals the real issues in and of learning science, technology, engineering, or mathematics. I offer some alternative avenues, both theoretical and methodological, for framing pertinent issues. In so doing, I (endeavor to) open up new avenues for research

[1] To me, research writing is about ideas, which are social phenomena. Too often, however, some members of our community come to be wedded to specific ideas or theories. When the idea or theory is subjected to critique, they then feel personally attacked.

not only in science education but also in STEM education more broadly. In essence, therefore, I offer possible avenues in response to the question, "What more can there be done by science education research?" that would allow us to eschew what I perceive to be hidden contradictions that interfere with making theoretical and practical advances in our field. Because the target of my critique is a discourse—that of science education—rather than a critique of the authors of the specific article, I refer to the latter as "the text," which, in fact, is part of a larger body of text that represents the current cultural-historical discourse of our field. This larger text constitutes the ideology of the field (Vološinov 1930). This ideology is the scientific object of this book taken in its entirety.

Deconstruction is not destruction

The feature text that constitutes the object of this chapter sets out to scrutinize student learning in the context of virtual (literally artificial) worlds that offer learners different «representations» of events designed (intended) to develop their understanding. The text articulates an interest in understanding the nature of the human-computer «interactions» and how the visual «representations» offered in the particular task setting together with spreadsheets mediate «interactions». The research is couched in what has become a familiar method for learning scientists, the design experiment, and a theoretical framework that aligns itself with socio-historical and socio-cultural traditions (for a review see Roth and Lee 2007). The main focus of the article is «meaning making». Thus, the term "meaning" appears over 40 times in the text, in the title, and on 10 pages as running head (it also appears 3 times in the references). The text presents an interesting analysis of how students and their teachers work through science «problems» in an innovative learning environment.[2] The study thereby adds to an existing literature that provides descriptions of learning at the interface of the individual and the collective, that is, at the interface of individual and social constructivism. By situating itself in the context of research on «meaning making», however, the study realizes—perhaps, or likely, without the article's authors being conscious thereof—an agenda that is antithetical to the cultural-historical activity theoretic and phenomenological efforts of overcoming (Kantian) subjectivism and the dichotomy between body and mind. In fact, even researchers and theorists in the embodiment literature fall into this trap, as they tend to focus on their phenomenon in terms of the contradiction between the material and ideal, the unity of which escapes precisely because of the way in which it is thought as the unity of opposites (Mikhailov 2001). The problem is engendered by a search—i.e., hunt— for «meaning»; but the problem escapes and is made invisible because of the use of the concept «meaning» and everything that the search for it and its making (construction) entails. Although I also was concerned with «meaning making» for an important part of my scholarly career, my own present predilections lie elsewhere: in the

[2] Terms such as "problem" really need to be bracketed, because in each study a case has to be made for what the real problem is that *learners* engage with rather than what researchers and teachers consider being the problem. These may be very different issues.

living and lived work that constitutes the societal structures that are so evident to us in our daily lives. This work involves human beings in flesh and blood. Although my research employs concepts such as transcendence, it does not accept the existence and primacy of a metaphysical world of pure ideas and «meanings».

In the opening paragraph I refer to the "feature text" and "texts" more generally, which warrants a comment. The text of this chapter refers to the text presented in the feature article signed by I. Krange and H. C. Arnseth. However, no author owns a text. Any text—a point on which L. S. Vygotsky, M. Bakhtin, J. Derrida and many others agree—is co-owned by producers (authors, speakers) and recipients (readers, listeners). This means that the reader reacts to the text as s/he has read it rather than as that which the author has written (intended) it. Accordingly, I counter-sign the feature text and I sign this text, which, in turn, is countersigned by its readers. Signing and counter-signing is a process not unlike that of the signing of a contract by two parties. The text binds authors and readers in an ethical relation that is of the same kind as the discursive relation discussed below. The relationship between the feature text and this chapter is not unlike that between the locutions of two speakers, the later one considered as a reply to the earlier one (Figure 1.1, p. 15). The later text, therefore, is an integral part of a response, which also includes the active reception of the earlier text. In turn, this earlier text really has to be taken to be part of the response to other texts that preceded it and to which it refers. The text of this chapter is simply the continuation of a conversation within an ongoing scholarly discussion.

The text of this chapter is subject to the same statement that I make concerning the text to be analyzed here and all the other texts analyzed in this book. Thus, it is a text for an audience. As such, it presupposes its own intelligibility. It is a text that is part of the totality of texts available in the STEM community generally and in the science education community specifically. It may be that the forms of text deployed have less currency than others, for example, those about «conceptions» or «conceptual change». But it is a text possible and therefore constitutive of the STEM education community.

Here, as throughout this book, I call for an extended reflection concerning the concept of «meaning», the supposed process of «meaning making», and the methods for researching events from which educational researchers extract "meaning(s)" and "meaning making." I offer this reflection with the intent to articulate where and why science education research might want to explore new ways of understanding that do not reproduce the logical contradictions that are embodied by the various forms of constructivism and their search for individual and «shared meanings». My theoretical reasons for doing so are circumscribed by the introductory quotations of the *Preface*, which (a) take the traditional concept of «meaning» to be based on "a primitive idea of the way language functions," so that we may (better?) drop from our considerations in science education and (b) adopt a perspective—consistent with dialectical materialist, pragmatic, ethnomethodological, and phenomenological ways of thinking—according to which everything of relevance always already occurs in the societal relations between people. Important for the reproduction and transformation of societal relations is what participants in transactions make available to each other, that is, everything of relevance for

understanding the *internal* dynamic of the transaction is "on the table." This allows us to abandon the hunt for «meanings», which many philosophers have shown to be not only elusive but also a remnant of Greek metaphysics that today is keeping itself alive in the various forms of constructivism. Abandoning the hunt for the elusive tiger called «meaning» also allows us to abandon and overcome "all the incoherences of psychological and historicist constructivisms" (Derrida 1990: 21).

To reiterate: the present chapter is not intended to be critical of the authors of the feature text or the work that the text reports. Identifying structures in the way this is done in the feature text is a perfectly legitimate endeavor. This study does it according to the going, accepted criteria of what constitutes legitimate research in science education. Yet my own predilections go further. I am interested in investigating the work and competencies by means of which social actors—e.g., science students and their teachers—make available to each other resources for recognizing these structures. Thus, for these researchers to recognize "procedural issues" or "conceptual issues," evidence for "meaning" having been made, the students and teachers they observe have to actively produce and make available to each other and for each others' benefit certain resources that the researchers take as indications for the phenomena of their concern. I am interested not in these phenomena per se but in the *transactional work* by means of which the members to the setting—i.e., science students or teachers—achieve this exhibiting of relevant structural resources. In fact, researchers already have to be competent in identifying these resources and structures because otherwise they would not be able to perceive and recognize them as evidence. I am interested in the societal event as a dynamic event, which means, that my theoretical concepts require capturing the *dynamic* nature (mobility) itself and the *inner forces* that keep the event going. And this requires working with non-self-identical, dialectical units and categories that are non-self-identical and thereby embody inner contradictions.

«Meaning» and «meaning making» as theoretical concepts

In the field of science education, «meaning» and «meaning making» constitute pervasive theoretical concepts—a graduate student counted for me the occurrence of "meaning" in the 2010 volumes of 4 major science education journals and arrived at more than 1,000. The previous chapter provides further evidence from the *Journal of Research in Science Teaching* that this term is indeed prevalent. However, there has been no apparent attempt to understand and theorize the notion—even though language philosophers including L. Wittgenstein, M. Heidegger, M. Bakhtin and others have done so long ago and others, such as J. Derrida, have done so more recently with very similar results. They all conclude—consistent with the analysis provided in chapter 2—that the concept is consistent with a metaphysical philosophy that has its origin in Greek thought, which has emphasized the mental over the physical. As a result, the mental somehow came to float over and above, accompanying (Gr. *meta*, with, after) the physical—and separated trans-individual theoretical knowledge (*épistemé*) from applied knowledge (*tekhné*) pertinent to concrete situations. The separation of the physical world and the ideal world finds its early expression in Plato's allegory (also analogy or parable)

of the cave. In it, human beings only see shadows on the wall to which they ascribe form. This is as close as the prisoners of the cave get to reality. In an analogous way, the words students and teachers use in STEM education are but shadows of the «meanings» that are inexpressible and do not exhibit themselves. This leads to a split between the words that members to some setting use and something else theorized to be their «meanings». This split has lead to the mind-body problem—cognitive scientists' "grounding problem" being only one example of it—the split between knowing and application, the separation of thought and affect, and many other associated dichotomies. This split and the theoretical and practical problems that arise from it are the direct consequences of theorizing learning and sense making in terms of «construction» and «meaning», theorizing that precisely juxtaposes concrete praxis to theoretical concepts. The distinction between theory and practice is quite clear in the (radical) constructivist approach, where the concepts in the mind are tested for viability in the physical world.[3] It is this very statement that separates knowing something from applying this knowing to the world. In the following subsections, I trace the conceptual underpinnings of this theoretical notion, thereby bracketing «meaning» and investigating it prior to any use in/for scholarly purposes.

Meanings are elusive in practice

When researchers are concerned with «meanings» in the mind, they can only speculate about processes. They can only speculate because these processes are inherently ideal and therefore inaccessible. Thus, it is not surprising to read the text describe a student Henry as picking "out a V8 gasoline engine, different kinds of tires and completes building the car before he starts driving" (CSSE: 594).[4] The text then speculates: "This does not *appear to be* problematic for him, but it *does not seem* to stimulate any kind of conceptual reflection either" (ibid: 594, emphasis added). Here, as elsewhere, the text speculates about (inner, internal) processes; this is the best that can be done when there is no direct evidence for the phenomenon of interest. It is conceptual reflection and the question whether the subject views/experiences something as problematic. This pursuit is very different from another one that focuses on what members to the setting *actually* make available to each other. The text can only speculate about what might be the case, but for which there is not direct evidence that the participants could definitely agree upon. Such speculation is a purely scholastic endeavor. Mental phenomena, such as «mental representations», inherently are unavailable and therefore of little interest for the understanding of the *inner* dynamic of the conversation Henry has with his teacher—unless the participants themselves would bring up «mental

[3] In a concrete, Marxian human psychology, this problem does not arise. In such a psychology, "the question whether there is objective truth to human thinking—is not a question of theory but a *practical* question" (Marx/Engels 1958: 5). This is so because "in praxis man has to prove the truth, i.e., reality and power, the this-sidedness of his thinking" (ibid: 5). As a consequence, "the dispute over the reality or no-reality of thinking—in isolation from praxis—is a purely *scholastic* question" (ibid: 5).

[4] Throughout this chapter, I refer to the text that Krange and Arnseth (2012) signed by means of the acronym *CSSE*, thereby denoting the community of scholars reading and publishing in *Cultural Studies of Science Education*.

representation» and make them the topics of their discourse (see chapter 5). In this case a concrete discourse practice would make elusive «meanings» present for those present to the setting. For example, analyzing a discussion at a STEM education conference where the concept of «mental representation» is mobilized, we could study precisely the particular functions that the concept has in the conference talk. But these «mental representations», resources of talk, are not the mental phenomena that psychologists of mind are interested in. This is the approach chosen in discursive psychology, which is not interested in psychologists' concepts such as «mind», but in the everyday, mundane use of "mind" in discursive constitutions of the situation at hand (chapter 5). «Meaning» and «mental representation» would therefore be of interest only if students and teachers made these, in their mundane transactions, the topic or resource of the conversation. Let us take a concrete look at the way in which the featured text deploys the notion of "meaning" and of the composite action of "meaning making."

At issue in the analysis is a particular exchange between the student Henry and the teacher. In the lesson fragment, Henry and Mary produced a graph. The text suggests that the students "have problems to understand what the graphs mean" (CSSE: 599). As part of the transcription, we find the following turns.

> 10. Henry: Yes, there it becomes good.
> 11. Teacher: Yes, there it becomes good. Then . . .
> 12. Henry: Yes, how to get them equal? *Henry refers to the y-axis on the other graph.*
> 13. Teacher: When you are going to get them equal, you turn to the same place and then scale.
> 14. Henry: Yes, yes. *Pushes the y-axis and chooses scale.*
>
> (ibid: 599–600)

Concerning the last two turns, the text states: "Again, the teacher explains how to change the presentation of the graph (turn 13), but this time it is Henry that pushes the buttons (turn 14). This indicates that he is about to make meaning of the graph as a computer representation . . ." (ibid: 601). The text thereby suggests that Henry's pushing the button is an indication of the fact that he is "about" "to make meaning," and the sign that he «makes meaning» of is "the graph as computer representation." The text does not actually tell us *what* that «meaning» is or how we have to understand or use the term. We therefore do not know what the student actually makes, because «meaning» is a generic term that covers many situations in which students can make it even in this text (see chapter 2). In the present instance, it is a graphical representation; but elsewhere in the feature article it might be something different. «Meaning» comes to be something that is attached to or accompanies "the graph as computer representation"; and the action of pushing the button is an "indication," that is, points us to and stands for, the process that is "about" to happen: «meaning making». In fact, «meaning» may already exist and what students achieve in doing is to bring the unfamiliar representations, virtual world, and discourse into what they are already familiar with. This is certainly the pragmatic and phenomenological position that an analysis of everyday being in the world has revealed whereby words accrue to «meanings» (chapter 1). That is, following a detailed analysis of how language is used and

functions in the everyday world, Heidegger (1927/1977) tells us that «meanings» are not made, are not attached to words. His analyses—as those of the lifeworld concept conducted by his teacher E. Husserl (2008)—suggest that we are always already familiar with our lifeworlds, which are plain, clear, and self-evident. We take this world at face value without doubting its reality. Any unfamiliar things (words or material) simply become part of this familiar world in and through their (extended) use. This world that we inhabit is always already given, it is always already *there*, when we become conscious (Husserl 2008). Thus, "each of us says 'I' and knows himself speaking in this way as an I. It is as such that he *finds* himself, and he finds himself at all times as a center of a *surrounding* (*Umgebung*) (Husserl 2006: 2). In the natural attitude that characterizes our lives, the things that make for the surrounding are *not* the result of constructions. Rather, these are the *same* things for different members to the setting, even though these things may appear differently because of the different spatial positions of the perceiver.

We immediately note that the way in which the theoretical notion «meaning» is deployed in science education language is precisely the one that Wittgenstein deconstructs in his later work as a whole and in the quotations introducing the *Preface* specifically. He suggests that the view of words as having «meaning» derives from a primitive idea of how the language functions, which he elaborates by stating that this is equivalent to saying that the idea is "of a language more primitive than ours" (Wittgenstein 1953/1997: 3). As various historical analyses of thought and language have shown, the idea dates back to the ancient Greek (Aristotle), who conceived of language as the outer sign of the soul, which, in and through the voice as a vehicle, renders the imprints nature has left in it (see chapter 1). The spoken words, themselves the signifieds of written words that merely transcribe them, thereby become the signs of the state of the soul (mind). Just as the Greek did have ways of thinking Being and «representation» differently prior to Socrates—e.g., if they had followed the ideas of Heraclitus of an ever changing world, which can be theorized only in the dialectic of life and death—STEM discourse has the possibility to articulate learning issues differently. This is also the case for the feature text when it adds to its speculation the suggestion that Henry becomes familiar with the computer representation, so that he, "with a certain purpose, can change it (make the graphs comparable)" (CSSE: 601). In this statement, the text describes what has been seen: Henry pushes the buttons without further teacher instruction and thereby changes what is on the screen apparently in the way he intended it—as per his satisfaction with the result of the action. Focusing on the pushing of the button in the exchange with the teacher would lead us to a more pragmatic approach in understanding.

The events described may be much more aptly thought about in terms of the opening quotation from Vygotsky's work, according to which, as stated in the quotation that introduces this chapter, the *psychological* nature of human beings is to be understood as a set of societal relations shifted to personality and its structure. In other places of the same article, Vygotsky suggests that all higher psychological functions are societal relations (first). Although Vygotsky uses the qualifier "first," to be able to write that these societal relations that are then shifted to the inner sphere, they already have to be of the inner kind. Thus, his Russian students and followers emphasize that we should not think of this process as one where some

phenomenon is shifted from the exterior, inter-psychological plane to the internal, intra-psychological plane (e.g., Leontjew 1982). Rather, the minimal intelligible unit is material and ideal simultaneously—where we should hear/read the simultaneity not in terms of a "both . . . and . . ." operator conjoining two contradictory terms but as the non-self-identity with itself that is expressed in the different ways in which the phenomenon manifests itself in consciousness (see below). Thus, even when a person participates in a societal, that is, external practice for a first time, the corresponding internal processes are already in existence.[5] The external societal practice *immediately* has its ideal, psychological reflection rather than a reflection that is generated only after some delay. What we require for a proper understanding are concepts that include the non-self-identity that can express itself as inner or outer, inter-psychological or intra-psychological, as societal relation or as psychological function:

> There is nothing other for us from the outset that would not be our own. For the very existence of the mind is possible only at the borderline where there is a continual coming and going of one into the other, at their dynamic interface, as it were—an interface that is defined not by the fact of their difference (in other words, not by a difference in outward [discernible by the subject] states between what is psychologically self and what is other, the stuff of natural science, as it were), but by the single process of their mutual generation and mutual determination. (Mikhailov 2001: 20–21)

The inseparability of the two manifestations is apparent in the example that the feature text provides: A teacher exhibits the practice of changing representation without being assisted, which means, she manifests a certain psychological function in a concrete way as part of the societal relation with Henry. That is, in their transactional performances, the inter-psychological and intra-psychological are functioning simultaneously in both participants: "by the single process of their mutual generation and mutual determination." The next time they make changes to the graphical representation, the teacher describes it in words whereas Henry completes the operation that changes the graphs. Here, the change in the graph is the result of a societal relation—between institutionally differently positioned "teacher" and "student." It is precisely such results that matter to Vygotsky, because words are always a means for changing the behavior of others before they become a means for changing the behavior of the user (Vygotskij 2005). But when Henry pushes the required button, it is not as if he were an empty vessel into which familiarity and «meaning» are transferred or within which these are «constructed». Rather, for Henry to push the button at the required instant in time to achieve the mutually exhibited (intended) purpose of changing the graph there is already a capacity to comprehend the situation (teacher's talk) in a particular way and to bring about the associated action. That is, there already are existing psy-

[5] Without further discussion I participate in the common distinction of "inside" from "outside" as occurring at the level of the skin. On purely geometrical grounds, human beings constitute something like a tub or elongated torus, where the "inside" is itself an "outside" with sufficient surface area and permeability for food to be absorbed into the walls. On philosophical grounds, we could not ever talk and think without language, which is never our own. Even our most personal reflections, therefore, always already are perfused by the *Other*.

chological characteristics that operate at the very instance that the new functions are learned while being produced for the first time, a dialectic that is of a similar kind as the one underlying the conception of teaching to learn to teach (Tobin and Roth 2006). That is, to understand learning as a process, we need to think of the psychological function in dialectical terms: as existing and not existing simultaneously. It is only when we theorize learning at the dynamical interface where there is a "continuous coming and going of one into the other"—in a process where self already is other and other is already self—that we can have any hope of understanding how people learn something initially completely foreign and strange to them.

Impossibility of mediation unless there is an interleaving of self and other

The text analyzed here brings together «representations» and virtual world (inherently another «representation») to suggest that students may use these to «make meaning»: "it [episode] makes evident how they made meaning with the representations of the energy resources, and how the virtual world and the spreadsheet with possibilities to make graphs had *impacted* their meaning making" (CSSE: 592). In this excerpt, «meaning», which in essence is from the ideal world, and concrete materials, are brought into relation. The material representations are said to be mediators in the «making» of «meaning». But there cannot be mediation of «meaning making» by the material «representations»—i.e., material signs—offered within the virtual world unless there is already an interlacing of the material and the ideal both at the level of the «representations» and at the level of the acting subject. This is so because the sign inherently involves the (outer) relation of two segmentations of the material continuum one external to the other. The relation, resulting from an "arbitrary connection of things that are external to each other, does not yield a law" (Hegel 1979: 236). That is, there cannot be a transaction of two manifestations that are external to each other (because one is mental and ideal, the other physical material and real): one «representational» (sign) phenomenon cannot influence another other unless they are already alike in some way because of an inner connection. Externalities at best *inter*act, mutually affecting each other. Thus,

> the sign *is by no means* a mediator: it is not a mediating link in the behaviorist S–R model, but an internal (already completely one's own) prop of the will, i.e., the subjective reality of an inner voice, born of its externalization for the Other, and thus also for oneself as for the Other within oneself. (Mikhailov 2001: 17, emphasis added)

The difference we are concerned with here is that between *inter*action and *trans*action. In the former, there are two elements that are exposed to each other to get a collective phenomenon. This phenomenon, therefore, is reducible to the two elements. In transaction, the two parts are *not* independent of each other. The nature of one is co-determined by the nature of the other. The phenomenon cannot be reduced to the independent functioning of the two parts that now are in a relation. As a way of explicating transaction and mediation, consider this example:

Marx showed that there is a relation between use-value and exchange-value only because value is not self-identical, is different from itself but manifests itself as use-value and as exchange-value. That is, use-value and exchange-value are expressions of the *same* thing, value. There is therefore an *inner* relation between the two so that exchange-value can mediate between different use-values. To be of any use, social-psychological phenomena—e.g., thought and affect—have to be part of a unity *internally* different rather than bearing an external relation (Vygotskij 2005). This unit cannot be one where externally (logically) contradictory phenomena are stuck together and combined by a logic of "both . . . and . . ." that mutually determine each other within the unit:

> The premise and the condition for postulating a unity between *nature* and *culture*, intellect and affect, and the higher and lower forms of behavior cannot be phenomena rooted in mutual determination of the "different aspects" of that unity: the "inner" individual subjectivity of the human mind and the "external" objectivity of the things of existence that we are able to *experience* and *perceive*, including the "biological principle" of its "organismic" corporeality. (Mikhailov 2001: 17, original emphases, underline added)

Here, Mikhailov emphasizes a point already made by G. W. F. Hegel that "aspects" or "factors" cannot determine anything, for these are only *manifestations* of the phenomenon rather than the phenomenon itself. Thus,

> in the first place, the outer acts only as an *organ* in making the inner visible or, in general, a being-for-something-else; for the inner, in so far as it is in the organ, is the *activity [Tätigkeit]* itself. The speaking mouth, the working hand, and, if you like, the legs too are the performing and actualizing organs that have within them the acting *qua acting*, or the inner as such. But the externality that the inner obtains through them is the action as a reality separated from the individual. Speech and work are outer expressions in which the individual no longer keeps and possesses himself within himself, but lets the inner get completely outside of itself, leaving it to the mercy of an Other. (Hegel 1979: 234–235, original emphases)

The inner unit of nature and culture, therefore, has to arise from within the unit rather than arising from its aspects, which are but *outer* signs. To provide an analogy from the natural sciences, an equivalent situation would be to establish the nature of light, the phenomenon of interest, by somehow attempting to arrive at it through a mutual determination of its *wave* and *particle* natures. Prior to quantum theory, physicists just could not wrap their heads around this dual manifestation: light *is* a particle and light *is* a wave. We do not get light by adding the two manifestations, by somehow synthesizing them, or by dialectically transcending them by means of the worn and incorrect formula: "thesis, antithesis, synthesis." In quantum theory, however, whether we take Heisenberg's matrix approach or Schrödinger's wave equations, the phenomenon and its temporal unfolding are appropriately described. What we observe, an expression of its wave or of its particle character depends on the nature of the observation (modeled in quantum theory by means of an "operator" that specifies what can be observed in an ex-

periment). This observation is external to the phenomenon (modeled in quantum mechanics by means of the wave function ψ).[6] In the meantime and prior to any observation, any talk about light as particle or light as wave is meaningless. The former and the latter are very different things.

The text signed by Krange and Arnseth points out that the students "experience issues" while they are making the graph and with making the graph that displays the relation between distance traveled and carbon dioxide produced by cars that travel at different speeds. The text then states a conclusion: "this also implies that they have problems with transferring knowledge from the virtual world and the ready-made table over to a graphical representation of the same disciplinary phenomenon" (CSSE: 600). This observation should not be astonishing, as there is a differentiation between knowledge and use typical of all constructivist approaches, leading to the identification of something as knowledge independent of its use. In radical constructivism, knowledge is first constructed and then tested for its viability in the world. If, on the other hand, knowledge were defined in terms of use (*praxis*)—even in the case of conceptual words employed in the course of discursive action—then this problem would never appear.[7] In dialectical materialism, knowledge is the *consequence* of practical action (and therefore practical competence) in the world. Knowledge, or rather knowing, always pertains to what people actually do and exhibit *to* and *for* each other in this doing, and is therefore never separate from praxis. This also eliminates any question about the truth of human thought: "The question whether there is truth in human thought—is not a question of theory but a *practical* question. In praxis man has to prove the truth, i.e., reality and power of his thought. The arguments over the reality or non-reality of thought—isolated from praxis—constitute a purely scholastic question" (Marx/Engels 1846/1958: 5). That is, statements that some skill or concept is used in one context but not in another are typical for a theoretical gaze that is very different from the perception characteristic of practitioners.

Passivity in the first constitution of intelligibility

The idea of «making meaning» or «constructing meaning» fails to recognize the essentially passive dimension in first constitutions (e.g., knowledge). That is, precisely because we do not know something we are unable to intend knowing it. If we nevertheless come to know something, it cannot have been intended. This unintentional aspect of coming to know has been referred to as passive constitution (Husserl 2008). Explicating the appearance of sense by means of "a conceptual

[6] In the matrix approach to quantum mechanics, a phenomenon is characterized by a vector /ψ>. An observation *a* is the result of multiplying this vector with itself, after transforming it by means of the observation matrix *A* (i.e., <ψ/A/ψ>) to yield something like the "length" of the vector. The phenomenon (mathematically a vector) and its observation (mathematically a scalar, "length") are very different kinds of (mathematical) entities. So are *light* and its manifestations as *wave* and *particle*.

[7] Even the most "esoteric" sciences, such as pure mathematics or theoretical physics, are *practices*, that is, they are done in *accountable* ways (e.g., Livingston 1986). Accountability would not be possible if mathematics and theoretical physics were happening in the mind only. It is precisely because proofs and objects are materially available to the members in these fields that these fields are *objective* sciences arising from the embodied practices of their members.

construction supposes already *that* which one pretends to construct; explicating it by the genesis of a simple facticity is denaturing sense, *renders impossible the appearance of the fact 'as such'*" (Derrida 1990: 21). That is, focusing on «construction» presupposes that which is constructed as idea or plan, and this focus precisely interferes with the *appearance* of intelligibility. But consciousness always is consciousness of something. In terms of development—whether this is cultural-historical or ontogenetic—"perception therefore is primary, objectivity has an originally lived foundation; the synthesis that renders this objectivity possible is not a construction, an association *a posteriori*" (ibid: 59, underline added). That is, this synthesis, which is at the origin of intelligibility, overflows any unity established on the basis of a multiplicity of subjective acts.

«Meaning», as used in the literature, pertains to the relation between some worldly (material) something—a word, sentence, graph, or images of a virtual world—and some other, ideal realm inhabited by meanings and consciousness (see chapter 2). The "relationship of consciousness and the world, always being constructed, determining the absolute origin of this construction, is to forbid understanding the movement and making impossible the passage of the subject to the object [of construction]" (Derrida 1990: 76). Pure observation, as this is presupposed in all forms of constructivism, requires intuition to

> originally see [*voir*] and receive [*recevoir*] the concrete presence of an object, which gives itself to all construction, to all derivation, and sends us back to the original act of donation. Whether perception is perception of time or of a spatial object, it appears . . . that a primitive passivity constitutes the actuality of a consciousness. (ibid: 151)

As a result, as soon as we speak about the (*active, agential*) «construction of meaning» or «making of meaning», we take a point of view that occludes the passive dimension that is constitutive of any action. This is so because "in any case, the construction of an activity necessarily presupposes, as its lowest level, a passivity that gives something beforehand, and when we pursue it [the actively constructed] then we find the constitution by means of a *passive* generation" (Husserl 1950/1995: 80–81). Focusing on the «making» or «construction» of «meaning», therefore, *occludes our access to an aspect essential to an understanding of learning*: an originary passivity and a process of donation that are integral aspects of learning something new and unknown, therefore invisible to, unseen, and thus unforeseen by the learner.

«Meanings» are elusive on theoretical grounds

A critique of the classical view of language, embodied by Saussure's articulation of the nature of the sign, has come through a line of work in post-WWII France, generally referred to as post-structuralism and through Marxist critique. The classical view presents a sign in terms of signifier and a signified such that, for example, the word "graph" (signifier) signifies, even in and precisely when absent, the thing «graph» (Figure 3.1a). Similarly, the graph when produced signifies, as stated in the text, that the students have "made meaning" (CSSE: 602). That is, the graph

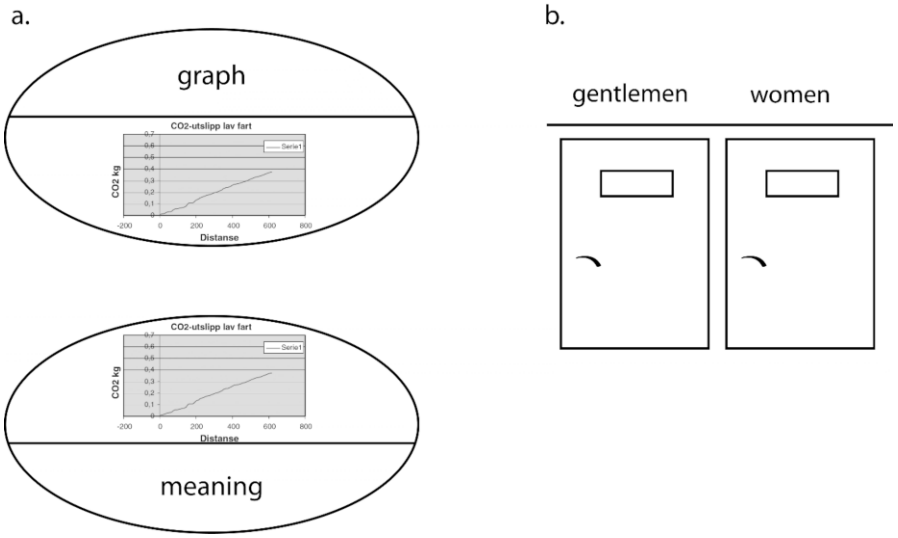

Figure 3.1 a. According to de Saussure, a sign consists of a signifier and a signified, above and below the line, respectively. b. Lacan criticizes de Saussure, emphasizing that we only ever deal with signifiers, which, as here, once inscribed in the world, change it.

and students' descriptions are signifiers that point to some «meaning», which itself is absent. But, just as the French critique points out (e.g., Lacan 1966), «meaning» is not only absent but also forever elusive. «Meaning» is in fact absent in for two reasons: First it does not exist in French, where the French terms *signifé* (signified) and *sens* (sense) are used (often rendered by the term "meaning"); second, it is absent because it cannot ever be attained even if the French had an equivalent term.[8] We know this to be a fact from those situations where interlocutors are asked what they mean by what they have said, leading them to articulate precisely the same sound-words (students then say that teachers do not help them) or say in different words what they have been presumably saying. That is, the teachers engage in a translation of one statement into another statement taken to be the same; and this translation occurs at the heart of one of the same language, which therefore *cannot be* self-identical. Because two non-identical statements are taken to say the same, language is taken to «mean» the same all the while it is apparent that two phrases are different. Moreover, if a student comprehends one statement but another, the two statements are not equivalent in the praxis of speaking. It is the same and not the same simultaneously.

[8] For a scholar bilingual in French and English, translations often are tremendously frustrating because they may turn the sense of a statement on its head or because they hide what an author attempts to make a figure (see chapter 4). Thus, for example, in French, Lacan (1966: 10) uses the expression *rendre le terme à son emploi commun* ("rendering a term to its common use") appears in the English version as "returning to the usual meaning of the term." My translation is actually more consistent with a pragmatic approach outlined here than with the metaphysical discourse of the translation.

Lacan (1966: 498) completely rejects the idea that the "signifier serves the function of *re*presenting the signified, or to say it better: that the signifier has to justify its existence in terms of whatever signification it may be." Questions about «meaning» only divert our attention from the real way in which language functions in everyday life.

We see this at work in the feature text, which uses the verb "to mean," to separate two statements that are equivalent, one translated into the other. For example, the text states that the analysts compared all the numbers in the blue squares on the screen with the numbers entered in one of the tables it displays, which showed that the former were correct. They follow this description by saying, "this means that the students are able to translate" (CSSE: 598). If the listener asks again what the original speaker "has meant," confusion and even annoyance may set in (Garfinkel 1967). That is, the problem of «meaning» is not addressed but deferred to another signifier, another phrase, then to another, and so on. This gives rise to continual deferral and chains of signifiers none of which have any chance to reach «meaning». Rather than the de Saussurian idea (Figure 3.1a) of the sign as a signifier–signified relation, the resulting relation is that of a chain of signifiers (S), each of which can be taken in place of another (i.e., which happens when we ask others person what they mean), none of which, however, has any chance of attaining a signified (*s*), which remains forever elusive (therefore denoted in italics):

$$\frac{\mathrm{S} \ldots . \mathrm{S}}{s}.$$

We then have a multiplicity of horizontal expressions (the Ss in the numerator of the expression) all of which are taken "to mean" the same thing or, to state this more consistent with the pragmatic stance I am taking here, all of these expressions can be used to get the same thing done. Whereas the Ss are real in the sense that they are verbal expressions, the *s* cannot ever be reached. It does not exist in the world of human beings. It is more like a desire that cannot ever be satisfied. In the classical approach, therefore, «meaning» itself is continually deferred and, therefore, it is elusive. It is a ghost, elusive and haunting, haunting in its elusiveness. On the other hand, there are real consequences when sound-words come to be inscribed in the world, leading to a change in perception and action. For example, two formerly identical doors lead to very different social practices when the words "women" and "gentlemen"—or some iconic representation referring to the different sexes—come to be inscribed onto these things of the natural world (Figure 3.1b). It is not that there is «meaning» in or attached to these words but that there are real practical, and therefore observable, consequences in a world where ink traces as "Gentlemen" and "Women" or icons such as

are inscribed. What matters are not «meanings» but the real changes in behavior: male folks only tend to take one door, whereas female folks tend to take the other door.[9] There are variations, and these variations and the possibility to deviate from the "norms" themselves come to be contested not in ideality but in real world situation, including the courts. That is, what matters is how material signs—including words, icons, and graphs—change the behavior of people.[10] Thus, from a socio-historical perspective, a word is first a command for others: word use and verbalized behavior genetically arise from real, physical relations between people: "the functions of a word were first distributed among people, then became part of personality" (Vygotskij 2005: 1024).

The position outlined in the preceding section also is consistent with the pragmatic approach to language-in-use (Wittgenstein 1953/1997). For science teaching, the problem is not one of allowing students to construct the «meaning» of such terms as "women" and "gentlemen" or of the alternatively used icons; rather, the problem is one of learning how to act in a world such that students do the equivalent of males taking the left and females the right of the two doors. The «understanding» of any individual is evidenced when their word-use corresponds to the common use of the two doors—by custom, one door is generally to be avoided, the other one to be entered. Knowing a language (a system of signs), in this way, becomes indistinguishable from knowing one's way around the world: we knowledgeably walk into the "right" door.

The very hunt for «meaning» in the context of «(mental) representations» leads us into a metaphysical pursuit of specters. The relation between «(mental) representations» (graphs, words) and «meaning» is but a second way in which the non-present is to be made present again; and taking the two—i.e., presence (presentation) and *re*presentation—as the same, constitutes the fundamental position of metaphysics. By means of «representations» we can make present again that which is absent. But the very use of a «(mental) representation» implies the absence of the thing represented, for we do not need to make present again what is already present. Without «(mental) representation», without the capacity to make present something that is absent, there would not be human knowing and learning: not in the way we know it. This was apparent in the research of J. Piaget, who showed that toddlers of about 8 months develop the capacity for "object permanence." That is, before that instant in human development, when a screen is pushed between the child and an object, the latter becomes inexistent to the former, a fact that is described in the popular adage according to which "out of sight

[9] This situation is made more complicated in the case of transsexualism and cross-dressing (drag queens and kings).

[10] Made thematic in the grounding problem of cognitive science, the question how immaterial things like «meanings» or «ideas» are connected to the real world, for example, leading to applications, has not been solved by constructivist theorists—despite all hand-waving to the contrary.

is out of mind." For toddlers to be able to look intentionally for the object behind the screen this object has to exist in, and be present to, their consciousness: the object has to be present in its absence. The power of the word, therefore, arises from the inner contradiction that it can make present again an object or phenomenon that is actually not present.[11]

Parenthetically noted, it is for precisely the same reason that we cannot «construct» new knowledge because such a construction requires an orientation to the knowledge still absent. But just as the toddler cannot orient toward the absent object behind the screen, learners cannot orient towards something for which they would not already have a means of making it present (i.e., representation). But it is precisely that construction of that representation that a constructivist approach denotes as learning.

Orientation requires a way of making something present in its absence. This is where «*re*presentations» come in. With the object made present in consciousness in its absence, the child can orient to and look for it even though it is invisible. A graph, in the way presented in the feature article, presents something that is absent, a moving car that produces carbon dioxide as it drives a certain distance. In this particular case, the world itself is virtual, a «representation» of something else not actually present. Here we therefore have the continued deferral made thematic in the previously denoted relation. In this context, we can easily see how words, too, are tools for making present something that is not actually there: «meaning». Thus, the text cannot ever point to «meaning» itself, because it is that which by nature remains absent and unattainable. The text therefore can only tell us when to see something as an index that points us to the fact that «meaning» has been made but cannot make this «meaning» appear in itself and for itself. For example, the text states that "it is quite easy for the students to make meaning of the virtual world" (CSSE: 597) and then substantiate this sentence by writing that "this becomes evident in that they do not have a problem driving through the test race with high and low speed, nor to [sic] they find issue in picking up relevant information and filling it into the ready-made table" (CSSE: 597). That is, the observable fact that the students have no problem *is evidence of* the non-observable, an index to their having made «meaning»; the observable fact that they do not find issue with "picking up information" and "filling it into the ready-made table" becomes a pointer to and sign for the non-observable «meaning» that students are said to have made. But if we have everything in our hands that we need for understanding the situation, why do we need to invoke some absent and invisible «meaning»? Does it not suffice, as pragmatists suggest, that we exhibit competent use and knowing our way around the world?

An argument for abandoning the concept «meaning»

There is precedence in the philosophical literature that helps us understand episodes such as those that science educators describe—e.g., Krange and Arnseth (2012) or Bellocchi and Ritchie (2011) in chapter 1—without drawing on «mean-

[11] For analyses that exhibit STEM learning in parent–child relations involving children as young as 1 years of age see Roth et al. (2013).

ing». Thus, Wittgenstein (1953/1997) actually uses examples that share a great deal of similarity with the data that the feature text presents. It is therefore useful to take a look at how the philosopher conceives of the functioning of language in situations of the type that we observe in Krange and Arnseth's article. Wittgenstein describes the situation between a builder A and his helper B, who use different forms of stone in their work:  [block],  [pillar],  [slab], and  [beam]. As the builder produces certain sounds, which, using the conventions of the International Phonetic Association, are transcribed like this: /blɒk/ ("block"), /'pɪlər/ ("pillar"), /slæb/ ("slab"), or /biːm/ ("beam"), the helper—after being taught by means of ostension—brings an object  ,  ,  , or  without being rebuffed by the former. That is, the helper learns what to do when s/he coordinates certain sound (-words) and forms of stone and, therefore, acts in apparent concordance with the (also inaccessible unless expressed) "intent" of the builder. Wittgenstein points out that we do not require any theory based on the construction of «meaning». In his pragmatic approach, the (proper) use takes the place of «meaning».

Krange and Arnseth describe an analogous situation: the student Mary says "the diagram doesn't look right," which is followed by the teacher speaking and acting simultaneously.

> 7. Teacher: Yes it is a standard formula, yes. And what you can do then is—you can change these very easily by pushing the x–y-axis or the right button on the mouse. *The teacher pushes the y-axis. By doing this, a new diagram pops up and she can format the axis.* Format axis. *A new window pops up. "Format axis".* And then you turn to . . . If you like standard numbers, ordinary numbers, push Numbers.
>
> (CSSE: 599)

Here, the teacher provides what we hear to be a description of the actions that she brings about. That is, she engages in the same kind of ostensive definition that teaches the person B to be an actual helper by bringing the stone required as per A's initially ostensive instruction /'pɪlər/ →  . When A produces the sound /blɒk/ and B picks up a  , this is the precise equivalent of the teacher uttering /'fɔːmæt 'æksɪs/ (or, rather, its Norwegian equivalent) and Henry's pushing a button that makes a window appear entitled "Format axis." We do not require the concept «meaning» that the texts mobilizes (e.g., "[Henry] is about to make meaning" [ibid: 601]). In fact, using the word «meaning» in this context gets in our way: if we look at the example "we may perhaps get an inkling how much this general notion of the meaning of a word surrounds the working of language with a haze which makes clear vision impossible" (Wittgenstein 1953/1997: p. 4).

In this example involving the teacher, Mary, and Henry, everything we need descriptively and analytically is there, out in the open, for the members to the setting (stone mason and helper) and, therefore, for us. They make available to each other whether to hear a statement as a question, an instruction, a rebuff, or a joke. They also make available to each other whether to hear a statement *as* ostensive definition. That is, a common, practical ground of experience has to exist before any word can do its work. It is because they know their way around (a part of) the

world that children come to learn language. The process of teaching in both of the examples provided, here by means of ostensive definition, can be thought of "as one of those games by means of which children learn their native language. I will call these games 'language-games'" (Wittgenstein 1953/1997: 5). We do not require the concept of «meaning» to denote something in the head of the helper; that he acts appropriately—here by matching stones and sounds—is all we need to know that he has learned and is competent.[12] As a result, the same concept denotes "processes of naming the stones and repeating words after someone" (ibid: 5); and we may extend the notion to "the whole, consisting of language and the actions into which it is woven, the 'language-game'" (ibid: 5). That is, the teacher, Mary, and Henry are involved in a language-game, where sounds (statements) are as much part of a totality as the representations, images, Excel, and the computer. This totality cannot be reduced to the sound-words—which would be the case if we postulated some «meaning» in the metaphysical netherworld of pure entities that we cannot know but only obliquely index by means of the words that appear on this, the physical side. The words would then be reduced to mere shadows on the wall of Plato's cave, evidence of things that never (can) make themselves present: ideas, «meanings», or «mental representations». Rather than investigating these shadows, I am interested in the real, practical work that produces the words and (institution-specific] societal relations. That is, I am interested in the language-games people play in the different settings of their everyday lives, not in their formal rules, but in the actual praxis of playing the games as these unfold in real time, produced by members to the setting, who exhibit intelligibility (or lack thereof) as an integral part of the ongoing game. I articulate this concern in my analyses in the next section.

An important structural aspect of STEM discourse is the distinction between "procedural orientation" and the desired "conceptual orientation" that the students and teacher *ought to have* taken. Such distinctions are a direct result of the focus on «meaning» as distinct from thinking about words in language-games. The very separation of theory and practice derives from the metaphysical approach that separates discourse *in* practice and discourse *about* practice. In the end, "Most of the time, the students' meaning making processes are procedurally oriented, and the ways they speak and make meaning of conceptual issues are not made explicit" (CSSE: 602). From a pragmatic perspective articulated by the later Wittgenstein and the cultural-historical activity theoretic perspective articulated by Vygotsky, the conceptual and the procedural-practical actually are but manifestations of the same inclusive unit of social affairs. Taking the unit apart makes the phenomenon disappear. Thus, the real issue is not about whether the helper B has a «conceptual understanding», «mental representation», or «meaning» when he hears the sounds /'pɪlər/ or /slæb/ but whether he brings the requested  or so that the work can proceed. If the focus were on practical action and use, STEM educators would no longer have any reason to complain about someone knowing a «concept» but being unable to use it. What might it mean to know a concept but not to be able to apply it? What might it mean to know soccer but not to be able to

[12] I do not intend to intimate that learning is a mere association of things and sounds. Here it is simply one of the ways in which knowing, learning, and teaching manifest themselves.

apply this knowledge? Although some readers might be tempted to claim that there is a difference between playing soccer and doing science or mathematics, what these different forms of activity have in common is that they involve *doing* something and playing the language-games that go with it. From the pragmatic and cultural-historical perspectives, knowing and use are but different manifestations of the same activity, and, when a practice is not exhibited, this also means that the associated «concept» is not known. The very idea of a separation between knowing and use derives from the metaphysical position where ideas are separate from the physical world; it is an approach that K. Marx has attempted to overcome in saying that theoretical «concepts» emerge from and therefore follow life rather than the other way around.

Wittgenstein draws the consequences of his analyses that had turned up the inherently problematic nature of this notion. Because the notion of «meaning» is something that a word can have is rooted in a primitive idea of how language functions, the philosopher *drops it from his consideration*. Similar, for Heidegger (1927/1977), «meaning» (*Bedeutung*) is not something a word can have. There are lived-in worlds that we are familiar with; and it is to these worlds that words accrue. That is, Heidegger thinks and theorizes together our familiarity with some aspect of the world and our familiarity with the sound-words that are an integral part of this world. There is no need for «meanings» or «mental representations» in the heads of people. In the following section, I show that abandoning the theoretical concept «meaning» does not limit research in science education but in fact opens up new avenues for investigating societal relations and how these are constituted in and through interactional work.

Investigating societal (ruling) relations and interactional work

> For us to speak about the *external* process means to speak of the social. Any higher psychological function was external, this means that it was social; before becoming function, it was the social relation between people. (Vygotskij 2005: 1021)

In the introductory quotation to this chapter, Vygotsky orients us to the societal relations as the important phenomenon to understand, because it is also the place where knowing comes to be exhibited and enacted concretely and for every participant and onlooker to see. In the quotation that opens this section, Vygotsky identifies the external and the social.[13] That is, every higher psychological function is observable in soci(et)al relation—we do not have to speculate about what is in the mind because we can observe the "higher function" in the external relations that produce society. As a result, mind is in society to the extent that society is in the mind, and society is in the mind to the extent that mind is in society. There are

[13] Actually, he sometimes uses the equivalent of "societal"—i.e., the stem общественн (*obshchestvenn*)—sometimes the equivalent of "social"—i.e., the stem социаль (*sozial'*)—to refer to the relations. English translations tend to inappropriately translate both Russian words using the same adjective "social." There is a difference, however, just as there is in the German that K. Marx uses; and when Vygotsky refers to or quotes Marx, he uses the Russian equivalents of the German *gesellschaftlich* (societal) and *sozial* (social).

therefore no societal relations without the competencies that enacting these require: something like a queue—at the bank, before the movie theater, at the bus stop—is *actively produced* and, when something is wrong with it, people display their understanding of the underlying work required for forming a queue correctly (e.g., by pointing out to the first person that the teller is calling for the next person in line).

Personally I find interesting the investigation of the collective *work* that brings about the societal relations and, therefore, the kind of cognition that constructivist approaches have attributed to individual minds or additive collections thereof. Moreover, the attention to societal relations and to the particular accents of the language that participants produce for each other provides access to the ruling relations that inherently privilege and exclude some at the expense of the successes of others. Unfortunately, the transcriptions that the feature text provides are insufficiently detailed to allow me an exemplary analysis in the way I would conduct it if I had access to the videotapes. Researching interactional work is actually very different from researching soci(et)al structures. The latter form of research has been termed *Formal Analysis* and employs quantitative or qualitative methods; the former is researched by means of *ethnomethodology* (Garfinkel 1996). The fundamental difference between the two approaches is that once the interactional work is known, we can formulate *any* soci(et)al structure that could be produced under the given circumstances, whereas knowing the soci(et)al structure only allows us to know that structure and not what structure we might observe under different conditions. Moreover, investigating soci(et)al structure by formal methods requires description of methods of how researchers extracted the patterns they observed and how frequently these phenomena can be observed in a population. The ethnomethodological approach is different because the methods that members use to produce societal structures are the same that investigators are required to employ for recognizing those structures in their data. Thus, ethnomethodologists propose "that it is the workings of the phenomenon that exhibit among its other details the population that staffs it" (Garfinkel 1996: 5).

Societal (ruling) relations orient research to different units of analysis

Underlying the feature article signed by Krange and Arnseth (2012) are data that lend themselves to the study of societal *processes*—here teaching-learning processes. This, however, requires that the theoretical concepts capture the movement rather than theorizing process in terms of differences in state. To exemplify, consider the way in which learning generally is conceived in STEM education: as difference between prior knowledge and knowledge after intervention. Procedurally, the concern is realized in this form by assessing—sometimes using paper-and-pencil tests, sometimes using interviews—what students know (or their conceptions, conceptual frameworks) before (K_1) and after a unit of instruction (K_2), that is, as the difference $\Delta = K_2 - K_1$. This approach is operationalized in the practice of taking difference scores as indicators of learning that has occurred while students engage in a particular curriculum unit and as a consequence thereof. We may use the analogy of the change that occurs when a shearing force operates on a rectangle transforming it into a parallelogram (Figure 3.2a). Here, the rectangle is the

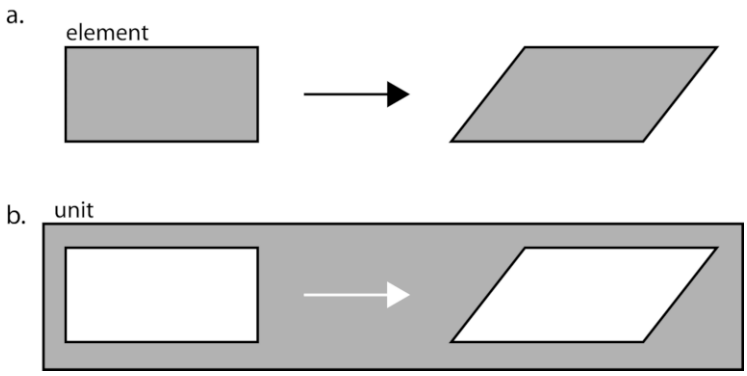

Figure 3.2 a. In the classical approach, the rectangle is the element that is transformed, by a shearing force external to it, into a parallelogram. b. In the dialectical approach, difference itself is theorized: rectangle, parallelogram, and force are integral and irreducible part of the *unit of change*.

analytic unit upon which operates a force that is *external* to it.

On the other hand, to conceive learning as process we need a minimal unit of the form (K_1, K_2), a unit that *cannot be reduced* to K_1 or K_2. This unit (K_1, K_2) or (K_1 → K_2) therefore contains an inner contradiction because it *manifests* itself as K_1 or K_2 but it cannot be constructed by some logical combination (e.g., both . . . and . . .) of the two. This situation is represented in the analogy of a minimum unit of *change* (Figure 3.2b). This unit of change includes the rectangle, the parallelogram, and the force: None of these aspects can be understood on its own because the unit of change is *irreducible*. The unit is precisely a unit of *change*. The force is *internal* to the unit. This is precisely the difference between analysis in terms of elements and the analysis in terms of units that Vygotsky was writing about. He wants researchers to take the latter approach, which alone allows us to understand activity, whereas the former leads us to chimeras.

What is special about this unit is that it captures flow and its movement. Inherently, the unit cannot be self-identical, for it is different with respect to itself, for example, if we change when or where to look, sample, or measure it: In our analogy, there is a rectangle, parallelogram, or force depending on when and where we look. But all of these are just manifestations of the whole unit, which cannot be reduced. It is the process of observation that reduces the whole into one of its manifestations: rectangle, parallelogram, or force. The problem is similar to that of light discussed above or to that embodied in the well-known quantum mechanical problem of E. Schrödinger's cat in a device ruled by a quantum mechanical phenomenon. Before we look, we cannot say that the cat is *both* dead *and* alive, because this is a *logical* contradiction. But as soon as we open the box, we make one of two observations captured in one of two observation sentences: "the cat is dead" or "the cat is alive." In quantum mechanics, the situation prior to the actual observation is modeled by means of (invisible, unobservable) state vectors, which, during an observation, "collapse" into this or that observation (e.g., a value of +½

or -½ for the spin of an electron).[14] The situation is also similar to thinking flow in liquids. If our minimal unit is flow, such as flow of water in a pipe, then inherently the pressure on the left end of the unit is different from the right end. That is, although we are dealing with a unit, it is different with respect to itself, exhibiting different characteristics depending on when and where we look: within our unit of analysis, the pressure is different. If we ask questions about pressure, we will get different answers depending on when and where we measure. Thus, units of flow harbor inner contradictions, which are consistent with and expressive of the changes themselves. Units of *learning*, which is also a change, will be of a similar kind.

This form of contradiction, which is a contradiction in forms (of knowledge), constitutes "the necessary form of development of knowledge, as a universal logical form" (Ilyenkov 1982: 234). We cannot understand the *development* of knowledge unless it is based on the inner contradiction of forms of knowledge within the unit. If we want to theorize learning *processes*, then we require concepts that *embody process* and therefore change itself, some phenomenon that manifests itself differently at different times or under different conditions. That is, *learning* is a diachronic—time-wise shifted—phenomenon, and therefore can be captured only by a concept that captures this diachronic nature. In the following, I show how speech acts, taken as the units of pairs of turns, constitute precisely such units that are spread over time and across interlocutors (see Figure 1.1, p. 15, and the associated discussion).

Let us look at the following example. The feature text states: "the graph seems to be much more in line with how Henry wanted it to be" (CSSE: 600). What Henry actually says is not that he wanted it this way. He says, "Yes, there it becomes good." In fact, from a dialogical and diachronic perspective, where we intend to understand the *flow of the* con*versation*, we look at the sequence of turns taking each pair as the minimum intelligible unit. From the linguistic approaches that Wittgenstein's work has spawned—such as speech act theory and discursive psychology—and dialectical materialist approaches to language, Henry's vocalization (locutionary act) is only the second part of a turn pair that constitutes the minimum unit of analysis; it is the *perlocutionary* moment or effect of the entire speech act. This is precisely the same relation as that described above, where author and reader take the role of the persons uttering the first and second turn. Bakhtin delineates exactly the same structure as Derrida, in considering a novel or poem as a statement, which receives its social evaluation by the reader: "the reality reflected in the text, the authors creating the text, the performers of the text (if they exist) and finally the listeners and readers who recreate and in so doing renew the text—participate equally in the creation of the represented world in the text" (Bakhtin 1981: 253). We may conceptualize it as the *social evaluation* moment that constitutes an integral part of the statement. The statement is theorized as the yoke between the interlocutors: it belongs to the speaker and recipient *simultaneously* (e.g., Figure 1.1, p. 15). That is, the word someone utters does not belong to him/her but, as a moment of the phenomenon *con*versation, it belongs to two

[14] Under the entry *Heisenberg model (quantum)* of Wikipedia, interested readers can find such operators for the spin of an electron. See note 6 (p. 49).

persons simultaneously. This is so because "the word is in consciousness that which according to L. Feuerbach is absolutely impossible for one person and [but] is possible for two" (Vygotskij 2005: 1018). That is, the word is heard *while* it is spoken.

What has to matter to our analysis, therefore, is not only that the word is articulated but also that it is received. This is so because the helper in Wittgenstein's example brings the building blocks only because and after he has heard a particular sound. A conversation, such as the one between the builder and his helper or between the teacher and students (Mary and Henry) is a *societal* phenomenon. The minimum unit of analysis, therefore, has to be *transactional* in nature. But individual actions—self-actions or *inter*actions—*are not transactional* (Dewey and Bentley 1949/1999). Thus, to have a *transaction*, the individual and collective need to be *within* and *part* of the minimum unit as a condition. The turn pair satisfied such a condition because it is impossible to identify independent parts.[15]

When we do look at the relation, that is, at turn pairs as the minimal unit, then something else becomes apparent rather than what the claims say that are stated in the text that Krange and Arnseth signed and that readers (including me) countersign. Henry's locution constitutes the effect, from a speech act theoretic perspective, and the social evaluation, from a Bakhtinian perspective: "Yes, there it becomes good." This is an evaluative statement about something that is "there," something that "becomes good." As a result of the preceding action, where a button inscribed with "Standard" has been pushed, the "it" "becomes good." With the action of pushing, the "it" becomes good, thereby making the action appropriate for producing what is denoted as good, much in the same way as Wittgenstein's builder might have nodded or produced the sound /gʊd/ ("good") when, after having produced the sound /blɒk/ the helper returns with a ⊞.

> 9. Teacher: It is now on Exponential. Then you push on ''Standard''. *She chooses standard and thereafter OK*. And then . . .
> 10. Henry: Yes, there it becomes good.
> 11. Teacher: Yes, there it becomes good.
>
> (CSSE: 599)

Science educators have become very familiar with a phenomenon referred to as triadic form of discourse (i.e., I-R-E), according to which a teacher *I*nitiates an interaction, the student *R*esponds, and the teacher *E*valuates. In the present instance, the text shows us how the students initiate a sequence by assisting the teacher in understanding what they are wrestling with. Once the teacher understands, she produces an action, and it is Henry's statement that evaluates it as one that makes "it become good." There is therefore a relation that by far exceeds any-

[15] Dewey and Bentley (1949/1999: 132–133) distinguish self-action, inter-action, and transaction:

> *Self-action*: where things are viewed as acting under their own powers.
> *Inter-action:* where thing is balanced against thing in causal interconnection.
> *Trans-action:* where systems of description and naming are employed to deal with aspects and phases of action, without final attribution to "elements" or other presumptively detachable or independent "entities," "essences," or "realities," and without isolation of presumptively detachable "relations" from such detachable "elements."

thing that we might be able to theorize with the term *scaffolding* or by means of the concept of «meaning», which, as the text states, is "made" by students while leaving unarticulated what the teacher is making at the same time. Let us pursue this idea for a little while.

In turn 11, the teacher follows Henry apparently repeating precisely the same locution. The feature text does not say anything about this turn but moves on to write about turn 12 after commenting on turn 10. Just as turns 9|10 form a pair, turns 10|11 also form a pair. To say anything about turn 10 requires us to look at turn 11, because each constitutes only a moment of the minimum unit that makes sense. However, the unit 10|11 is a consequence of and arises from turn pair 9|10. In fact, turn 10 thereby has a double allegiance in that it concludes one turn pair (pair 9|10) and opens another (pair 10|11). It is an irreducible link between two turn pairs and it is an irreducible part of each pair.

The turn pair is the minimum unit because it is only in this way that we begin to understand the *internal* dynamic that moves the *con*versation ahead as a transactional event: turn 10 does not only (arbitrarily) follow turn 9 but is occasioned by it for the benefit of its speaker. The conversation is a social fact and, as such, requires a *social* unit: the turn pair. The end result of a conversation exceeds anything that any individual participating in it could have brought to the meeting. The conversation is a transactional phenomenon that exceeds any psychological (self-actional) phenomenon. This framing is consistent with the experience any one of us may have had in committee meetings, where the joint decision taken in the end may actually contradicts the initial positions that any individual participant has arrived with.[16] Conversations are not the sum total of the contents of minds that the interlocutors bring to the situation; they are not the result of *inter*actions, where elements contribute to the whole without changing themselves. Rather, the conversation has its own life that exceeds the power of individual members to the setting. Without that unit of two turns, the conversation would be carried by apparently independent speakers (the teacher, Henry, Mary), who make sense for themselves and dump the contents of their mind (soul) without apparent connection to the preceding and succeeding talk.

The upshot of the preceding analysis is that we can understand language as a living phenomenon and the historical changes that a language undergoes in speaking only when change itself is the minimum unit. Thus, for example, from the cultural-historical perspective that both Bakhtin and Vygotsky take, every time a word is produced, it changes. In the turn pair 10|11, the entire locution comes to be repeated. But it is no longer the same because the second statement occurs against a background that now includes the first articulation of the statement. From the traditional synchronic perspective on language nothing can be learned from analyzing turn 11 because it only (re-) produces more of the same. However, based on the analyses of the Dostoyevsky story referred to above, where 6 drunkards utter the same sound-word, we would have to state that turn 11 constitutes more than a mere reproduction of the same. As part of the pair, turn 11 occurs against turn 10 as the background; it would not require re-articulation if it were

[16] This can be modeled using constraint satisfaction networks that precisely have the property that the state of each node depends on the states of all other nodes (Roth 2004c).

mere reproduction. But if we were to replay the video, we would be able to *hear* that the two statements are not identical: they become identical only in, through, and because of the transcription. The statement actually transforms the situation. There is a function that the statement has in this conversation, and our analysis has to work out what this function is. In this situation, it can be heard as an affirmation, that is, as an evaluative of the identical locution that precedes it. The situation would dramatically change, with highly probable changes in the turns that follow had the teacher produced the locution with rising intonation so that the transcriber would have seen the need to render turn 11 with a question mark ("?"):

10. Henry: Yes, there it becomes good.
11. Teacher: Yes, there it becomes good?

In such a case, where the intonation is rising, competent speakers tend to hear a question even though the locution does not have the corresponding grammatical structure. But this rising intonation would make available to Henry *how* to hear the statement—which is precisely not to repeat what is said but to ask him what he «meant» to say. What would have happened if Henry had heard the locution in turn 11 as a question? This leads us, of course, to speculation. But we might hypothesize him to explain why "it" has "become good," before the conversation could have further unfolded. That is, turn 11 is the evaluative moment of the turn pair 10|11, which, in the case provided by the text, constitutes a confirmation because it is articulated with an intonation that can be heard as an affirmative statement rather than a question. The conversation now can proceed in the way that the text describes without having to deal with the possible question in turn 11. This example also shows that the transcription may hide a lot of the competence that the speakers clearly exhibit. For example, the text capitalizes the words "Exponential" and "Standard," even places quotation marks around the latter word. This is evidence of the fact that the transcriber has heard something that makes these words special, to be capitalized or placed in quotation marks. That is, the teacher makes available for Henry and Mary that these words, in written transcription, may also found on the computer monitor. The transcriber, in making the transcription choices that s/he has made, provides us with evidence that s/he has heard a differentiation that is then marked in the text by means of special textual features. Whatever it is that the teacher has made available in his voice would allow Henry to push the button on which the word "Standard" is written if the teacher were to say "push 'Standard'" without having to wonder just what he has been instructed to do: to push a button rather than to push the screen where the word "standard" can be found.[17]

In the present instance, however, turn 11 itself becomes the opening part of the next turn pair 11|12. It can be heard as a confirmation that the preceding action has made the "it" "become good," but that it also has left an insufficiency:

11. Teacher: Yes, there it becomes good.

[17] Elsewhere I provide an extended analysis of how speakers distinguish, for example, direct speech (i.e., quotation) from indirect speech and quasi-direct speech (Roth in press).

12. Henry: Yes, how to get them equal? Henry refers to the y-axis on the other graph.

In the "Yes," we have a third instantiation of the evaluative aspect with respect to the preceding turns; but this "Yes" is followed by what has been heard as a question. In fact, we might gloss[18] the transcribed locution in this way: "Yes, 'it' 'has become good', but how to get the two graphs equal is the real question." Whether this gloss describes the manner in which the actual locution is heard *in this situation* can only be answered by looking at the turn pair as a whole (i.e., with this turn as the first part), a turn pair that interlocutors would expand into a sequence of turn pairs if they were to find any trouble.

We may summarize the foregoing analysis in this way: Each locution belongs to two turn pairs, which therefore become *inherently* linked. They are different manifestations of the same unit (see chapter 1, Figure 1.1, p. 15). That is, in this approach, the conversation has an *inner* dynamic and constitutes a whole, unfolding process rather than being constituted by the independent contributions, expressions of two separate minds who have to interpret what the other says and who, at best, can have a taken-as-shared understanding. The preceding analysis transcends the psychology of individuals and, in so doing, the need to draw on «meaning» or «mental representation». By taking this approach, we are actually analyzing the *con*versation, which is our *transactional* (social) phenomenon, rather than the *individual* speakers, about whose inner makeup we can only speculate. By taking this approach, we are also forced to attend to what is actually public, what the interlocutors make available to each other, not in some metaphysical netherworld of ideas but in the concrete praxis of their societal relation that they contribute to produce, qua subjects, and to which, simultaneously, each subject is subject and subjected to. That is, from this perspective, we cannot think and theorize the subject as an independent contributor (see chapter 4). From a transactional perspective, the subject is constituted, in part, by its relations to other subjects and to the situation as a whole. As a result, each contributor, qua subject, also is a patient, subjected to and constrained by the transactional event. Without the constraint, a passive moment of human experience, there is no agency (Roth 2011b).

When we take the turn pair as the minimum unit, our analysis changes. We can no longer attribute actions to individuals, as some scholars claiming to do social and pragmatic analyses do (e.g., Johansson and Wickman 2011). Interactions, where individuals with their personal «meanings» and «mental representations» are taken as isolatable units, cannot explain collective phenomena. Typical for such analyses would be that they attribute "wordings" to students and distinguish them from wordings that a teacher or scientist might use. That is, words are attributed to one party in a conversation rather than to both; only the latter is consistent with the pragmatic position of Wittgenstein and the cultural-historical position of Vygotsky. If *joint* action is reduced to individual (self-) action or individual contribution to *inter*action, we no longer have a *social* phenomenon sui

[18] A gloss may be heard as a "lose" statement the specific nature of which comes to be delayed until further discussion has developed the discourse sufficiently to render the statement problematic.

generis. As a result, we would be in the same situation as attempting to explain the properties of water (a liquid) by means of the properties of hydrogen and oxygen (gases). Although any scientist knows that this makes no sense, (radical, social) constructivist analyses of *con*versations still do the equivalent explaining social phenomena by drawing on individualistic psychological properties.

«Conceptual» versus procedural

In the STEM literature, we often find a preference for the «conceptual» over procedural explanations to be produced by students and teacher. The ideology of STEM discourses privileges the «conceptual» over anything else that students might learn. This is also exemplified in the text I analyze here. Thus, for example, in the episode with the graph, the text notes that the teacher "gives the students a highly procedural explanation" (CSSE: 600). Throughout the text, the procedural aspects are treated as something of lesser value (e.g., "Their discussions are *only* related to procedural issues concerning the presentation of the graphs and *do not* touch upon more conceptually oriented interpretations of what the two graphs represent," emphasis added). Despite this choice, the text later observes that Henry "is about to make meaning of the graph" (ibid: 601). Something positive, therefore, has arisen from this highly procedural explanation. That is, the procedural has given rise to the «conceptual». But rather than looking for this transformation in the heads of the participants, I would seek for it in the relation that binds teacher and students into a transactional unit. Many Vygotsky-inspired researchers or researchers who employ the «cognitive apprenticeship» metaphor might have seen in the episode the presence of a «zone of proximal development» or of «scaffolding». Taking an ethnomethodological approach, we would alternatively ask what the work is that makes the situation such that researchers can identify this zone or scaffolding (Roth and Gardner 2012). Even the students and teacher might characterize the event as one of successful teaching or helping. But what is the work underlying the event so that it can be recognized as offering a zone of proximal development or as constituting scaffolding? What is it that teacher and students exhibit to and for each other so that they recognize each other as helper and helped? As noted, the text provides insufficient detail in its transcription to conduct such an analysis in the way it should be done. It provides insufficient detail that shows what the participants made available to and for each other to hear *what* they are saying from *how* it is said. In the following, therefore, I provide but a sketch along the lines that I would push such an analysis.

The students Henry and Mary do an important, integral part of this work. This has led me in other contexts to respecify the nature of a zone of proximal development as an instant where *all* participants learn and develop (Roth and Radford 2010). This learning and development includes the teacher or more advanced peer, in contrast to the normal framing of the concept, according to which the student alone is provided with learning opportunities. The episode begins with the identification of a problem, discussed by Mary and Henry, who agree to call the teacher. That is, there is an initiation of the interaction that is brought about by the students who call for assistance. More so, the students also articulate that they "have major problems with Excel" (CSSE: 599). That is, we observe more than a

teacher helping students: the students themselves articulate at least part of the problem to be addressed. It is a problem with the spreadsheet program *Excel*.

Before proceeding with this analysis, a note on method is relevant. I normally do a "first-time through" analysis, where I analyze a transcription and tape from the beginning without knowing what will happen later. I then can produce hypotheses about what might be happening, and test the hypotheses at subsequent stages of the analysis. At this point, therefore, I might actually be led to anticipate that what the teacher will do is help the students with Excel, that is, articulate something procedural rather than something «conceptual».

In this episode, Mary has already articulated the location of the problem in the Excel program. Yet the teacher asks: "What are you struggling with?" (turn 4). In this, the teacher is not just asking a question but also formulating the preceding description, the problem being with Excel, as insufficient to help. But rather than ascribing turns and actions to individuals, we need to look at the social phenomenon sui generis.

> 4. Teacher: What are you struggling with?
> 5. Mary: Yes, well. The diagram doesn't look right. What is this? *Mary points to the y-axis on the upper graph* (see Fig. 6). The unit is probably kilo, but 0,7 [sic] and so on . . .
>
> (CSSE: 599)

What is the nature of the problem, which we know to be in the context of the software? The interactional work that follows first identifies the problem and then the solution. In the first transcribed turn unit, we observe an invitation–acceptance pair: the teacher invites the students to specify the problem and Mary accepts (turn 5). The two locutions *together* produce the invitation|acceptance or question|reply pair. There is joint action at work, and this joint action cannot be reduced to individual self-action or contribution to *inter*action, just as the properties of water at room temperature and standard pressure cannot be derived from the properties of hydrogen and oxygen under the same conditions. In this way, members to the setting produce the beginning of a structure that might be glossed as "clarification of the problem." This is a *transactional* phenomenon that cannot be reduced to the individual self-actions or their contributions to interactions even though the persons are required for really bringing the phenomenon about.

Actually, a lot of the work done is hidden in the transcript. For example, the text or its transcriber has already placed a question mark ("?") at the end of the teacher's locution to indicate that s/he has heard a question. But, from the perspective of a transactional analysis, this is not really relevant. To understand the *process* underlying this event, to understand the course that this event takes, we need to understand its underlying engine that drives the conversation. We therefore look at the pairs of turns to see whether there is indeed a question|reply turn pair. There is another locution followed by a question mark in the middle of Mary's turn 5. It is difficult to say much here, because the text does not provide an indication whether there are pauses and, therefore, whether Mary continues to speak because there is no response to the offering to begin a question|reply turn pair. As transcribed and presented in the text, there is no evidence that such a turn

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of individual actors, to whom we may all too easily ascribe psychological properties, self-actions, and contributions to *inter*actions, I move the analysis to the transactional (social) level. Social phenomena are not plagued by things like «personal meanings» or «representations» of some phenomenon. Rather, transactional phenomena have a dynamic of their own, a dynamic that cannot be explained by taking recourse to individual phenomena, produced in solo performance or performance with others. I draw on the physical-chemical phenomenon of water, hydrogen, and oxygen as an analogy to bring into the foreground the need to do unit analysis when it comes to *social* phenomena. To explain the properties of water, we need to take a water molecule as the fundamental unit rather than the properties of its elements hydrogen and oxygen. In the literature, however, researchers try to explain *con*versations, social phenomena, by taking recourse to individuals and their properties.

We may use another physical phenomenon as an analogy for transactional phenomena involving humans: Benard cells. When water is placed between two copper plates the extension of which is large compared to the distance of a few millimeters between the plates, one can observe random movement when the plates are at the same temperature. If one plate is heated until a specific temperature difference is reached, the water molecules all of a sudden move in hexagonal (Benard) cells arranged like the cells of a honeycomb. Now this behavior cannot be derived based on our knowledge about the movement and relation between water molecules. It cannot be derived on the basis of our knowledge about the copper plates and their temperatures. Rather, a totally new phenomenon, a new form of order, emerges from the details of the configuration. This new phenomenon (order) *cannot be* reduced to the water or the plates or to the interaction of water and plates. It can be explained only from the entire experimental set up involving *this* configuration. It is a whole new phenomenon of order that cannot be reduced to independent constituents.

In the same way, a *con*versation and the *social* relation it implies needs to be seen as a complex, transactional phenomenon that cannot be reduced to the individually identifiable constituent parts. As soon as we consider the parts individually, we can no longer get to the complex phenomenon. We then also have to let go of «meaning» and «mental representation», inherently the properties of individuals. We can no longer explain a complex phenomenon by reducing it to constituents. The only way to get at an appropriate explanation is by considering the social unit as irreducible and by developing an explanation entirely in terms of this new transactional unit. This approach, then, has repercussions on how to theorize the individual, the subject, and its subjectivity. This is the topic of chapter 4.

4 «Meaning» and the subject

The problematic notion of «meaning» is not specific to the currently dominant (radical, social) constructivist discourses; it reappears in virtually unchanged form in discourses that use the adjectives postmodern and post-structural to distinguish themselves from other STEM discourses. This chapter aims at contributing to the building of a post-constructivist theory in STEM education by reframing the discourse about the subject. In a post-constructivist theory, the subject no longer has or makes «meaning» or constructs «mental representations». The purpose of this chapter is to re/write two major theoretical positions in the field: with respect to (a) L. S. Vygotsky and the activity theory he gave rise to, which are subject and subjected to critique and (b) Lacan and his theory of the subject, which radically change signification in and through their adoption in the book. The present chapter should be read as a contribution to an ongoing dialogue on theory, incomplete and partial, as (perfectly) imperfect as our STEM discourse as a whole. Although this text emerged as a critical reading of *Mathematics Education and Subjectivity* (Brown 2011), it in fact constitutes a commentary on the current attempt to overcome, by means of a pragmatic approach, the prevalent constructivist discourse that dominates the STEM literature concerning «meaning» and «mental representation» and the implications thereof. Although some recent STEM discourses attempt to overcome the ravages of constructivist discourse, these yield "more of the same" rather than something different—as long as these discourses retain the same focus on «meaning» and knowledge. Even though supposedly post-structuralist and postmodern—e.g., exemplified in *Mathematics Education and Subjectivity*—current STEM discourses constitute the same kind of metaphysical pursuit that has been the subject of much of the mostly-misunderstood critique produced in largely French philosophical writings during the latter part of the 20th century—including scholars such as J. Derrida, G. Deleuze, J.-L. Nancy, or J. Kristeva.

The role of dialogue and re/writing

> The philosophers only *interpreted* the world differently; but the point is *to change* it. (Marx/Engels 1846/1958: 535, original emphasis)

Karl Marx realized that not only do life and the world change but human beings—although we are subject to and subjected to *not only to the social* but also the ma-

terial conditions of life—can also, qua subjects of activity, change the conditions. Some of the changes Marx writes about are intentional; other changes, like those related to the working of the incarnate material body that produces mathematical communication, occur unintentionally (e.g., we tend to get better at drawing geometrical diagrams by drawing them). Participating in STEM dialogue means listening/reading and speaking/writing, both of which are processes (in the sense of "activity" as Aktivität, aktivnost', explained below) that change us—participants in STEM education culture. This is why the discourse exemplified by *Mathematics Education and Subjectivity* (MES) is an important contribution to the STEM field: it changes us, whether we agree or disagree with it. Constructivism presents us with a set of ideas, an *ideo*logy, and like any ideology, it has its blind spots.[1] In this critical analysis of STEM discourses exemplified in *Mathematics Education and Subjectivity*, I co-articulate those phenomena that fall on the blind spots of this discourse. Taken care of blind spots is important because, as we know from driving a car, if we are unaware of the blind spot (i.e., rearview mirror), dangerous accidents may happen. But there is so much to say. In this chapter, I am barely able to scratch the surface of the topics I have marked as needing to be addressed in my conspectus of the book and associated marginal notes; and while writing the present chapter I was wishing to be in the situation of Derrida, who sometimes gets to write a whole book to articulate his commentary on an article while complaining that he does not have enough space.

There is much in current STEM ideology that not only has to be deconstructed but also calls for deconstruction. As I point out in chapter 3, "to deconstruct" does not mean to destroy theory, but to take apart so that we, STEM educators, can rebuild it: "Deconstruction, if there is, is not a critique, even less a theoretical or speculative operation, but if there is one, it takes place . . . as experience of the impossible" (Derrida 1996b: 73). Writing (*écriture*) is a suitable theoretical metaphor, because it also means erasure. With every new word, (the old) language dies and (a new) language is re/born. This is consistent with the sociological approach to linguistics, which holds that every statement changes language (Vološinov 1930). A (theoretical) language is dead—unchanging as Latin—precisely when it is no longer spoken or re/written. Writing in STEM education troubles, in fact, rewrites STEM education even at the instant that it reconfirms the field. This is so because every text that writes STEM education, in writing it again (rewriting) and thereby writing it anew, also erases (a bit of) STEM education.[2]

It is in this way that I understand the fundamental goal of post-modern attempts in STEM education, exemplified in *Mathematics Education and Subjectivity* (MES)[3], to build a new theory, which, as all "new theories can trouble more familiar approaches in mathematics education research where standalone 'humans' apprehend distinct mathematical 'concepts'. The theories can disturb conven-

[1] This comment about a system of ideas is value also for the discourse of this text.

[2] The same is the case for any one of our beliefs or forms of knowledge (e.g., Roth 2012a). If we had to carry around all the beliefs we once held, our minds would have to be tremendous storage spaces. With a new belief or knowledge, therefore, much of the old is erased to make space for the new.

[3] As in chapters 2 and 3, the text I analyze, *Mathematics Education and Subjectivity*, is but an instant of a discourse rather than a particularity of its author (T. Brown). I therefore refer to the pages in this book by means of the acronym *MES*.

tional understandings of what mathematics is and how it exists in an 'objective' sense" (MES: 2). Born in an intense engagement with post-modern discourses in STEM education, one manifestation of which we find in MES, the present chapter not only comments but also rewrites, and therefore, erases its subject: STEM education and subjectivity. In its partiality it should be read as a contribution to an ongoing dialogue, incomplete and partial, as [perfectly] imperfect as the post-modern or post-structuralist discourse itself. In writing theory, both the post-structuralist discourse and the text I sign do not only interpret the world differently but also change it by contributing to the re/writing of STEM education and subjectivity. Writing is re/writing, and therefore dialogue. There would only be death if we were ever to achieve a final (ideal) state when no change would be required. This is why I permitted myself to author this partial commentary on post-structuralist, post-modern discourse in STEM education with a critical tone: to engage in and continue a dialogue. Without such dialogue, STEM education would not exist: for everything ends when dialogue ends (Bakhtin 1994).

The first aspect of theory that we need to overcome is the creation of a divide between the mental and the physical, a divide that is maintained when we separate sound-words from non-material things such as ideas and «meanings» and the inaccessible «conceptions» or «mental representations» that require application or grounding to be connected to the material world. A first step to overcome the contradictions of metaphysical approach, in which «meaning» and «mental representation» have their place, is to work towards a *materialist, concrete, social* human psychology. Here the adjective "social" is used to indicate a *transactional psychology*, which, by its very name, questions traditional assumptions about the *independent* subject engaging in *inter*action with others. In interaction, the subject is a unit, an element that contributes to the action and, in so doing, is influenced by the other. In a transactional social psychology, the social situation and joint action is itself the minimum unit so that the individual no longer may be identified as thing-in-itself. Who someone is depends on the whole activity, and, therefore, on all other participants and relations. In a transactional approach, the person is not an element because it characterizes the activity as a whole and therefore all the other participants.[4] A transactional social psychology, as the title of one article/book chapter aptly notes, is a step towards establishing a *concrete human psychology* (Vygotskij 2005). This concrete human psychology makes it unnecessary to seek recourse to otherworldly «meanings» and «mental representations» that are inaccessible to those inhabiting a completely material world.

A *materialist* social psychology

The current "social constructivist" scholarship does injustice to L. S. Vygotsky, his psychology, and the school it has given rise to. This is so because ideas fundamentally inconsistent with current forms of Western constructivism have absorbed

[4] Physicists and mathematicians know this phenomenon all to well. Although some systems of differential equations can be solved by a separation of variables leading to independent equations, there are many systems that do not allow a separation of variables. In this case, the equations cannot be solved separately for different variables. The variables in equations may serve us as analogy for people in social relations.

fragments from a theoretical system that as a whole is antithetical to it. In part, poor translations of the Russian scholar's work into English can be blamed for the misunderstandings, which exist, for example, around the concept *značenie slova* translated as "word meaning." This term is taken up and employed in the manner of «meaning». However, *značenie slova* is a continuous *process* rather than a thing attached to the word (Vygotskij 2005). It is observable in the story of the six drunken artisans (see chapters 1 and 3), where the same word *does not «mean»* the same but rather has very different functions each time it is used: "The real word-meaning is not constant. In one situation, some word obtains one signification in another a different signification" (ibid: 1003).

Another drastic example of the misreading that occurs in the concept of the zone of proximal development in the context of which many STEM scholars might say that "children are brought into the social world" (MES: 117). But *socialization* is Piaget's constructivist position—who "accustoms us to interrogate the genesis of the social world in individual consciousness" (Lacan 1966: 652). Vygotsky *theorizes*, explicitly citing the pragmatically oriented Marx, that through the child, the societal (social) becomes individualized and concretized (e.g., "societal functions . . . become functions of the personality" (Vygotskij 2005: 1023) and "development proceeds not toward socialization, but toward *individualization* of societal functions" (Vygotskij 2005: 1025, original emphasis, underline added). We note that in his native language, Vygotsky uses the adjective "societal" (obščestvenn'ix) rather than "social" (social'nix), which allows us to understand immediately the reproduction of classist society. First, young working class people tend to interact with their families and friends in their neighborhood, which, because of the societal nature of their relations (i.e., obščestvenn'ix otnošenij), are individualized into the consciousness and being of the next generation of working class adults. In a post-constructivist approach we would understand child development as much as a process of individualizing the social as it is the socialization of the individual, the two developmental processes constituting but manifestations of the same phenomenon. Thus, Vygotsky's sign (artifact, tool) is not a mediator, as we can often find in the STEM literature, but "the subjective reality of an *inner voice*, born of its *externalization* for the Other, and thus also for oneself as for the Other within oneself" (Mikhailov 2001: p. 17, original emphasis).

Rather than thinking of development in the zone of proximal development as a "neutral place" (MES: 117), Vygotsky explicitly relates development to "*societal* ideology," which "corresponds to a psychological structure of a specific type—but in the sense of a subjective perception and ideological medium" (Vygotskij 2005: 1028). His concern is for the development of what is specifically *human* in human individuals. We are *human* precisely because of the *societal* relations that the *human* individual contributes to producing and transforming. Vygotsky intended to build a psychology based on Marxist principles of the transformation of the world through human praxis. He understands his work as "the child of revolutionary psychology" (Vygotsky 1927/1997: 338) and suggests that "we must create our *own Das Kapital*" and that "[p]sychology is in need of its own *Das Kapital*—its own concepts of class, basis, value, etc." (Vygotsky 1927/1997: 330, original emphases). The current uptake of Vygotsky, therefore, appears to be misrecognizing his transformative intent ("in the theory of class struggle: Marxism and individual

psychology must and are called upon to extend and impregnate each other" [Vygotsky 1927/1997: 341]) and transformative potential of this work. Rather than using Vygotsky to theorize how children are subjugated to the ruling relations of society—by reproducing patterns of inclusion (middle class students) and exclusion (working- and under-class students)—Vygotsky's work should be used to work toward a transformation of the ruling relations. He was interested in overcoming the individualization, which, as an integral and dominant part, rests on the assumption that we «make meaning» or «construct representations» *individually*.

Recent conceptualizations of Vygotsky's concept of the *zone of proximal development* do show how *teachers* learn and develop in the very societal relation that also is the basis for learning and development on the part of the child (Roth and Radford 2010). Teachers, as much as the children they teach, are subject and subjected to the society and culture, which they, as agential subjects, reproduce and transform together in the *societal* relations that they entertain. Surely, class struggle means to transform societal relations rather than simply "to bring students into existing practices" (MES: 6). Current STEM discourses, exemplified in *Mathematics Education and Subjectivity*, articulate some of the issues that arise from the perspective taken on a psychology that Vygotsky has fathered and, in motherly fashion, gave birth to and that has been of increasing interest over the past three decades, i.e., cultural-historical activity theory (Roth 2004a). The latter provides the tools to deal with the theoretical shortcomings of constructivist discourse and its vestiges in postmodern and post-structuralist STEM discourse.

The structure of (scholarly) activity (Tätigkeit, dejatel'nost')

Cultural-historical activity theory is a pragmatically oriented form of social psychology originally conceived by Vygotsky and subsequently developed by his coworkers and students, most prominently A. N. Leont'ev. The work of the latter was subsequently developed in two independent lines, one concentrating on the structural aspects of activity, the other one on its dynamic and subject-oriented aspects. The latter is especially relevant to the STEM literature in the way that it has been developed into a *science of the subject* (Holzkamp 1983). In the Anglo-Saxon literature, there is a confusion of two very distinct Russian/German terms, both of which are translated into English as "activity." The confusion is deadly for anyone who wants to do good activity theory or who wants to critique its weaknesses. *Tätigkeit/dejatel'nost'* (activity) is a collectively motivated and structured configuration that meets a generalized (collective) need. Farming produces grain or vegetables to meet the generalized human need to eat, constructing houses meets the generalized need for shelter, and schooling serves the handing on of cultural knowledge and the reproduction of society and (inequitable, iniquous) societal structure. Activity is the minimal unit of analysis of the life of the material subject (Leontjew 1982); that is, cognition, subject, subjectivity, emotions, motives, motivations, beliefs, or learning are unintelligible unless we take into account the totality of the activity realized by the actions of an (individual, collective) subject (Roth 2007). The noun *Aktivität/aktivnost'* (activity), on the other hand, names a process that is not oriented toward a collective motive: For example, activity theorists might refer to the Aktivität/aktivnost' of consciousness to indicate that conscious-

ness is busy doing something irrespective of the Tätigkeit/dejatel'nost' and its motive; it is mere vital business. When students measure or calculate the area under a string suspended in a church from anchoring positions at different heights, they participate in the activity of schooling; when students do a titration in chemistry, they participate in the activity of schooling. But what they do is a task, the purpose of which they cannot yet know (Roth and Radford 2011): in the absence of a motive, they complete an Aktivität/aktivnost'.

The notion Tätigkeit/dejatel'nost' is important because it constitutes a minimum unit for identifying intelligibility. It is consistent with the network of signification that pragmatic philosophy has identified as that to which words accrue (Heidegger 1927/1977). Knowing words specifically and language more generally is indistinguishable from knowing one's way around Tätigkeit/dejatel'nost'. The latter *always* is societal. We do not require «meaning» as a theoretical term denoting something that stands over and above the word in some metaphysical realm. Speech activity is part of practical, material activity; in its first function, it is not about this material activity but subservient to its motive.

In the Anglo-Saxon STEM literature, we find the term "social" in articles and books that (only) apparently espouse the works of Vygotsky and Leont'ev. In most instances, activity theorists—like Holzkamp and Leont'ev—would use the adjective "societal." Even Vygotsky uses the term, for example, when grounding his ideas in Marx. But English translators of Vygotsky and Leont'ev, however, frequently translate the German and Russian terms for "societal" (*gesellschaftlich*, *obščestvenn'ix*) by "social" (*sozial*, *social'nix*), thereby changing the texts in significant ways. A problem of the social may be local, between two people, but a *societal* problem always pertains to the political system (ideology) as a whole, even if instantiated between two people. Retaining the adjective "societal" would mean introducing and reproducing the political and ideological dimensions of STEM education, dimensions important to those who do work in ethnomathematics, ethnobiology, ethnoscience, or traditional ecological knowledge. That is, the critical potential of activity theory gets lost when analysts focus on the social rather than on the societal dimensions of human praxis.

Postmodern discourses assert the existence of significant differences between tasks in which STEM educators aim at teaching a specific concept and tasks in which mathematics educators pose a specific problem. Thus, for example, someone might be held accountable for his/her attempt to allow algebraic generalizations to emerge from specially designed tasks, whereas others are hailed as revolutionary changes in STEM education when students "predict by which pocket [of a pool table] the ball will leave" (MES: 152). From the perspective of activity theory, both are tasks that realize the activity of schooling: a *societal* rather than merely social issue. This task is institutionalized, with attendant institutional structures and relations (of ruling, power), division of labor, rules, means of production, or community. Because of this organization, instructors are located differently than their students, have different responsibilities, and are differentially accountable in and to the institutions. Thus, our teacher education and graduate students still seek diplomas, for which they *have to take* certain courses, receive grades or pass/fail marks. The fundamental conditions of mathematics education *have not been changed* when the task conditions are changed a bit.

Similarly, there is a difference with respect to the relation between reader and author than what some STEM scholars tend to emphasize. We can sometimes find extended critiques that the research literature is irrelevant to teachers. There is indeed a point to the point such scholars make, but there is also an apparent naiveté in the argument—from the perspective of Derrida. Thus, such STEM scholars charge research studies with not addressing teachers or policy makers without asking whether it is possible to use exactly the same sequence of words (narrative) to meet the needs of all possible audiences (e.g., "Yet such teachers, or those managing their work, are not conceived as part of the research audience" [MES: 100]). Do we tell what has happened to us during any particular working day *in exactly the same way* to our five-year-old son, our STEM education colleague, the hairdresser, or spouse? We don't! Inherently, what we say about the day and how we say it will be *for* the person, whose linguistic repertoire we anticipate (see below), whose level of language is one that has come to us from culture generally, and to a specific instantiation it returns specifically. Why not view writing from the perspective of societal relation, where we theorize the individual statement as the effect of the relation rather than as some independent singular production that implements the intent of the speaker only. We need to think about discourse and work not from the perspective of the act of *individual* speaking and producing something like «meaning» or expressing «mental representation». Instead, we need to analyze talk from the perspective of listening and responding, which involve the hybridization of voices rather than the monologic voice that points us to «meaning» and «mental representation».

Activities as (language) games

Constructivist discourses focus on the stuff students «construct» and associate with words: «meanings». These are viewed as specific to individuals, who are said to construct and then hold «personal meanings». This discourse remains unchanged in the so-called postmodern and post-structuralist approaches. To come to grips with the contradiction that postmodern discourses articulate for their readers consider the following analogy between activities (*Tätigkeit, dejatel'nost'*) and games. As pointed out in the preceding chapters, rather than trying to get at the «meaning» of words, or at the «mental representations» thereof, we might think about words in terms of games. Games are the kinds of things we play in the real world. Just as we walk without thinking where to place our feet, so we play games without wondering about «meaning» and «mental representations». Activities and games involve subjects (players), material entities (objects, tools), rules, division of labor, and forms of transformations (actions). Whereas one may state that "all mathematical concepts can be understood from a multitude of perspectives and indeed the concept can often be uniquely a function of that perspective" (MES: 148), such statements are understood differently in light of the analogy of a game. Once I decide to participate in a particular game (activity, mathematical domain), then it is evident that I am not only the subject in/of the game but also *subject to* its «rules». But these rules are not something in the abstract. In chess, for example, there are rooks, kings, bishops, queens, knights, and pawns. To play, I do not require to know the «meaning» of a king, bishop, queen, knight, and pawn.

All I need to do is move these pieces. But within the game, my moves are constrained. However I might look at ("interpret the «meaning» of") a king, whatever I might imagine when I see such a figure, whatever the «meaning» a researcher might impute to me, when I participate in playing *chess*, then there are admissible and inadmissible moves, the latter being disallowed in the game of chess. I can use the board and figures to play according to different rules, but then I am no longer playing chess. Although different individuals may claim to play "football," they may in fact play American football, Canadian football, rugby league, Australian rules or footy, Gaelic football, or rugby union. Even "Do you see what I see?," which allows me to see a cloud in very different ways, is played according to specific ontologies (entities, rules, moves) and a violation of these means that I am no longer playing that game—which is entirely possible and may lead to interesting curriculum dynamics—or that I have made a move that is not allowed and therefore am subject to penalty (yellow and red cards in soccer, 2, 5, 10- or game suspension in hockey, fouls and foul-out in basketball). Participating in the playing of the game is not about «meaning» and «mental representation»: it is about keeping the game alive.

We can already read about how such games come about and are kept alive, including the one called "geometry" that is played in the mathematical community and in school mathematics: anticipating Lacan and Derrida, Husserl notes that there is a "free play of associative constructions" (Husserl 1939: 213). It is precisely for this reason that the creators of games need to and do in fact "put a stop" to this free play. I can play different games in which the sound-word or written word of "circle" comes into play, but if I play at the (language) game of (classical) "geometry," then the rules are fixed just as these are when we play hockey, chess, or football. Husserl uses geometry as an analogy for describing cultural processes in general—it was written as part of the "crisis of European sciences"—and he also suggests what happens in a particular science to counter this cultural process. Thus, scientific works are written in such a way that alternative readings of the data are made all but impossible.

From this perspective, it is difficult to understand why anyone in our STEM fields would complain that the "individual is obliged to use these languages if they are to be included in social exchanges" (MES: 105). If I want to participate in playing a game, then I take up its object/motive, including the rules by means of which we collectively play the game. It makes little sense to complain that "[i]n this way the human subject identifies with something outside of himself. They see themselves in the social languages, but the languages never quite fit" (MES: 105) because the difference between inside and outside is sublated[5] in my participation. This is so because my decision to participate in some game anticipates the dual role of being the active *subject of* the game and *being (pathically) subject* and *subjected to* it simultaneously. It is only through my (pathic) subjection to the game that I also can become the (active) subject in the game. I cannot be the subject of a game, participate in it as an active player, without also subjecting myself to it.

[5] The verb "to sublate" translates the German *aufheben*, which has both the sense of "to cancel" and "to keep." The verb is integral to dialectics as G. W. F. Hegel developed it, where an outer contradiction between the manifestations of a phenomenon is cancelled but the inner contradiction within the phenomenon is retained.

Much of post-modern/structuralist discourse runs up against a wall because it focuses on individual agency rather than theorizing STEM activity in terms of the dialectic of agency and passivity. That is, this discourse confronts a problem arising from its own discourse, much in the same way that Zeno's paradox is a function of the language it is framed in. The problem disappears as soon as we choose a different language. Once we choose a (language) game in which we want to play, we are subject to its rules (unless we create our own game, but this is not what schooling is about). This also means that there cannot be a "free play" of «meanings», personal or otherwise, which occur in some transcendent netherworld; there are real games where people hold each other to the rules in play. Thus, for example, the relation $x^2 + y^2 = 5$ defines a circle only in a particular game, where it constitutes one of the relations between objects given certain conditions. So the statement "We all know what a circle is but some people may not know that $x^2 + y^2 = 5$ defines a circle" (MES: 147) cannot be correct as such. The moon, sun, ball, and shape on a piece of paper, though classified among circular objects, *are not* circles—the latter belonging to the class of idealized objects that mathematics (geometry) is about rather than the "original materials of the first sense constitution" that are the "ur-premises [*Ur-prämissen*]" that present themselves "prior to all sciences in the world of life, which is not merely material Umwelt but already constituted cultural Umwelt" (Husserl 1939: 219). These ur-premises come from the lifeworld that we are familiar with and encounter while becoming conscious of our surroundings—e.g., when growing up through the baby, infant, toddler, and child phases—and prior to having any capacity to «construct» «meaning» and prior to having any «mental representation». In growing up, we discover these ur-premises as the facts of our lifeworld that is *given to us* together with the sound-words rather than being actively constructed (Husserl 2008).

The corporeal material dimension of (societal) life

> The incarnation of the subject is therefore the possibility of signification, the donation of sense and the sense of donation and far from being incompatible with significance, materialism . . . describes its structure. (Franck 2008: 63)

Incarnation and the corporeal dimensions of societal life are necessary to understand any signification (i.e., «meaning»). That is, rather than seeking to explain human behavior in terms of inaccessible because *meta*physical «meanings» and «mental representations», which require special research methods to be identified, real human beings make available to each other everything necessary for conducting *this* world's businesses. But post-structuralist/modern discourse has a blind spot with respect to the non-thematic experiences of humans that exist in excess of language. Thus, these discourses evoke forms of experiences that its language cannot describe. For example, the teacher "Tony Brown" requires his students to engage in tasks, in one of which these end up walking "the loci of certain geometric objects" (MES: 18). They create figures or computer representations of what they have done, for example, when implementing the instruction "*walk so that you are always equidistant from your partner who is standing still* (circle)" (MES, p. 18). What is presented in the instruction, figures, or computer «represen-

tations» is precisely the «represented» but not that which resists «representation»: the force overcoming the resistance of the body to walking, the opposition of the body to gravity, or the walking of the walking—that is, everything that a recipe *does not and cannot «represent»* to instruct us in the baking of bread, constructing a mathematical proof, or producing a mathematical generalization. It is precisely this non-representable that is constitutive of intelligibility generally and mathematical or scientific intelligibility specifically. Precisely because the Freudian unconscious is structured like the conscious it cannot explain all grounding of human knowledge in the pre-noetic experience of the flesh (body).

The body/flesh is a blind spot for a post-modern/structuralist discourse that focuses on «meaning». We note this every time that a scholar makes reference to J. Derrida's phrase "There is no outside-text" (*Il n'y a pas d'hors-texte,* Derrida 1967: 227). But the body/flesh is necessary for any reasonable theory of learning, as can be found from the following task for the reader: Attempt doing mathematics without sitting in a chair, standing at a desk, walking in the garden, or however else we engage entities that we could modalize using the adjective "mathematical." Attempt to communicate mathematics or science without using your vocal cords, a pen, the computer keyboard, body orientations, or gestures! Attempt doing mathematics or science while drowning after the car veered off the road and into a river, while falling off a cliff during a hike in the mountains, or while receiving a dental implant! In all these situations, the *material* nature of human being provides affordances and constraints to what I (can) do. The ways in which our eyes move *determines* what we can see as objects that mathematics and science describe. I do not have to construct the conditions; we do not require language to be enabled or disabled. There are aspects of human experience that the focus on language does not and cannot capture precisely because language constitutes a generalization of experience; it therefore cannot stand for or depict those aspects that are precisely our own, in my body. Derrida, despite all assertions made to the contrary, recognizes the need for the tension between ideal sense («meaning») and material being that founds mathematics: in the concept of *khôra.* The difference between the material and ideal is the same difference that separates Being (*das Sein, l'être*) and beings (*das Seiende, l'étant*), this is the non-location of *khôra*, the spacing where all things including mathematics and science originate. The philosopher emphasizes that we must not conflate the two in stating that "there is *khôra* but *the khôra* does not exist" (Derrida 1993: 32). If we take the stated position of postmodern discourse, where everything is reduced to the text and its «meaning», Being, and therefore *khôra* as well, will fall on a blind spot.

There are two related, but mutually irreducible dimensions to Tätigkeit: it is material and ideal. Consciousness constitutes the (ideal) reflection of material Tätigkeit. Idealist conceptions focus on this (ideal) dimension presupposing that we can understand what a human subject does considering mind alone. These conceptions include those developed by I. Kant and G. W. F. Hegel, but also (radical, social) constructivism, information processing theory, and, pertinent in the present context, those (post-modern) theories that focus exclusively on text and the «meanings» and «mental representations» it produces in our heads, leaving out the real life material activity of human individuals in flesh and blood. This also includes Lacan, whose work is grounded in Hegel and Freud. On the other hand,

some STEM educators do take into account the corporeal dimensions of human life by focusing, as he does, on gestures, body orientations, prosody, and rhythm. Moreover, such work does indeed emphasize not only corporeality but also *inter*-corporeity, the *sensuous* dimension of human relations and the ethical debt associated with it (see below). That is, this work is grounded, as I show here, in a Vygotsky who is very different from the one depicted in/by the (social) constructivist and sociocultural STEM literature.

The corporeal-material dimensions of mathematical learning are important as it historically preceded language and linguistic consciousness—unless one accepts spontaneous creation of humans and their cognitive/linguistics capacities. Such an approach thereby overcomes the retreat of STEM researchers to hidden variables and phenomena, including «meanings» and «mental representations». In fact, nothing I do—speaking, thinking, walking, arguing, writing—is possible without material processes that enable and constitute life. When I look at an object and "see a cube," I am not actually seeing a cube. I never see the six equal sides, I never feel the twelve edges of equal length and oriented either in parallel or at 90° with respect to each other, and I never see the eight corners simultaneously. Even if I were able to touch all twelve edges, I would not *feel* the twelve-ness of the edges of a cube. From what appears on my retinas and in my brain, I "know" what will happen when I move the object in our hands; and this knowing *that* I can move and what will happen when I actually move arises from primary, arbitrary movements of my body prior to any conscious activity. Without speech organs that know how to move, I would not be able to say "x-squared plus y-squared equal five," without material neurons, I would not be able to think about "the locus of all points with same distance from a point," without hands and arms, I would not be able to make a circular gesture or write "$x^2 + y^2 = 5$" onto a chalkboard. As cultural-historical activity theorists (psychologists) take for granted that consciousness and cognition are *the consequences* of sensuous, corporeal material work (*leibliche Arbeit*) not its antecedents.

There is actually a reference to the body in the psychoanalytic literature subsequently taken up by embodiment accounts and discussions thereof in French philosophy. At the very end of his life, literally on his deathbed, S. Freud realizes that he might have overlooked the material nature of the psyche when he states that "[s]patiality may be the projection of the extension of the psychic apparatus. No other derivation possible. Instead of Kant's a priori conditions of our psychic apparatus. Psyche is spread out, does not know thereof" (Freud 1999: 152). That is, Freud realizes on his deathbed that the psyche is materially extended, and this extension constitutes the physical space that Kant has taken as an a priori of an enabling all forms of experience. This extension gets lost in theoretical approaches focusing on transcendent «meanings» and «mental representations», that is, idealist approaches that underlies much of what postmodern and post-structuralist discourses espouse.

Cultural history of societal life and «concepts»

Activity theory also allows us to understand the cultural-historical dimensions of the «concepts» themselves—and this is the point that is not generally recognized

at this point. In fact, in some places the postmodern STEM discourse conflates idealities (e.g., the concept of circle) with realities, material objects that have a circular shape (sun, moon, balls), and therefore also inappropriately takes up Husserl's (1939) study on the origin of geometry. To arrive at a *concrete human psychology*, we do have to think about and theorize STEM knowing and learning through the pragmatic-material reality of our lives and of those who historically preceded us in the creation of cultural knowledge handed down through artifacts and culturally specific praxis. Thus, the ancient Greek did not just «construct» ideas that have become foundational of what we call Western culture. Rather, material things surrounded the ancients: the *kírkos* (with the Latin diminutive *circulus*, ring), *kúbos* (die, to play with), *sphaíra* (ball), *kúlindros* (roller), and *puramís* (shaped like an Egyptian tomb). These everyday, material and experiential entities were subject to continual material refinement that made, for example, the different surfaces, angles, and edges of a *kúbos* increasingly the same. The Greek then began to think reflectively about what these everyday entities might turn into in the never-achievable *ideal* limit—this is the origin of thinking about an ideal world, consisting of ideal objects, which are materially realized always only in imperfect form (Derrida 1962). The pre-Socratic thinkers—Anaximander, Heraclitus, Parmenides—still could think in a different way, life as a form of continuously changing Being, but with Plato, ideas and the ideal came to have their own realm separate from material life.

Unlike what tends to be found in much of the STEM literature, we never encounter in the material world those circles, cubes, spheres, cylinders, or pyramids that matter to geometry—we encounter material shapes that are more or less good approximations of circular, cubical, spherical, cylindrical, and pyramidal shape. Just as the Banyankore[6] children that appear in MES, children in a Canadian second-grade class had a difficult time with sound-words such as /'sılınd(ə)r/ ("cylinder"), a foreign sound no longer related to the elongated rolling experientially real objects (trees) of the ancient Greek people (Roth and Thom 2009). The problem is not one of «personal meaning» that students have or do not have constructed or the «meanings» that are associated with the sound-word. The problem also is not one of this or that «mental representation» that would go with this or that sound-word. Rather, at issue is the existence of a lifeworld aspect where the sound-word has its integral place in the way the sound-words shoe, glove, chair, or table have in the everyday lifeworlds that we inhabit. These students are just unfamiliar with the language game played when these objects are concerned in mathematics classes. Here, it is not as frequently claimed that everything is in the discourse, but rather, the pre-noetic experiences of material life that we have since we are born—whether represented in consciousness or not—are *foundational* to finding our way around the worlds we inhabit. Unacknowledged in the STEM literature, Derrida frequently uses—as do the philosophers Norbert Elias, Maurice Merleau-Ponty, and Bernhard Waldenfels—Heidegger's notion of *Geflecht* (Fr. *entrelacs*) to make thematic the entanglement of the words with material (always collective) human life and, thereby, the inherent entanglement of the individual and collective. In a text highly relevant here Derrida notes: "The relation of

[6] The Banyankore are the people of the Ankore region in Western Uganda.

the gift to the 'present,' in all the senses of this term, also to the presence of the present, will form one of the essential knots in the interlace of this discourse, in its *Geflecht*" (Derrida 1991: 21). It is "in the knot of that *Geflecht* of which Heidegger precisely says that the circle is perhaps nothing but a figure or a particular case, a possibility inscribed" (ibid: 21). Circular objects and sound-words about circles are integral to particular games (activities) that involve specific language games (speech activities).

Because of the interlacing, the original presentation, pure presence, comes to be related to the non-present, itself made present through delayed representation. The "circle," the locus of a signifier par excellence, comes to appeal to the discourse concerning a set of points that all have the same distance *r* from a point *M*. None of those circular entities that students «construct» (e.g., drawings) in various ways meets this criterion, because these are only particular material instantiations which only in the limit come close to the idea of a circle.

«(Mental) representations» have a history, a point that STEM researchers only sometimes make, but that we can indeed find in the postmodern scholarly discourse. But did Husserl see "geometrical understanding as being linked to an implicit awareness of its historicity" (MES: 46)? Nothing could be further from what Husserl actually writes: "The trading of statements and methods, always enabling the construction of new statements, can continue uninterruptedly through time, whereas the *capability of the reactivation of the original beginnings*, that is to say the sources of sense for everything that appears later, has not been handed on" (Husserl 1939: 217, original italics, underline added). This is why my second-grade children in the study referred to above have a hard time with the sound /'sılınd(ə)r/, which, for the ancient Greek, was used in the context of a certain kind of rolling objects that they were familiar with in the context of their everyday lives. The children were familiar with elongated objects that they could roll on the floor, and the sound /'sılınd(ə)r/ was part of the games they played—e.g., trying to stand on a tree floating in water. In my study, in using the sound-word "cylinder" neither the two teachers nor the children in my second-grade mathematics class were aware of the historicity of the term or of its beginnings and the corporeal experiences in which it is grounded. That is, there was no implicit awareness of historicity, as the term "cylinder" is a dead metaphor (of corporeal experience metaphorically extended into discourse, in the sense of Lakoff and Núñez, 2000).

In the preceding paragraph, two terms appear that are central to the work of Derrida, which also allow us to link up with the work of Lacan. Unpacking these two terms allows us to think about the notion of «(mental) representation». The pair is constituted by "presence" and the "presence of the present," that is, the present made present again. Making the presence present requires, since Husserl (1928/1980), *re*-presentation. This leads to a difference between presence and the presence of the present. What postmodern just as constructivist discourses tend to theorize is only the latter, the language that affords the presence of the present. What this discourse does not theorize is presence itself. As suggested above, material, (bodily) presence (*Anwesen*) is associated with Being (*das Sein, l'être*) and the presence of the present with beings (*das Seiende, l'étant*). Between the two there is a gap, *khôra*, which, since Plato, is the generatrix of consciousness. Because the beings (*re*presentations, signifiers) can be reabsorbed by and into

Being, there is actually a proliferation the possible, leading to series of signifiers and signification (see chapter 3). For Derrida, *écriture* (writing) is the metaphor par excellence of this generatrix, because every instance of writing is an instance of re/writing and therefore also of erasing. That is, whereas everything that we can represent is, and inherently must be in some form of "text," not everything exists in the form of text. Text itself, as material entity, instantiates a form of Being (*das Sein des Seienden*), but may *appear* (manifest itself) in this or that form of beings. This is also where we join up with Lacan, as presented in the next section. As this discussion shows, rather than being preoccupied with «meanings» and «(mental) representations», we more profitably engage in a discourse about presence and the presence of the present. Words, in making something present that really is absent, constitute the ultimate contradiction: the presence of something actually absent, present in its absence.

For Vygotsky and his students, too, the ideal and the societal-material dimensions of life are related, because "*the relation between higher psychological functions was at one time a real [physical] relation between people*" (Vygotskij 2005: 1021) and "*the relation of psychological functions is genetically [developmentally] linked to real relations among people*" (Vygotskij 2005: 1024, original italics, underline added). These quotations allow us to understand that much of the current STEM discourse does not appropriately characterize consciousness when it states that the "Vygotskian formulation see[s] learning as the process by which cultural concepts are transformed into objects of (individual) consciousness" (MES: 166). Not only does consciousness arise from material activity, as Marx suggests, but also "language constitutes consciousness-for others as well as consciousness-for-myself" (Vygotskij 2005: 1018). Consciousness is not something in the metaphysical netherworld but characterizes what we are aware of in our everyday lives. For example, while hammering a nail into the wall, handy persons tend to be aware of the hammering but not of the hammer in the same way that we are not aware of the shoes we are wearing while walking. Consciousness, as the word suggests (from Lat *con-*, with, together, and *sciēre*, to know), is a collective phenomenon. *Self*-consciousness inherently involves knowing and being aware of oneself *in terms of the* with *that always relates me to the other:* "Self-consciousness exists *in* and *for itself* if, and by the fact that, it exists for another in and for itself; that is, it exists only in being acknowledged" (Hegel 1979: 145, original emphasis). A cultural-historical activity theoretic perspective, as for the pre-Socratic philosophers, sees culture as continuously undergoing change, and, therefore, learning as continuously occurring at both collective and individual levels, the two inseparably being the same in relations. From this perspective, there is therefore nothing special in the statement that "teachers and students, understood as human subjects, are presented as fluid entities responsive to ever changing social demands" (MES: 104).

The diachronic dimension of life and culture is precisely what cultural-historical activity theorists (e.g., L. Radford) emphasize so that there is not something like "mathematics," "the very state of" which MES intends "to disrupt," but there are forms of continuously changing activities in which entities and actions associated with and denoted by the label "mathematics" (or "science," "engineering," and "technology") also take part in a changing manner. Under certain condi-

tions, of the same kinds that govern games like chess or monopoly, what we observe today or tomorrow will bear a great deal of family resemblance with what we observed yesteryear. Artifacts like the playing field and other material entities in play contribute to the stability—chess in its present form emerged in the 15th century. Once we play the game in ways that others recognize as playing by the traded rules keeps the game continuously alive. This is so for the game of (Euclidean) geometry, which has been played virtually unchanged for almost 2,500 years. This game also is played in rather similar ways simultaneously around the world and throughout history. So a construction in geometry today looks like those that readers may have done during their high school years or the ones that PISA-leading or British students do today. Similarly, the game of science is kept alive by those playing the game of science according to its (implicit) rules. Here, there is no use for ponderings of «meaning» of objects and words in the same way as there is no use for pondering the «meaning» of chess figures. There are only ways of playing chess, where participants are held to account for their actions: certain moves will be called incorrect and others accepted as falling within the rules that are in play.

Texts, subjects, and audiences

Activity theory also allows us to contextualize another critique: the relationship between texts, their subjects, and their audiences. At issue are not «meanings» of words and texts but whether words and textual genres are appropriate for the intended audience. When STEM educators write articles, these are oriented toward their audiences, that is, the readers of the journals. Just as we give different accounts of a day at work when talking to a spouse, child, colleague, buddy in the pub, or the supermarket employee behind the fish counter, so mathematics educators write differently when they intend to publish in *Educational Studies in Mathematics* than in *Mathematics Teacher* and science educators write differently when they intend to publish in the *Journal of Research in Science Teaching* rather than in *Science & Children*. This is so because, as made quite explicit in activity theory (as in the phenomenology of everyday consciousness), the anticipated outcome of productive Tätigkeit takes into account the future use. The issue is not about «meaning» but whether the readers are familiar with the words and phrases, that is, whether they can relate these words and phrases to their familiar world. It makes very little sense to complain that there is little or nothing for mathematics teachers in a story intended for university-based STEM educators. We could redirect the same complaint at other articles in the STEM literature: it contains very little that elementary mathematics or science teacher could use to cope with the task of teaching algebraic generalization.

I do however agree with so-called postmodern discourses when they suggests that much of STEM education is focused on the tasks or cognition or learning irrespective of the larger questions concerning gender, social class, or culture. Thus, teaching about “circles” or “atoms”—that is, teaching the games where the circle or atom word has a place—where their native tongues do not have equivalent terms inherently disadvantages students, just as it disadvantages working class students or girls. The question is not at all about the «meaning» of the circle and

atom word—whether this is «personal meaning», «situated meaning», «constructed meaning», or any other suitably (adjectivally) modified version of «meaning»—but the use of such words in serious language games. The seriousness of the game of schooling, where students fail when their talk is about things such as "circles" and "atoms," is shown by its results: the reproduction of an iniquitous, inequitable society. In fact, the activity of schooling, as it historically has emerged and subsequently evolved, serves the (partial) needs of a middle class that the school as it is designed inherently reproduces. It is therefore a lie to claim that participating in schooling activity will lead to better futures for all students. Economists agree that a structural unemployment of about 7% is necessary for labor costs to be kept in check and, thereby, to control inflation. Even if every student were to have a PhD in mathematics or science (education), a well functioning economy would require 7% to be out of work and a number of about the same order would not even be looking for jobs (stay-home moms and dads, hobos, prisoners, chronically ill, [early pensioners]). In fact, on the evening of the day when I wrote this phrase, the French news reported high unemployment rates among Italian university graduates and periods spanning years before they find a first job. BBC online reported the same several months earlier. It is not only that spatial perception is regulated just for the fun of it: this regulation has a particular function in determining success, and it turns out that some groups in society are more highly represented among those who succeed (upper class, middle class, male) in mathematics than others (working class, under class, women, African American).

Discourse and/on the subject

Lacan is important because of the way in which he frames the sign and its use (see chapter 3). Throughout my engagement with postmodern (e.g., Lacanian) texts in STEM education (more frequent in mathematics than in science education), I had the sense that these texts are reading someone else: another Lacan or someone else's Lacan (see the next section on translation). Lacan's work has been used to redefine the subject in STEM education. Thus, for example, "Lacan's work enables a conception of subjectivity that . . . provides a bridge from mathematics education research to contemporary theories of subjectivity more prevalent in the cultural sciences" (MES: 5). But Lacan's project is a metaphysical one from which post-structuralist scholars distance themselves. We therefore have "to read Lacan . . . in a problematizing and non-dogmatic manner, one also has to read, for example, Husserl and some others, *read them in a problematic or deconstructing manner*" (Derrida 1996b: 78, emphasis added). To occasion a theoretical development in this conversation with MES, I therefore read it in a problematizing, problematic and deconstructing manner, while articulating some of those aspects of Lacan's writings that current postmodern and post-structuralist STEM discourses do not describe or explicate.

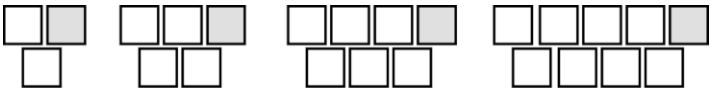
Lacan, signification, and the subject

In the discourse that F. de Saussure has initiated in linguistics, there are signifiers (e.g., words, images) and signifieds (i.e., the things that the signifieds point to). The

relationship between signifier and signified is one of signification (rather than «meaning»). Lacan (1966) provides a critique of the Saussurian conception of the sign, which associates a specific signified with a particular signifier. Thus, we have already seen in Figure 3.1a how a particular signifier has as its signified the image of a circle. A sign includes a signifier (top) and a signified (bottom). Lacan instead suggests that the signified s (below) is never attainable in itself but only mediated through an ever-expanding sequence of signifiers S (Figure 3.1b) (Saussure 1916/1995). However, the signifiers can become inscribed in the signified world such that—in the current example—otherwise identical doors come to be differentiated and different. Words have real consequences that matter to societal life rather than being mere shadows of (Platonic) ideas and «meanings». Perhaps because he mainly listened to the stories of his clients, Lacan never was concerned with their real material life but only with the *verbal* accounts his clients provided thereof (this is what Lacan says to constitute the difference between himself and Derrida). Even his unconscious is structured like the conscious, consisting as it does of the sedimented aspects of language (discourse). The unconscious is the collective consciousness represented in language. Not surprisingly, because Lacan focuses exclusively on language, more recent French scholars have categorized him among other *phallogocentrist* scholars (Plato, Freud, Kant, Hegel, and Husserl), denoted him a metaphysician, and listed him among other practitioners of metaphysical onto-mimetology.[7] That, is, Lacan and Freud can be critiqued for the very orientation that postmodern discourse questions in STEM education, for example, the attempt to inculcate «mathematical concepts» in, and indoctrinate children to, classical, Eurocentric (Greek) «concepts» of mathematics such as "circle," "pyramid," "atom," or "element." One of the problems of the presentation of Lacan in current STEM discourse is that for the psychoanalyst the mathematical object "circle" is not a signifier but the *locus of a signifier* that cannot ever be fixed because it is continually displaced and shifted. Just as the circle is the locus of points with a common distance from a given point, a signifier (for Lacan) is the locus (subject) of all other signifiers that point to it (e.g., drawings, words). But the life that the signifiers are *integral* to is a material life: real people of all sorts open one of the doors in Figure 3.1b to relieve themselves, a fundamental need that children have to meet before they have representational capacities and even the most primitive forms of life have such needs and undergo relieve.

It is not «meanings» and «mental representations» that matter. It is corporeal-material life. With the corporeal-material nature of life also enter passibility, pathos, and passivity into the picture that can appear in the Lacanian and STEM versions of the world only through the mediation of language. We do not need language to feel a need to pass through one of the doors in Figure 3.1b, to be in pain, to feel the resistance to understanding what $x^2 + y^2 = 5$ is all about; a child that has not had a breakfast because her coffee-growing parents are too poor does not need language to feel the pangs of hunger sitting at her desk asked to arrive at a general way of expressing the pattern in the following figure:

[7] Mimesis refers to the process of imitation. Mimetology is the study of mimesis. The prefix *onto-* refers us to the being of mimetology.



Lacan conceives of the subject as an effect of the chain of signification: "A signifier is that which represents the subject for another signifier" (Lacan 1966: 819); and, "without this signifier, all the others would represent nothing" (Lacan 1966: 819). In English, as in Lacan's French, "subject [le sujet]" is ambiguous and may refer to at least three aspects of a statement: the subject who makes the statement, the grammatical subject in the statement, and the subject of the statement (i.e. topic). Attention is therefore required to distinguish which subject we are re/writing (about). Here again, what matters is not «meaning» or «mental representation» but the use we, author and readers, make of the words.

An adaptation for the present purposes of several Lacanian diagrams yields Figure 4.1, which locates the real talking subject at the crossroads of a vertical dimension with the chain of signifiers signified by the vector $\overrightarrow{S.S'}$. The intersections show that the chain is oriented toward the other (O), who, through a temporally reverse effect, influences the intention i(O). The delta (Δ) stands for the differential that attempts to attain the barred signifier ($), which makes the vector $\overrightarrow{\Delta.\$}$ stand for the desire that so frequently appears in Lacan-inspired analyses. In an interesting twist of events, there are many representations in Lacan's *Écrits* that STEM educators generally and mathematics educators specifically would be familiar with, such as the vectors, sets, algebras, and so forth. Readers will see the mathematical discourse elements in the following excerpt:

> Now insofar as the battery of signifiers is, it is complete, and this signifier can only be a line that is drawn from its circle without being able to be counted in it. This can be symbolized by the inherence of a (-1) in the set of signifiers.
>
> It is, as such, unpronounceable, but not by its operation, for it is that which produces itself each time a proper name is pronounced. Its statement is equal to its signification.
>
> From which results, by calculating it according to the algebra I use, namely
>
> $$\frac{\text{S(signifier)}}{\text{s(signified)}} = \text{s(utterance), with S} = (-1), \text{ we obtain : } \text{s} = \sqrt{-1}\,.$$
>
> This is what the subject is missing in thinking itself as exhaustively in terms of his *cogito*, that which is unthinkable about him. (Lacan 1966: 819)

Are the signs (e.g., line, equal sign, parentheses, functional dependencies) Lacan uses the same as in mathematics? Are these analogies to mathematics? It is interesting that Lacan notes that the statement of the name equals its signification. In this, Lacan situates himself among Wittgenstein followers and the idea of language use: the statement is equal to its signification, or, in terms of what I consider to be the most problematic word in mathematics education generally (including this text), the «meaning» of the *statement* lies in its use.[8]

[8] Here I use "statement" rather than "utterance" to translate the Russian *vyzkazyvanie* that Bakhtin and Vološinov use.

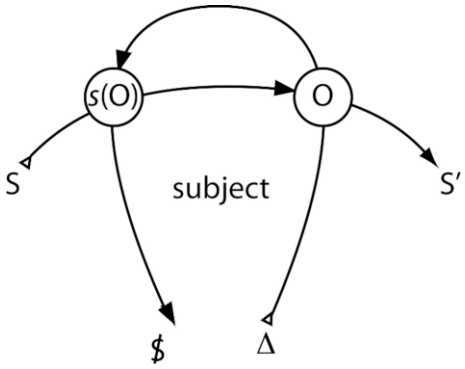


Figure 4.1 The origin and locus of the Lacanian subject.

How can Lacan or postmodern STEM educators think of the statement ("utterance") as something immaterial and divorced from the body? They focus on its repeatable parts: and not even that. It is only that part of the sound material that hearing recognizes as a content, leaving aside intonation, rhythm, speed, and so on. They also leave out that which is utterly singular in the voice, which allows us to recognize another person without seeing her, a recognition that is based not on the repeatable parts but on those parts in the material sound spectrum that belong to this person alone: timbre. It is precisely timbre, which is a function of my flesh: that I am I and no other. The incarnate, sensuous (corporeal) subject always is in a here and now, always grounded in the real world, not a subject lost in the cyberspace of discourse.

In Figure 4.1, "Ludwig Wittgenstein" would be the effect of the signifying chain that links the texts signed by all those reading him, with the co-signatories in the corresponding sequence of the reader perusing this book. This is so because the diagram expresses nothing other than the objectification of the subject in labor. In writing their journal articles and books, STEM scholars objectify and therefore alienate themselves. This diagram allows us to understand much of the argument of those (feminist, post-modern, post-structural, or critical) scholars, who deal with the politics of «representation», politics of mathematics, politics of schooling, including teacher training. This raises a question: "Is the place that I occupy as subject of the signifier concentric or eccentric in relation to the place I occupy as subject of the signified?" (Lacan 1966: 516–517). That is, one can be the subject of a statement in two ways: speaker and the spoken about, a point that I elaborate upon in the context of a concrete example below. Moreover, in speaking, I am also patient, subjected to the language (S) that through my mouth (or pen) returns to the other (O) for whom it is designed s(O) in the form of S' (Figure 4.1). Statements—which may be made by means of spoken words, poems, short stories, dramas, or novels—are always relational phenomena. As a consequence of the inherently societal relations, "We become ourselves through others" (Vygotskij 2005: 1021). It is evident that the Russian scholar has anticipated Lacan for whom

"The ego [Lacan] envisaged 'depends on the subject's relations with others'" (MES: 108).

Discourse, relationality, and subjectivity

One of the problems of much of STEM research is that it presents transcript excerpts without specifying the activity (*Tätigkeit/dejatel'nost'*) within which it occurs and without specifying the Other, to which the statement is irreducibly related, directed, and intended for. Classroom talk is oriented towards schooling. Its participants talk in the way they do because they are part of schooling rather than part of some other activity. In present STEM research, however, the discourse frequently becomes a-temporal and a-topical and, therefore, problematic as the subject (content) of the writing: literally and metaphorically. It appears to me more consistent with Lacan—even though I disagree with his leaving out the incarnate dimensions of human being—to take a relational perspective on the incarnate, sensuous (corporeal) subjects of mathematical knowing, learning, and subjectivity. Thus, for example, in a lesson that I describe and analyze in more detail, a second-grade student Thomas (t) has a turn; both teachers present, Mrs. Turner (T) and Mrs. Winter (W) participate in the exchange (Roth 2011a: 101–102). The research strategy for understanding relations is to take them as social phenomena sui generis. I therefore use as unit of analysis two consecutive turns at a time.

We begin considering the turn pair 26|28. Even though the intonation drops in turn 26, as it would in constative statements, we can hear it, after the fact, as a question because the turn sequence has the structure (question, beginning of reply). There is a long pause without completion of turn 28 in a grammatical sense or it completing a statement commenced by another speaker. The next turn sequence (28|30) can be heard as another pair: (incomplete reply, restatement of question). Using Lacan's notion of the subject, "Thomas" settles out as the result of the two turn pairs. We need to consider the sequence of two turn pairs, as turn 28 both completes the first of the two turns to produce 26|28, and it sets up the next sequence 28|30. We might *gloss* these two sequences in this way: Thomas did not and perhaps could not answer the first question, leading to a restatement or respecification of the question.[9] The subject Thomas as a student (subject) who «does not know» or «does not understand» «the question» (turn 26) is produced, even though nobody talks about him as a subject or person, in the manner in which the turns unfold. Thomas's own statement (turn 28) is an integral part of this production of the subject.

Fragment 4.1

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26 W: what does thAT one feel like. ((Moves his finger along the edge
```

[9] As suggested in chapter 3, a gloss is a temporary description that in many ways lacks theoretical tightness. It is used to assist readers to reach the intended level of theoretical tightness. Here, the statement is about Thomas doing or not doing something, which is actually inconsistent with an approach that takes the *social* as an irreducible unit. Each part of the following question needs to be bracketed and interrogated in the way indicated because it is, from the *social* perspective, an effect of the *joint* action that cannot be reduced to individual action (as the properties of water cannot be reduced to and explained on the basis of the physical properties of hydrogen and oxygen at the same temperature and pressure.

```
       [of a cylinder].))
27    (0.88)
28 t: it feels like um;
29    (4.26) ((Mrs. W moves his finger repeat-
        edly around the circumference)) ((Thomas
        has questioning look, Fig.))
30 T: does it feel the sAME or does it feel
        different;
31    (0.32)
32 t: feel different.
33    (0.93)
34 T: what is different about those two edges.
35    (0.77)
```

```
36 t: because um this one is round and this one is ap (0.48) isa
        square
37    (1.63) ((Thomas looks up to Mrs. W, as if looking for confirma-
        tion))
```

The production of turn 30 can be justified after the fact, for the next turn sequence 30|32 produces what turns out to be the sought-after response. That this is the case can be found from the next turn pair 32|34. In the turn pair "feel different" | "what is different about those two edges," the different feel is accepted (at least temporarily) as a proper response and now the nature of this difference is asked about. That this is a question in this context is available from the next turn sequence 34|36, which has the structure (question|reply).

A closer look at the transcript shows that some statements with falling intonations *are* heard as questions, reified in the nature of the sequence pairs. Or rather, in question|reply pairs, the first part also may be associated with falling intonation. As soon as we ask, what is Thomas's «meaning» or what does Thomas «mean» in uttering "feel different" (turn 32), we actually run counter to Lacan's recommendation to see the subject in its relation between signifiers. There is a chain of signifiers of which one signifier represents the subject for another signifier. This is so even and precisely in the situation where signifiers are repeated, such as in the case of "feel different" (turn 30), "feel different" (turn 32), and "what is different" (turn 34). Although the "different" may appear to be the same in this sequence, it is not, for each time it appears against a different, always changing background of "once-occurrent being" (Bakhtin 1993). Glossing the situation, we might say that Mrs. Turner "introduces" the term at this instant, Thomas takes it up being "cued" or "prompted," and Mrs. Turner now "deepens the interrogation" or "poses a follow up question."[10] Similar statements can be made about the verb "feel," which appears in turns 26, 28, 30, and 32. There is therefore a shift in signification, a *differend* and a deferral from—i.e., a différance—the *same* word that is

[10] Again, I exhort readers to approach *joint action* as a *social* unit that cannot be arrived at by adding the statements (discursive actions) of individuals. Rather, the joint action exists in the turn pair and the individuals are integral part of both constituent turns. This is so because Mrs. Turner has to actively receive what Thomas articulates so that "feel different," for example, has two sides: It is produced by the vocal cords of one speaker and reproduced by the auditory mechanism of the other.

different simultaneously. This way to think about the word is inherently different than thinking about some «meaning» that in one or another way goes with it but that cannot be pointed to other than by the generic term «meaning»; and how should with theorize the associated «mental representation» if the word itself already differs and defers? A good example is Derrida's theoretical term *différance,* which embodies an entire philosophy of difference. This is so because there is a difference that cannot be heard when the word is pronounced, as Derrida would while giving a talk—we might say that there is an indifferent difference, a differential (deferring) indifference. The idea is the same as that denoted by the term *khôra.* As presented and discussed in chapter 2, Bakhtin and Vygotsky use the same excerpt from Dostoyevsky's work to exhibit this aspect of a language, which changes in use because it is, and reproduces itself as, living.[11]

Another point that is very important in the works of Bakhtin and Vygotsky can be made in the present context. Words do not belong to one person but constitute the realities for two; words are not the words of individuals but always belong to speaker and recipient simultaneously: they are as much heard as they are spoken. This is the point of Derrida, and, not withstanding his critique, also the core of Lacan. If we take turn 30 as an example, we cannot consider it as belonging to or being owned by, and therefore expressing the thoughts of, Mrs. Turner alone.

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30 T: does it feel the sAME or does it feel different;
```

The statement is *for* Thomas, who thereby is solicited to respond; it is in *his* terms that this statement has to be framed if it is to lead to a response from Thomas. While she is *speaking* he is *listening*—a fact that we establish from the conversation. He would not be able to *reply* if he were not listening. Attributing turn 30 to Mrs. Turner alone overemphasizes agency at the expense of the agency|passivity dialectic at play in listening: actively opening up to be affected by the words of the other. If it is not so, then we might not get a reply, such as is the case in the turn pair 26|28. The language, however, cannot be that of Mrs. Turner alone. She does not invent or own it here, but it comes to her from the generalized other, to whom, in her statement, it returns. She not only is the subject who uses the language, but also is subject and subjected to it and what it can express. It is precisely this dynamic that is represented in the figure

$$\frac{\mathrm{S} \ldots . \mathrm{S}}{s},$$

where a signifier is followed by another signifier, and another, and so on. This sliding is also available in Figure 4.1, which expresses the movement of the signifier towards the other. That is, any signifier now is designed for and destined to the other. The subject momentarily grounds this sliding from signifier to signifier in the chain (here 3 chain links).

Fragment 4.1 also allows us to understand the multiple determinations of the subject. Thus, Thomas is the *subject of* the statement "feel different" in at least two

[11] A similar shift occurs in jokes, which are based on the co-existence of literal and non-literal hearings.

ways. *He* is the subject who produces the sounds that we hear as words. He is also the grammatical subject: he touched the cube and the cylinder and then states "feel different": *He* feels (has felt) the two things different. But there are other dimensions of subjectivity. In participating in the classroom conversation, he is subjected to the configuration of the schooling activity as a whole. He is also subject to using language, which is inherently not his own, for no communication with the teacher and other members would be possible if the language were not already shared. That is, as agential subject producing sounds, he is also subject to and subjected to the conditions. Agency and passivity are but two manifestations of the same instant of life. This passivity is precisely that of the flesh, common to all of humanity, the condition for any consciousness to emerge. These dimensions remain unaddressed in current STEM discourses—constructivist or postmodern—but require to be addressed if we aim at a fuller understanding of STEM experience without making the metaphysical move towards invoking «meaning» and «mental representation».

From subject to subjectification and personality

In my own studies of knowing and learning in different STEM areas, I have come to the conclusion that we cannot stop with our consideration of the subject and subjectivity by considering what happens in a science or mathematics classroom alone and the «meanings» and «mental representations» participants «make» or «construct». Again, cultural-historical activity theory provides a larger frame within which the subject has a place. During any given day, a person takes part in many different, collectively motivated activities: family, school, after-school sports, friends, shopping, volunteering, and so on. In each activity (*Tätigkeit, dejatel'nost'*), the person is situated in the subject position (individual or collective). Participation in activity inherently means subjectification, that is, a process of evolving in and with the activity over time. Subjectification here denotes "the production—through a series of action—of a body and of a capacity for enunciation not previously identifiable within a given field of experience, whose identification is thus part of the reconfiguration of the field of experience" (Rancière 1995: 59). That is, the subjects are transformed by their own actions that are themselves a function of the *field of experience* and therefore are not entirely owned by the subject. This field has material and societal dimensions, both of which leave their effect in and are structured by the equivalent dimension of the body and *habitus.*[12] In this sense, the subject is alienated, because it is never itself, and not alienated, because it always already exists in and through its body.

We do, however, experience ourselves as individuals rather than as identical copies of others based on the fact that we are part of the same activities. In cultural-historical activity theory, the singular of the person comes into play for a second time: in the particular hierarchical arrangements of the collective object motives in which the person partakes. That is, although all the object/motives that

[12] Habitus denotes structured structuring dispositions. These dispositions are structured because they have arisen in structured social fields. The structures of the dispositions and the structures of the field are homologous. The dispositions are structuring, because they shape perceptions and actions.

define subject and subjectivity *within* a given field (activity), the hierarchical arrangements and the strengths of the relations are singular. A person cannot ever be identified by its subjectivity within the STEM classroom or within a STEM education discourse. Rather, the object/motives of participating in the activities of STEM education or doing STEM games/puzzles (leisure activity) is irreducibly entangled with all the other object/motives that constitute personality.

Babylonian transpositions: significations lost in translation

The reading of many STEM research texts makes salient to me a problematic issue in theorizing the subject when re/writing it involves multiple languages and, therefore, translations from languages other than English. There appears to be an underlying assumption that something like a core «meaning» can make it unscathed from being expressed in one language to being expressed in another. This something often is referred to a «meaning». For example, the works of Marx, Vygotsky, Vološinov, Bakhtin, or Derrida have been translated from German, Russian, and French for particular purposes and audiences. We have to ask: "What do these translations stand for?" "Which epistemologies underlie the translations?" "Which (political) ideology do the translations reflect?" So what is «meaning» if different ways of saying can point to but never reach it? We have to ask such questions because already within English, there are different ways we may say something, but precisely because these ways differ, they also say something different. This situation is amplified in translation between languages.

In music, a transposition refers to the operation of moving a melody or set of notes by a constant interval into a new key. The result is the same and different simultaneously. In music, transposition becomes problematic when it pushes an instrument to its physical limits. In language, transposition pushes intelligibility and signification—even if it happens within a language, let alone when the operation involves two languages. Translation provides constraints and opportunities to theorizing. Thus, the Italians say *traduttore traditore* (translating is committing treason); but translation occurs at the very heart of a language and each new signifier in the chain (Figure 3.1b) constitutes a transposition and translation.[13] For example, we can understand Mrs. Turner's turn 30 as "a translation of the turn 26 for the purpose of allowing Thomas to understand the question, which he has not answered in turn 28." Translation is possible and impossible simultaneously. If there were to be perfect translation, then two statements would say *exactly* the same and it would not be helpful to ask "what do you mean?" because the questioner would only get the same. Similarly, if translation were completely impossible, it would not be helpful to ask "what do you mean?" because the questioner would only get something different. It occurs continuously—as per the chain of signification—whenever a person utters a word (consistent with Bakhtin, for whom language changes with each statement of a word). I am of two minds on this issue because (a) English translations make possible new ways of understanding, thereby truly re/writing the subject, and (b) English translations do not say what

[13] Constructivist STEM researchers tend to be familiar with transposition and translations by means of which representations are transformed into each other.

the French or German or Russian texts say, thereby truly re/writing the subject. There is no way of getting around /ba/: the origin of language (in a child's talk) also enables babble (excessive, foolish talk, including misconceptions) and Babylon (the possibility and necessity of translation) (Derrida 1985).

It may be detrimental to good theorizing if the main categories shift in translation. A distortion in hearing/reading arises from translation. For example, neither Lacan[14] nor Derrida (in the French versions) ever uses the term «meaning»—because the French exclusively use sense (*sens*) and signification (*signification*) and because Derrida deconstructs the very possibility to *intend* something like «meaning»; and Wittgenstein has a stark warning for us. As pointed to in chapter 1, after providing the example of someone being sent to a store to get "five red apples" and then counts out five of the items that are in a bin marked "apples" and that match a particular color pattern, the author asks "But what is the meaning of the word 'five'" (Wittgenstein 1953/1997: 3). He then concludes in the next paragraph by saying that "that philosophical concept of meaning has its place in a primitive idea of the way language functions" (ibid: 3). He immediately rephrases his conclusion: "But we could also say that it is the idea of a language more primitive than ours" (ibid: 3). As quoted in the preface and chapter 1, the philosopher also states that understanding, meaning, drops altogether from a pragmatic consideration. Actually, Wittgenstein uses the term *Vorstellung*, which, in English translations of I. Kant, is translated as «representation». This would then lead to the statement that "«meaning» is at home in a primitive «representation» of the manner in which language functions." Why would STEM researchers want to continue using such a language that is more primitive than the one Wittgenstein uses?

In chapter 2, I note the pervasive appeal to «meaning» in a science education journal. The same pervasive use can be observed in mathematics education and the literature that takes a post-modern/structuralist perspective. Thus, for example, MES appeals to «meaning» a total of 112 times. What then could the following expressions denote?: "The meaning resides in the life around" (MES: 15), "[mathematical] terms' meanings derive from their relations with other terms" (MES: 53). How are we to read the two immediately consecutive statements: "[mathematical] terms' meanings derive from their relations with other terms. The terms *do not have* meanings in themselves . . . mathematical constructs would *have* . . . meanings rooted in different . . . circumstances" (MES: 47)? So mathematical terms do "have" «meanings», but, though they derive them from relations with other terms, they do not have these in themselves. Mathematical objects "depend on their meaning being built relationally" (MES: 60); "words derive *their* meaning through a play of difference with other words" (p. 79); "earlier work" is "assigned new meanings" (MES: 137); " 'prime numbers' does not have the same meaning in Euclid's language as it does in ours" (MES: 141). It is true, there "could be a considerable variety of meanings brought to" "the cultural object" "circle" (MES: 47). But this does not get us out of the quandary that Wittgenstein states. Would it not be better to follow Wittgenstein in dropping the term «meaning» from considerations in STEM education? Although we can find statements in the STEM literatures

[14] Lacan (1966) does use it but to make fun of those who search for the "meaning of meaning*," using the English term and suggesting that it is the language in which the logical positivists snort and which is the alibi for a particular kind of re/search.

such as "the 'meaning' might be strategically avoided to emphasize that the meaning of any expression is no more than its use in language" (MES: 49) the associated discourse does not actually implement this strategy. It might have been wise, however, to abandon the use of the term «meaning», as it evokes precisely what Lacan wants us to abandon: (a) access to the signified that is associated with the signifier or the chain of signifiers (Figure 3.1a) or (Figure 3.1b) the exact equivalence between a word and something else that the word *can have*. It is by focusing on the statement-in-use that we can abandon all talk about the relation between signifier and signified. This is what Lacan does when he replaces the vector $\overrightarrow{A.A'}$ in his more advanced graphs by the vector $\overrightarrow{\text{signifier.voice}}$.

In translation, the very points of the original writing may get lost. This point is recurrent in the STEM discourse, here exemplified by *Mathematics Education and Subjectivity*—e.g., with the manner in which the work of socio-cultural and cultural-historical theories created in Russian based on the reading of Marx are appropriated into Anglo-Saxon scholarship. For example, MES frequently uses the term *jouissance*, but what it "means" or why Lacan uses it is lost: it is a dead metaphor. Thus, in French "j'ouie" is equivalent to "I hear," a reference to the auditory dimension of speaking and language use. "Jouir" is the verb that would be translated as "to enjoy," and it is the origin of the noun form jouissance. Jouissance therefore brings into play self (the "I" ["j"] of "I hear" ["j'ouie"), otherness (I hear another person), and enjoyment. This is an instance of the original sense that has become lost in transpositions and translations that are part of the process of handing down as Husserl analyzes it in the context of geometry. In an exchange with Tony Brown, I communicated to him the problem of reading Lacan's *Écrits* in English, which does not do justice to how we can hear the psychoanalyst in French, when Lacan critiques the traditional conception of the sign as signifier-signified relation expressed by Saussure with a diagram containing the word tree and the drawing of a tree:

> Here [is] one example where the English translation of Lacan falls short . . . from p. 421 of the translation:
>
> > I need but plant my tree in a locution, *grimper à l'arbre,* or even project onto it the derisive light that a descriptive context gives the word, *arborer,* to not let myself be imprisoned in some sort of *communiqué* of the facts, however official it maybe, and if I know the truth, convey it, despite all the censors, *between-the-lines* using nothing but the signifier that can be constituted by my acrobatics through the branches of the tree. These acrobatics may be provocative to the point of burlesque or perceptible only to the trained eye, depending on whether I wish to be understood by the many or the few.
>
> The expression *grimper à l'arbre* would be used to describe an animal or person climbing a tree, but it also, by means of metaphor (as per the dictionary *Robert*), is a way of saying that someone is being enraged. And similarly, *arborer* has the literal sense of planting a tree or planting trees (as per opening of the sentence), but it also could be used instead of donning some clothing ostensively. So what he does in one sentence is use metaphor and metonymy simultaneously. And he writes here precisely about metaphor and metonymy, so that the content and form—pace McLuhan—draw on the same resources. And trees are used in linguistics (and psychology) to articulate the structure and genesis

> of sentences, allowing him to do his (linguistic) acrobatics, be provocative (as to enrage!!!), and in all of this he is "perceptible only to the trained eye." (Email January 17, 2011)

The English text is part of a different (language) game. Getting Lacan's paragraph right in the translation (i.e., being part of the game that Lacan plays) is extremely important, as the very signification («meaning») of Lacan's text about metaphor is produced in and through metaphor. Lacan teaches us about metaphor through metaphor. That is, the unavoidable nature of language as metaphorical is central to Lacan in French—even and precisely while explaining the metaphorical nature of language—but is lost in the English translation (and on the English reader). Lacan thereby renders obvious that we cannot ground language in an appeal to «meaning» or to some originary beginning. Because of the translation, the very linguistic distinctions Lacan makes get lost so that even a trained eye can no longer find the acrobatics, the metaphors, the teaching of metaphor by means of metaphor, and so on. The point here is not that some ephemeral «meaning» has gone lost but that metaphor is used to say something about the metaphorical nature of language. This, then, is a statement about the circularity of language that we cannot ever escape. Any signifier refers us to another signifier and so on. This is the same effect that we achieve if we ask our counterpart in a conversation "What do you mean by . . .?" only to ask again "What do you mean?" after s/he has provided a reply to the first query, and then repeat the game (ad infinitum). There is no way out, no way of grounding words specifically and language-in-use more generally in an otherworldly «meaning» or «mental representation». There is but an infinite play of language, a continual differing and deferring.

This very phenomenon was also exhibited within a very different research tradition: ethnomethodology (Garfinkel 1967). This author apparently had the habit of asking his students to report common conversations they had with someone else, which they would write on the left-hand side of a sheet of paper. On the right hand side of each turn in the transcription, students were asked to write what the conversation partners were understood to have talked about. Whereas students had no trouble to complete the first part of the assignment, reporting what was actually said, they found completing the second part of the assignment difficult. Many students apparently asked how much Garfinkel wanted them to write for this assignment. In his analysis, he notes: "As I progressively imposed accuracy, clarity, and distinctness, the task became increasingly laborious" (ibid: 26). The author pushed his students further up to the point that "when I required that they assume I would know what they had actually talked about only from reading literally what they wrote literally, they gave up with the complaint that the task was impossible" (ibid: 26). In fact, the very way in which language functions multiplied the troubles when students produced more text for the purpose of overcoming the indexicality of language. The author provides this elaboration:

> The format of left and right columns would accord with the "fact" that the contents of what was said were recordable by writing what a tape recorder would pick up. The right hand column would require that something "more" be "added." Because the sketchiness of what was said was its defect, it would be necessary for students to look elsewhere than to what was said in order (a) to find

> find the corresponding contents, and (b) to find the grounds to argue—because they would need to argue—for the correctness of the correspondence. Because they were reporting the actual conversation of particular persons, they would look for these further contents in what the conversationalists had "in mind," or what they were "thinking," or what they "believed," or what they "intended." Furthermore, they would need to be assured that they had detected what the conversationalists actually, and not supposedly, hypothetically, imaginably, or possibly had in mind. (ibid: 27)

We see here that the recourse to speculating about the contents of a person's mind, his/her beliefs, thinking, intentions, and «meanings» is an artifact of method that attempts to overcome the indexicality of language. As soon as we engage in the endeavor of trying to get at what a person really means, thinks, believes, intends, or means we begin a movement of infinite regress, for behind each thought, belief, or intention another one can be postulated that produces the previous one as a pretense: "He says X so I believe he thinks Y when he really thinks Z." This leads us to the ethical dimensions of communicating, whether by means of speech in face-to-face encounters with others or in writing (of scholarly texts).

Re/writing the subject: its ethical dimensions

When we speak and write, what matters are not ephemeral «meanings» and «mental representations» but the real effects of what we say on others. What matters are not our intentions in saying or writing something—e.g., to make a joke—but what our saying/writing brings about, which may be anguish and pain. To understand how a conversation unfolds, we need to understand the effects that statements have on others, who, in replying, provide further statements that develop the talk. What someone «*means*» or «*intends*» to say does not come into play and, when articulated, may subsequently be denoted as an excuse. Take the following hypothetical exchange:

Fragment 4.2a
01 Wife: Did you clean the dishes?
02 Husband: Why do you always have to be on my case?

In this turn sequence, we have a turn pair where the second part constitutes the first as an instance of "being on the case of." That is, irrespective of what the intentions of the first part of the turn pair might have been—e.g., a query to gauge readiness for departing from the home—we now are in a situation where the wife is stated to have been on the case of the husband. The next turn pair—to which turn 2 constitutes the opening part—has to address *this* new situation, which might come in this form:

Fragment 4.2b
02 Husband: Why do you always have to be on my case?
03 Wife: I am not on your case. I was just asking so that I can figure out whether we are leaving soon.

This turn pair can be heard as a query|explanation pair addressing the issue that resulted from the preceding turn-pair unit. The ethical issue is quite evident: in speaking, as in writing, we affect others; and we do so without being able to gauge what this effect might be. Again, the issue is not «meaning» but what the wife has done to her husband. This has consequences for the way we think about and theorize the subject, which has to transcend the limitations and contradictions created by «meanings» and «mental representations» in the heads of speakers.

My re/writing of the subject involves a reflexive component all too little theorized in STEM education. As authors and readers, we are responsible for one another: re/writing and reading the subject are ethical projects leaving little space for ad hominem attacks on colleagues. As re/writers of the subject, we are also (pathic) subjects in the community of STEM educators, where some have paid attention to the ethical dimension that arises from the teacher–student relationship when viewed from a cultural-historical activity theoretic perspective. Writing and reading/responding, too, are societal relations and therefore involve ethical dimensions not only with respect to our subject (what we write about and who we write about) but also with respect to ourselves as subjects. This is so because both speaking and listening/responding constitute forms of exposure: (a) Speaking (writing) comes with the "supreme passivity of exposition to the Other" (Levinas 1978: 81), it is the "hyperbole of passivity" (Levinas 1978: 83) and the "the most passive of passivity" (Levinas 1978: 85)—in writing, STEM authors expose themselves, make themselves vulnerable; and (b) listening to (reading) someone else, is equivalent to opening up to something that is foreign and that affects the reader. To capture that a statement hurts, we have to go beyond interpretation, «meaning», and «mental representation» (of a statement), because all of these refer to intellectual aspects of Being. It does not allow us to capture the relationship between communication and affect. The husband does not have to reflect and interpret what the wife has said to figure out its «meaning»: he is *immediately* affected, hurt or insulted. What matters is what we do to each other.

We therefore need to understand that "*what* I say in response owes its sense to the challenge of that *to which* I respond" (Waldenfels 2006: 58) and, thus, it owes its intelligibility not to my intentionality, «meaning», or «mental representation». Writing|responding and reading|responding involve the simultaneous processes of acting on and exposing oneself to the Other, who, in turn, is exposing him/herself to the other first in listening/reading and then in producing a reply. There is no place for «personal meaning». Each, writing|responding and reading|responding, comes with a double responsibility of the one-for-the-other; but this responsibility for what we say precedes what the respondent does, because it is occasioned in and by the exposition. This diachrony, where responsibility precedes the action, constitutes a way of re/writing the subject: "The diachrony of responsibility constitutes the subjectivity of the subject" (Levinas 1971: 45). In fact, there is further excess of responsibility in reading|responding that comes from its (backward) relation to the author and its (forward) relation to the reader. Therefore, this "one-for-the-other is not a lack of intuition but a *surplus* of responsibility" (Levinas 1978: 158, added emphasis); and, despite the violent dimension it has, the "*one-for-the-other* is the very signifyingness of signification" (Levinas

1978: 158, original emphasis). And, importantly, this "one-for-the-other is pain" (Franck 2008: 37). But exposition in speaking/writing not only means injury and pain, but also *jouissance,* "exposition to injury in pleasure, which permits injury to reach the subjectivity of the subject" (Levinas 1978: 104). In this manner, *jouissance* connects us up again with the subject in Lacan and allows us to re/write the (post-structural) subject in a second way. Any effort of re/writing the subject in STEM education also has to deal reflexively with STEM education researchers as the subjects of activity.

5 Culturing «conceptions»

> In general form: *the relation between higher psychological functions was at one time a real relation between people. . . . The relation of psychological functions is genetically correlated with real relations between people: regulation of the word, verbalized behavior = power–submission*. (Vygotskij 2005: 1021, 1022, original emphasis)

Over the past three decades, the STEM literature has accumulated a tremendous amount of research on students' «conceptions»—in science education alone, one bibliography currently lists over 7,000 entries concerning students' and teachers' «conceptions» related to science education. Yet despite all of this research and all the advances in the associated «conceptual change» theory, there is evidence that students' conceptual talk remains virtually unchanged by instruction even under the best conditions. In this chapter, I articulate a theoretical alternative, which ultimately allows me to understand the founded nature of student talk about STEM phenomena and why STEM instruction faces such challenges in bringing about «conceptual change». This alternative is grounded in the way we use language rather than in ephemeral things attribute to the individual mind, including «conceptions», «mental representations», «meanings», and so on. Thus, language itself provides to those who employ it resources for speaking about topics that any individual has not participated in talking about before. In a way, it is not people who speak but language itself. That is, as the introductory quotation implies, «conceptions» and «representations», if they exist, are at one point *real relations between people*. The word specifically, as language generally, plays a central role because it serves to verbalize and regulate behavior—of others and the self. There is no need to go into the minds of people to look for «meaning» and «representations». The study of real transactions and of the language used to entertain the former is all that we need to understand human relations. That is, for Vygotsky as for Wittgenstein, the function of the word is regulation of behavior in sympractical activity. As the prefix "sym-" suggests, this activity cannot be reduced to individual action even though individuals are integral part in it. The nature of this individual action depends on the joint action and entirely takes its sense from it. The action has to be understood as transactional rather than self-actional or interactional.

In this perspective, «conceptions» and «meanings» are not properties of individuals but are characteristic of cultural-historical discourses and their possibilities. What we get from interviews are precisely the results of familiarity with

these discourses, which, in the interview, return to the generalized other from whom the persons questioned return it. «Conceptions» and the «meaning(s) of concepts» are cultured, much like bacteria are cultured in a Petri dish, in and through participation in societal relations only to be reproduced in other societal relations, including those that concern research on «conceptions» and «conceptual change». Forms of speaking are nurtured in the culture, maintained because these are useful. But the «conceptions» and «conceptual changes» in the heads of individuals that we read about in the STEM literature are just as unattainable as the «meanings» we are told about. The «conceptions» are attributable to the same ideology whereby language is taken as a medium referring to another realm, one that is above and other than the physical—i.e., the metaphysical realm of ideas, constructions, conceptual frameworks, and so on. In this chapter I return «conceptions» to the culture from whence these derive in situated language-in-use and in the course of ontogenetic development.

To exemplify the presentation of the theory, I draw on videotaped interviews with a variety of participants from childhood to adult age. These interviews covered ground similar to the one featured in *A Private Universe*. This documentary features Harvard students on graduation day, who are asked questions about, for example, the distance between sun and earth in summer and winter. There were individuals saying that the earth is closer to the sun in summer, which would explain why it is warmer during that period of the year. There was much talk and writing about the scientific «misconceptions» that these students displayed: because the effect of the inclination in fact outstrips that of the distance, the earth is farther away from the sun during the northern summer than it is during the northern winter. But, as we know from everyday experience, it is in fact reasonable, intelligible, and fruitful to talk about feeling warmer when closer to the source of heat. That such kind of talk does not bear out in the case of the sun is a matter of familiarity with the (language) game involving sun, earth, rotations, and inclinations. All it would take are a few experiences with directional heat sources that are approached from different directions—along the centerline of radiation and in ways that are more oblique to it.

One theoretical alternative, grounded in *discursive psychology*, questions the fundamental presuppositions and assumptions made in the constructivist and conceptual change literature—including the locus of the «misconceptions» («mental representations»), the relation of individual and collective, and the situated and constitutive nature of the talk eliciting «(mis-, alternative, pre-, naïve) conceptions». The overall activity—e.g., an interview situation involving a science educator and the Harvard graduate students—is generating the speech activity, and the speech activity is generating the overall activity. That is, in talking about the earth and sun, the interviewer and interviewees not only talked about a topic but also produced the social relation. The students produced talk for the benefit of the interviewer and the audience of the documentary film. They would not have said what they said if they would have deemed it unreasonable. Precisely because science educators understood what the Harvard graduate students said could they determine that the latter had or held «misconceptions»; that is, students' talk is intelligible. In this chapter, I provide a description of how «conceptions» are the result of cultural processes, that is, how «conceptions» are cultured. I conclude

with some sobering suggestions and recommendations for the praxis of teaching in the STEM areas and the possibility to bring about scientists' science for and in *all* students any time in the near future.

Why we should rethink «conceptions»

Children and students see, experience, and act in the world in ways that are characteristically different from adults. Piaget used this to write about all the things children could not do at a particular age, where their thinking was of lesser quality than the «formal operational thought» that characterizes (scientifically thinking) adults. There is a great body of literature that shows students coming to school talking about phenomena in ways that lead STEM educators to note «misconceptions», «alternative conceptions», «naïve conceptions», «mental representations», and so on. Such ways of talking about phenomena are clearly evident in the following fragment that a graduate student of mine recorded while interviewing the seven-year old Anna.

Fragment 5.1

01 I: ‘wHY `do we have ‘dAY and ˇnI:Ght?
02 (2.69)
03 A: because if you dONt have dAY and nIGht .hhhh we cant sleep at ALL and if you dont have sUN it would really be COld.

In this situation, researchers working on the basis of a traditional paradigm may be tempted to suggest that the interviewer poses a question that asks for the reason of having day and night. In the same way, Anna would be said to respond to this question, telling us what she "thinks," thereby letting us know something located somewhere in the mind, under the skull and thereby hidden from perception. She does something like "spilling the beans," using language to express what is in the mind. Here such researchers might suggest that Anna has a «misconception» because she suggests that night to exist so we can sleep; and if there were not day with its sun, it would be cold. So Anna might be said to think that the reason for having day and night is to be able to sleep and to feel warm. Researchers into «misconceptions» might also be tempted to suggest that Anna "adheres" to an anthropocentric view (epistemology), because she explains natural phenomena in terms of human needs. Researchers may also write about the «meaning» that Anna makes, for example, of the question that the interviewer has posed. We note that there is a fairly long pause (turn 02), in conversational terms, which might lead some to conclude that she is thinking by herself for a while before actually spilling the beans.[1]

Implicitly or explicitly, «conceptual change» researchers contrast Anna's supposed «mental representation» with a scientific or general adult one according to which day and night are the result of the rotating planet earth that periodically exposes our location to the direct sunlight and shades the location from it. Thus,

[1] I know that constructivist researchers make such inferences because I have seen it in seminars on data analysis that I conduct and while working with colleagues who work from a constructivist paradigm.

STEM researchers would (a) make inferences from the *piece of talk,* attributing these existing «conceptions», «meanings», or «mental representations»; (b) attribute these «conceptions», «meanings», or «mental representations» to Anna; or (c) write about what we can hear and read Anna to say as typical for a girl her age.

In the pragmatic perspective proposed here, we are interested in the inner dynamic of such interview talk. That is, we are interested in how participants organize the event from the inside, endogenously, to exhibit its orderliness for and to each other. We attempt to understand how this topic, as any topic, arises from the *con*versation as an achievement in the *sym*practical (transactional) interview activity, which exists only in and as of the irreducible joint action of the group (pair). From this perspective, the words in turn 01 do not belong to the interviewer alone. If it were indeed in this way, we could not understand why Anna was replying in the way she did. We need to understand this *statement*—a term I use in lieu of "utterance" (see chapter 4)—as belonging to both speaker and listener, just as the next statement (turn 03) belongs to both. Moreover, turn 02 also belongs to both: providing each participant with an opportunity to take a turn at talk. Such an approach provides us with an alternative to the traditional ways that attribute statements to individuals. In the end, what should be able to arrive at is an understanding of (a) how a speech community culturally and historically evolves in such a way that it can make thematic issues such as (b) the grammar of the language they are using or (c) «conceptions», «meanings», and «mental representations» that come be theorized as *underlying* their talk. Consciousness of all these points *presupposes* competent language-in-use, which means that they *cannot be* the *causes* of this competence.

A discursive psychological alternative

Discursive psychology, according to a recent comment of one of its founders (J. Potter), is one alternative that allows us to eschew having to take recourse to «meanings», «mis/conceptions», or «mental representation». Discursive psychology is an "emergent discipline" with an approach to cognition that differs from other discursive approaches including sociolinguistics. It is different because its theoretical and analytic focus has moved away from the individual mind to processes of social interaction, making it akin to the language socialization paradigm in second language acquisition. Cognitivism and its problems constitutes one area in which discursive psychology engages with social critique, which is oriented toward traditional psychological topics, such as «cognition», «thought», and, here, «meaning», «conceptions», and «conceptual change»; and it re-specifies these topics in terms of the methodical, situated discursive production of mental entities. Some scholars take discursive psychology to constitute but a method for analyzing everyday talk. However, scholars whose names are synonymous with the field claim that discursive psychology is more than a method: It is a particular framework for theorizing phenomena that are explained in very different ways by cognitive and social psychologists (Edwards and Potter 1992). But it also is more than a simple paradigm: It is "an approach embedded in a web of theoretical and metatheoretical assumptions" (Potter 2003: 784–785). In this first section of chapter 5, I articulate both the theoretical and methodological aspects of discur-

sive psychology. In this, I describe a theoretical framework distinctly different from the one that oriented a generation of research on «meaning», «mental representation», «conceptions», and «conceptual change» and also distinctly different from sociocultural approaches that maintain the distinction between interpsychological (mental) and intrapsychological (mental) processes. According to the cultural-historical activity theoretic approach that Vygotsky's students have developed (see chapter 4), the distinction between intra-mental and inter-mental is not very useful, as all human activity simultaneously irremediably and irreducibly involves the inner and outer. Recent phenomenological studies, too, show that the Self (intra-mental) and the Other (inter-mental) are irremediably and irreducibly intertwined. Most recently, even formerly staunch advocates of the cognitive approach to «conceptual change» propose softening the boundaries between inside and outside the head but these are indeed consistent with the «conceptual change» approach. But my intentions are similar in that I provide a paradigm that may fruitfully orient a new generation of research.

Theory

The main focus of discursive psychology is the orientation toward the ways in which speaking and writing are employed in joint societal action. Thus, discursive psychologists are interested in theorizing the transactional work being done in and through talk. Here the preposition "in" means that talk is the context in which the work is being done and the preposition "through" indicates that talk is the main context in which this work is accomplished. The fundamental theoretical position of discursive psychology is that talk is both terrain/context and tool of human activity. Talk therefore not only establishes and maintains the topic, but also establishes and maintains the activity in which participants talk about a particular topic.

This theoretical position leads discursive psychologists to a double refusal concerning the relationship between everyday talk (e.g., in interviews) and purported contents of the mind. In the traditional forms of «conception» and «conceptual change» research, investigators employ at least two processes of abstraction to get from the details of everyday situations to «(mis-, alternative, naïve) conceptions» that discursive psychologists refuse as legitimate: gross categorization and restriction. The first process is at work when analysts attribute a stretch of talk (statement) to an individual, by abstracting what is being said from the conversational activity as a whole. In contrast, discursive psychologists consider stretches of talk as the contingent continuation of earlier communication and as a resource contingently used/referred-to in subsequent talk. Each statement no longer is treated as if it were standing on its own. The second aspect of this first process is another form of gross categorization when the talk is theorized as the public expression of an underlying «conception». In contrast, discursive psychologists do not attribute stretches of talk to one underlying «conception»; talk is no longer taken to be a neutral means for reading out and making public what is in the speaker's head. A suitable analogy would be the printout from a computer, which makes available the contents of the central processor or memory to the user. However, talk is variegated and even the most stringent interview protocols lead

to variations in questions and interactions. Coherence and reproducibility are achievements and require, because of the inherently hybridized and heterogeneous nature of language, some form of gross categorization to occur in everyday lay as well as professional discursive praxis. Discursive psychologists take the question whether two different expressions «mean» the same as inherently open, even if participants, for the purposes at hand, presuppose or construct them as the same.

Discursive psychologists reject a second reductive process, restriction, which is at work when researchers use questionnaires and structured interviews containing forced choice items or an interview protocol from which they do not deviate for the purpose of comparability across interviews. In forced-choice items, research participants typically are presented with a few alternatives, one of which corresponds to the ways in which scientists talk about the phenomenon, the other alternatives corresponding to typical ways in which those individuals express themselves that are said to have «mis-, alternative, naïve, prior, pre-, or pre-instructional conceptions». Discursive psychologists actively take participants' natural talk into consideration and reject approaches that take highly circumscribed responses to be data while disregarding natural talk. «Conceptual change» researchers generally are confronted with the difficulty to describe the transitions—if they occur—between two «conceptions».

From a discursive psychological perspective, highly heterogeneous talk especially during learning phases is taken to be the norm. Each particular «conception» requires specific forms of talk to conduct the reduction; but in the transition between more stable forms of talk, we expect forms of talk that cannot be attributed to one or the other «conception»—the talk has the appearance of conceptual muddle, which is just the way discourse approaches in philosophy and learning sciences formulate in a positive way the discursive patterns between two forms of more stable but nevertheless heterogeneous talk. Sabir, the language mixtures spoken by Mediterranean merchants—which consisted, depending on the particular situation, of varying amounts of Arabic, Greek, French, Italian, Portuguese, Spanish, and other languages—constitutes a useful analogy for languages spoken at the interface of two and more cultures, including those of the mundane everyday world and science (Roth 2008). Muddle and Sabir, therefore, are not deficits but are the necessary forms of talk during the transition between pre-instructional and post-instructional forms of talk about certain phenomena (Roth and Lawless 2002a). Muddle and Sabir are observed when one form of talk changes into another, where propositions are tested and discarded without an underlying conceptual framework driving the different forms.

So far we have established that talk is irreducible to a particular speaker considered as an independent "element" of the social situation who contributes something that can be attributed to him/her. A transactional perspective assumes that any statement always belongs to speaker and recipient simultaneously (see chapter 1). But if we want to understand how language evolves in talk, we also need to think about a unit of analysis that encompasses this change. The two ways of looking at ways of talking are compared in Figure 5.1. In the «conceptions» and «conceptual change» approach, the form of talk is reduced and attributed to individuals (Figure 5.1a). When there is a change, then investigators presuppose an agent

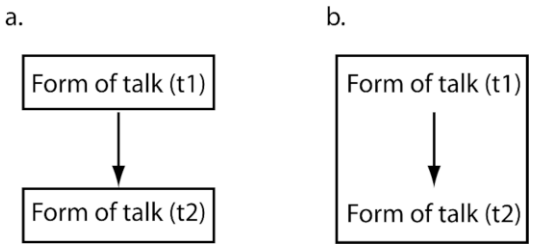


Figure 5.1 Forms of talk viewed from (a) the conceptual change and (b) discursive psychological perspectives.

who produced the difference between conception at time 1 and at time 2. In the discursive psychological approach (Figure 5.1b), the minimum unit is change such that the possibility for the form of talk at time 2 is already embodied in the form of talk at time 1; and the form of talk at time 2 has historically arisen from the form of talk at time 1. The forms of talk at the two time points cannot be represented independently of each other. Each form of talk is integral to the other as well as to the constitution of the whole. Moreover, the changes in forms of talk, which we experience everyday as a reality, are inherent in the minimum analytic unit.

For discursive psychologists, the forms of reduction made in traditional psychology are unsatisfactory because these adumbrate what they take to be the real phenomena to be analyzed and theorized. Talk in everyday settings, including the talk by means of which interviews for the purpose of identifying «conceptions» and «conceptual changes» are conducted, draws on the resources available in the setting. This talk is full of mumbles, stumbles, malapropisms, pauses, stupidities, and solecisms; and yet, conversation participants pragmatically employ these resources to make interaction work despite, and in fact drawing on, the production of what from the perspective of written language are errors. This was the case, for example, in talk about graphs in science involving an undergraduate physics students and a professor in his department, where uncertainty was used to manage uncertainty (Roth and Middleton 2006). More so, I show in this chapter, this talk is designed both for the interview generally and for this interviewer specifically. Although the fine detail of talk may appear to be messy at times, it is precisely this messiness that provides participants with the resources for making interviews and talk about concepts possible. "[T]he finest levels of conversational detail, every speech error, pause, overlap and lexical correction, might be there as a 'designed' or consequential feature of social action" (Edwards and Potter 1992: 6). Discursive psychologists believe that deleting such conversational detail comes at the price of understanding not only how the interview comes about (the *how* of talking or the *Saying*) but also what it is about (the *what* of talking or the Said). Thus, I was able to show in the mentioned study that participants in interview/think-aloud protocols at times treat pauses as indicating resistance to respond or as evaluations that they have done/said something wrong (Roth and Middleton 2006). Even if we assume that a speaker thought about and planned what she wanted to say and only then said it—which hardly, if ever, is the case in

real-time conversation where we speak rather than cogitate and then speak—her private intentions are not available to the recipient, who presupposes that everything made available to him in talk is designed and intended or expresses something directly available in some stretch of talk itself. Discursive psychologists theorize how people make use of talk as a resource, including all its shortcomings and in the way this use is made available, in turn, to other participants and recipients. As a principle derived from conversation analysis and ethnomethodology, the fine detail is crucially important for the intelligibility of the activity performed and the topics talk covered in the process. This fine detail constitutes the very resource that interaction participants pragmatically deploy and use for constituting and exposing the intelligibility of a situation. We know that intonation makes a difference in the functioning of a word or statement. Even a pause is taken as a form of communication, for example, as another's inability to respond, failure to hear, and so on.

Both forms of reductionism are unsatisfactory, because they do not account for the continuously unfolding nature of any culture generally and of language and forms of talk specifically. They do not account for the fact that ways of talking (understanding) change even when people do not explicitly focus on changing their ways of talking («understanding»), even in the absence of dissatisfaction and search for more parsimonious theories. The fact is that new «understandings» generally spring up unpredictably; they emerge from rather than are determined by the contextual particulars of societal forms of activity and specific social situations. In resisting gross categorization and restriction, discursive psychologists actively work against two forms of reductionism: social and cognitive. On the one hand—i.e., on the social side—this means that all phenomena of «thought» and «reasoning», «mind» and «memory», are reduced to social explanations as socioculturally and cultural-historically formed and then, in a process described as internalization, moved from an interpersonal plane to an intrapersonal plane. There are a number of works that show how remembering and forgetting, for example, are a collective rather than individual process. Although Vygotsky takes a dialectical perspective, he generally gets the credit for this non-dialectical framing of learning processes that he never intended (Roth and Lee 2007). The learners thereby come to be cultural dopes, merely doing what culture prescribes them to do. This form of reductionism is widespread and includes social constructivists and constructionists. On the other hand, cognitive approaches tend to reduce all phenomena of «thought» and «reasoning», «mind» and «memory» to events happening in the brain. These events are frequently modeled in terms of how computers work, that is, in rational information processing models. What people do and say in everyday situations, therefore, is thought to be a causal consequence of their «mental models», «cognitive frameworks», «personal theories», «meanings», «mental representations», and so forth. Language here mostly is treated as the neutral medium between someone's mind and another person (e.g., the researcher). The general practice in «conceptual change» research is to look for patterns in participants' talk and to derive from it «conceptual structures» in their minds. In this approach, individuals are treated as if their «mental representations», «mental models», «conceptions» , or «meanings» determined their (discursive, practical) actions. In contrast, the discursive psychological approach takes

the question about what counts as adequate «knowledge», «memory», «concept», «meaning», or «theory» to be a matter that participants themselves resolve in a pragmatic manner for the situation at hand. The criteria for these resolutions themselves may constitute a discursive terrain that is to be established on (and with) the resources provided in/by the same terrain.

Method

Discursive psychologists refrain from trying to get into the head of participants—e.g., by attempting to produce cognitive models that explain what goes on inside a person's head—but concern themselves with discourse that is publicly available to all participants in a conversation. To understand the development of a conversation, the researcher's interpretation of the «meaning» of specific statements is completely unnecessary and gets in the way. What we need to know is how others in the situation hear and take up the statement. We obtain an inkling of this uptake from the next turn that follows the statement. All the speakers in a situation have available is their mutual talk; they cannot ever be in the head of the respective other. To understand what is going on, therefore, researchers need to have the competence of hearing the conversation of interest in the way that its participants do. As a consequence, discursive psychologists theorize just what is there for everyone to see and hear, because this is the only thing culture has for reproducing itself and that newcomers have for becoming part of the collective.[2] Thus, for example, people can argue only over what they are saying and have said, not over the contents of their respondents' minds. They might speculate about another's hidden intentions, but this speculation matters to the conversation only when a speaker articulates it for others. That is, discursive psychologists are concerned with the ("vulgar," "everyday") competencies of people who participate in talk in and through which they simultaneously constitute the social (societal) activity (the work required to produce and reproduce the event as interview) and the topic of the interview.

Discursive psychologists treat discourse as a *social* practice, which they study as an irreducible phenomenon rather than as a theoretical abstraction. Irreducible *social* practice means that whatever happens cannot be reduced to individuals because the pertinent phenomenon is a *social* fact sui generis. That is, discourse-in-use is a transactional phenomenon. It requires a *social, transactional* rather than individual psychological explanation. Discursive psychologists are thereby consistent with pragmatists, who refuse to engage in the reduction of holistic phenomena: "What has been completely divided in philosophical discourse into man *and* the world, inner *and* outer, self *and* non-self, subject *and* object, individual *and* social, private *and* public, etc., are in actuality parties in life-transactions"

[2] Cognitive researchers might argue that they are not attempting to get into the head of their research participants but that they generate models. These models are those of the researchers. If this is so, then there is no hope that the model actually has anything to do with the real performances of people in their flesh and blood. An analogy would be the relation between the talk of a broadcaster talking about a game and what the players on the field actually do. The discursive psychological approach, on the other hand, is precisely concerned with the way in which people use language to produce effects such as «thought», «conception», «beliefs», and so on.

(Dewey and Bentley 1949/1999: 187). We now return to the opening interview situation without taking the turn pair as reducible unit—although it involves individual bodily and embodied performances. Thus, what the interviewer has been doing with his statement can be said to be a question only in and through the following statement. In the present case, we can easily see the situation as the reproduction of a question|response or query|reply pair. This would not have been the case if the situation had unfolded in the following (hypothetic) way:

Fragment 5.2

01 I: ‘wHY `do we have ‘dAY and ˇnI:Ght?
02 (2.69)
03 A: i dont have time right now.

In Fragment 5.2, the statement that the child articulates is considered as the second part of an irreducible pair: it sounds as if Anna had been asked to give some of her time to engage with the interviewer to talk about whatever he wanted to talk about. «Meaning» has no place in our understanding of what is going on here. That is, whereas from an individualistic perspective, the interviewer might have had the intention to ask a question about day and night, the statement comes to be treated in the conversation as a request for time. By defining *what* the turn has done *in the conversation*, we take it from the perspective of the next turn: There was then a request and rejection for donating time. That is, we make the turn sequence our unit of analysis. In this new unit, both turns become what they are *in and from* their relation: request and rejection. From the perspective of the conversation as an irreducible event, the initiation has been acted upon as a request for time rather than as a request for explaining the reasons of day and night. Conversation analysts now might focus on the fact that the child has performed what conversation analysts call a *dispreferred* response, that is, she has rejected an invitation to answer a question, and the problem this poses for the unfolding conversation is how the participants, here interviewer and child, are going to manage the rejection in subsequent joint action. One way to mediate the rejection might be for the child to provide an explanation, for example, by saying “My mother told me to be home at five” and the time is almost five o’clock. Or the interviewer might try to get agreement by saying, “Oh, it will only take three minutes of your time.” In any case, discursive psychologists are interested in understanding how talk unfolds and how talk is used in each case to manage social situations, both their forms and their contents. These two aspects are going on all of the time and simultaneously so that we cannot abstract the content of talk from its function without doing harm to our understanding of the phenomenon; and we cannot abstract the content of one person’s statement (“’Kay, because, we need day to play and we need night to sleep” or “I don’t have time right now”) from what other people have stated in the same setting.

It should be clear from the foregoing paragraph that our language resists the effort to describe social (transactional) situations from the collective perspective. We tend to continue attributing actions to individuals and thereby move into dangerous waters of cause–effect reasoning, which in fact takes its origin in the inven-

tion of the agential subject (Nietzsche 1954).[3] Thus, even if it has been noted that the nature of the first party of a pair depends on the second party, it is easy to slip and attribute the «request» to the interviewer and the «rejection» to the child. What we have in fact is a request|rejection pair, in which the first part falls onto the institutionally designated interviewer (researcher) and the second part on the institutionally designated interviewee (child). The discursive psychological position, therefore, also has serious implications for the way in which we have to understand the subject (see also chapter 4).

Procedurally, therefore, discursive psychologists take a turn pair as *one* unit. That is, they make the different speech acts proposed in speech act theory—i.e., performance (locution), intent (illocution), and effect on the recipient (perlocution)—integral and irreducible manifestations of the same unit. A speech act therefore is completed in and through the performance of the next person, which provides evidence for the perlocutionary dimension of the speech act. In this new unit, therefore, there is *one* transaction or one *joint* action to which two parties contribute. Readers easily will find many examples in their own everyday lives that show that illocution and perlocution may run in different directions, for example, when a listener states, in reply to previous statement, by saying "this is an insult" and the original speaker comes back saying "it was meant as a joke." Here the recipient and the original speaker articulate for one another the differences between perlocutionary and illocutionary dimension of a previous locution. (The overlap of speaker and addressee and irreducibility of the speech act to individuals goes even further, as the latter already commits him- or herself in listening *while* the former produces a locution.) In discourse analysis—the method discursive psychologists preferentially employ—articulating what one has said, done, or heard is denoted by the term of *formulation*. That is, in the last examples, the recipient *formulates* to have been insulted—rather than, as this sometimes happens in certain milieus, punching the other in the face—and the initial speaker formulates to have intended a joke. Thus, when an interviewer says, "I am asking you a very simple question," he formulates that he is going to ask a question and that it will be very simple one at that; he announces and circumscribes the performance and intent of the speech act that follows. But understanding *this* part of the whole transaction has to await the completion of the latter, which comes through whatever will constitute the second part, itself a function of the first part.

Principles of discursive psychology

To summarize, then, discursive psychology is an approach oriented to the functional analysis of language-in-use, written or spoken. It does not seek recourse to mental entities such as individual «meanings», «mental representations», or «mis/conceptions». The questions discursive psychologists pose pertain to the way in which language is employed and deployed pragmatically for managing transactional situations (the terrain, context) as well as their content (intent). The

[3] Nietzsche (1954: 485) describes the origin of the subject and of cause–effect reasoning in this way: "The psychological history of the notion "*subject*": The body [Leib], the thing, the "whole" constructed by the eye awakens the distinction of a doing and a doer: the doer, the cause of the doing, conceived in increasingly refined manner, has left in the end the "subject" as remainder.

focus is on *joint action*, that is, on a unit of analysis that is irreducibly social and encompasses comprises multiple social actors simultaneously. Each turn is owned by speaker (who physically produces the sound) and listener (who physically receives the sound) simultaneously (see Figure 1.1, p. 15). Each turn also is *for* speaker and listener simultaneously. Language thereby is thought of as the primary but not sole reality-constituting resource in and for practice; gestures, spatial configuration, bodily orientation, prosody, setting, and other features constitute integral parts of everyday communication that speakers and listeners orient to in an active manner (Roth and Pozzer-Ardenghi 2006). Gestures and other bodily forms of knowing may constitute the basis for any scientific language that eventually arises in and through communication (Roth 2000). As a form of summary, here are five major tenets in which discursive psychology distinguishes itself from other approaches (Edwards and Potter 1992: 28–29).

- Discursive psychology is a theory and method for investigating naturally occurring talk, such as, central to our concerns, interviews and classroom talk involving scientific concepts;
- it is concerned with the content of talk and its social rather than linguistic organization;
- it takes (discursive) actions, constructions, and variability as its analytic objects; variations in the way people account for some phenomenon yield insights to the role situational particulars play in forms of discourse;
- it has an interest in understanding the rhetorical functions of talk and it intends to understand the social functions that variations in talk serve; and
- it has a particular interest in how cognitive issues of knowledge and belief, fact and error, truth and explanation are constituted in and through talk.

In the following sections of this chapter I work out what this schematic articulation of a discursive psychological approach means for a theory of «scientific concepts» and «scientific conceptions».

Local talk makes culture and history

The conversation fragment transcribed in Fragment 5.1 derives from an "interview," a part of which is presented in textual form. It could have been 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 intelligibly participate in a conversation unless one is provided with contextual information. Without knowing the context, we do not know how to hear the sound /ðə bi:/. Among beekeepers, it may be heard as "the bee"; at a tramway stop, it may be heard as "the B [line]"; among sailors, it would be said in the context of a "bee block"; and in the context of a forced-choice item, it might be the option (b). This phenomenon therefore points us to the fact that the unit of analysis needs to be larger than the individual speaker. What aspects of the social world are these participants in the process of achieving? I 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 (Anna) but not the other, interested party ("interviewer"). In this section, I draw from another interview in which a graduate student of mine interviewed an adult (Mary) about the same issues (the relation between sun and earth, day and night, winter and summer).

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 I know, the conversations they normally enjoy do not follow the turn-taking pattern observed in an interview. 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 "replies," 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 «misconceptions» or «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 statements and the particular distribution across material bodies, the term transaction for what occurs appears more appropriate than interaction of two independent individuals producing talk only in and for themselves. But if there is a transaction, parts of the talk can no longer be attributed to the interviewer (i.e., the questions) or to Mary (i.e., the answers that are evidence of *her* conceptions).

The notion of transaction is to be distinguished from interactional and self-actional points of views (Dewey and Bentley 1949/1999). In the self-actional point of view, situations are explained in terms of the intentions of individuals. In the interactional point of view, individuals are thought of as independent elements that enter in a relation. Social phenomena are thought to arise from the ways in which *individuals* interact, that is, act upon each other from the outside. In the transactional perspective, individuals and the actions ascribed to them no longer are *elements* in and of joint action but rather they are the products of a higher order unit of joint action. That is, individuals and the actions ascribed to them are only manifestations of a higher unit: the activity. This, therefore, is the same type of formulation as saying that question|reply or statement|evaluation are irreducible units, for each is a unit of joint action. What the first part in such a unit is depends on the second part and vice versa. These parts depend on what the unit is as a whole. Saying that one is employing a transactional perspective is therefore equivalent to saying that the turn pair is the minimal unit. Even though we observe symmetry here, particular grammatical features may fall systematically onto certain individuals (individual bodies). The best-known sequence of this kind in STEM education is denoted by the acronym IRE—initiation, reply, evaluation—where the first and third parts *systematically* fall to the institutionally designated teacher and the second, middle part systematically falls to the institutionally designated student. Such a systematic distribution is also the case in the present interview involving Mary.

In addition to the use of "questions" for opening a topic, one person ("inter-

viewer") queries statements that the other makes, but the reverse is not the case here. This is apparent in Fragment 5.3, where the "interviewer" «questions» statements Mary has made.

Fragment 5.3

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?

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).[4] 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 knew 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 differences. It is this context itself that would allow a hearing of these latter statements as reasonable. That is, what is said and why it is said irreducibly depends on the situation as a whole and cannot therefore be attributed to one or the other speaker.

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 find it 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 the interview fragments presented here (e.g., Fragment 5.3)—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

[4] To repeat what I have stated in the preceding section: Our language makes it difficult to analyze joint action in a way that is not experienced as cumbersome. Placing the chevrons around the verbs typically associated with the self-actional perspective allows me to flag the fact that these assignations are possible only based on a consideration of a statement's role in the turn pair. Thus, when I use the expression "the interviewer «asks» . . ." then this implies that the turn is part of a pair in which the second part is a «reply».

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 including its role distributions. In the process, the talk that makes the conversation also produces its topic: the reasons for having day and night.

We must constantly keep in mind that in all of these situations, what matters is not what *we* say and contribute. The conversation unfolds on its own terms rather than on yours or mine. No individual participant in a conversation has total control over where it will end up. Otherwise we have a different phenomenon rather than a *con*versation in which two or more speakers contribute in ways that are unforeseeable by others and themselves.

In the present situation, the interviewer and Mary know that they participate in an interview even if they do not verbalize this participation as such during the transcribed part of their face-to-face encounter. But the very fact that a particular order is produced points us into the direction that a variety of resources for reproducing a type of event in which one person asks questions and another responds come to be played out. 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 «replied», 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 form. Even the undergraduate students in our universities who participate in research studies know that by entering the psychological laboratory they are contributing as research participants and therefore they orient themselves to re/produce 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. As we begin to say something we have of it a general inarticulate and unelaborated sense. This sense 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. We do not choose words in the same ay as we do not choose our steps in

walking: we talk in the way we walk. In fact, there is a good bit of truth in the aphorism that *we walk the talk*. 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 in and through that very performance.

Above all, participants use their context—frequently unmarked and unthematized—to elucidate the sense marked out and exposed in and by the ongoing events. Thus, in Fragment 5.4 below, the interviewer produces a hand/arm gesture while uttering a «question» about the direction in which the sun is moving, "from . . . where to where?" (turn 21). The interviewer moves her left hand/arm through a semi-circle, which a competent Anglo-Saxon, in the context of turn 21, can understand as a pointer to the sun moving through the sky. An iconic reproduction of this very gesture can be found again later on in the session in the form of an ephemeral—but nevertheless publicly available—drawing of the movement of the sun that Mary produces on her thighs. After identifying what we, competent adult participants in the Anglo-Saxon speech community, recognize as the four cardinal points and after making a cross as if drawing a compass, Mary then reproduces the interviewer's hand movement but extends it for a complete movement around the circle.

Fragment 5.4

21 I: s:o:: which? [direction (0.62) the sun will moving;
[((*hand moves back and forth, see Fig.*))
from; (0.36) you know; (.) where <<pp>to]> where?
((*as in pendulum motion*))
22 (0.26)
23 M: from east to west.

Knowing the type of activity (i.e., the interview) also allows us—and reflexively, the interviewee—to distinguish various forms of body movements that participants produce, (consciously or unconsciously) selecting some as relevant to the ongoing topic and others as irrelevant. 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 turn 21) subsequently comes to be reproduced in the drawing that 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 (Figure 5.2) is not reproduced later in the conversation or used in the production of the interview in some other way. Thus, we see Mary reusing or building on 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 I, the analyst, 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 (Figure 5.2). That is, we already bring to the situation particular communicative competencies that allow us to select some material productions (body move-

ments, sounds) as relevant and distinguish them from others that we consider as irrelevant. But these competencies are themselves the results of prior transactions. It 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. Analysts, therefore, must be 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 they can be analysts.

Figure 5.2 Some movements are recognized as having little relevance to the conversation.

Language produces activity, activity produces language

The participants in this and other interviews in my 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. Even though the physical acts of speaking fall to different individuals, what they actually do is joint action because this includes the recipient as well (i.e., listening). Just prior to the episode that makes Fragment 5.5, Mary has come to a temporary endpoint when, and already overlapping her, the interviewer «harks back» by «querying» 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. That is, it is the turn sequence that makes these interjections (turn 106) an affirmation.

Fragment 5.5

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," Figure 5.2*))
109 I: [yea]
110 M: the other part (0.24) [did]nt.

Figure 5.3 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 contributes to 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 (Figure 5.3) 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. The communication is the result of joint action because each turn in fact involves both individuals: one producing, the other receiving. Inherently, as with the sounds that they hear as words, each participant has to assume that her production necessarily exposes intelligibility, that is, intelligibility for the other, too. As a speaker, I say what I say because it is intelligible 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 intelligibility is available to third parties as well (e..g., researchers), intelligibility itself is a general possibility. Therefore, each marking and exposition of intelligibility is particular—i.e., a concrete articulation of intelligibility in this instance—and general—i.e., a possibility of intelligibility 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 be caught forever in our private worlds.

We may next ask how the sounds (words), body movements, and body positions are related. To investigate this problematic, I provide a more fine-grained description of turn 105 in Figure 5.4. As the interviewer formulates what is to come as yet another way of saying what it is that Mary «means» ("you mean" [Figure 5.4a]), 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" (Figure 5.4b). During an elongated "an::" and the pause that follows, the right hand moves from the lap upward above the shoulder position (Figure 5.4c) and then sharply downward to its final posi-

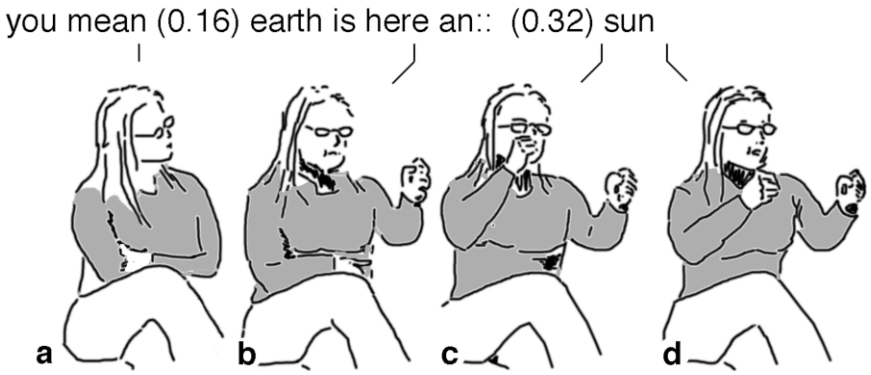


Figure 5.4 As the interviewer prepares for re-articulating the sense of what Mary just has said, she turns her body to first set the left hand in space while uttering "earth is here" and then sets the right hand precisely with the utterance of "sun."

tion Figure 5.4d while uttering "sun." Here, the two are producing the model for each other as much as they are producing it for themselves. In fact, they would not be able to access their thought if it were not externalized in some way from thought itself (Hegel 1979). The production is evidently satisfactory (intelligible), which is expressed in two ways. First, Mary utters "yea" (turn 116), adds and thereby completes the verbal articulation of the model (turns 120, 123) where the left hand can be seen to stand for the earth and the right hand 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. The moving on 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 now—after repeatedly asking Mary to further elaborate, explicate, or explain—the conversation is ready to move on. This therefore signals that the production of this conception has been completed.

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 that best explains what is happening? 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. In the very structure of this sentence—speaker using modalities, recipients perceiving modalities—the nature of the phenomenon as joint ac-

tion is made thematic. At the same time, thought comes into being—rather than having pre-existed and driven the conversation as it is unfolding here before their and our eyes.

The joint action cannot be reduced to individual action without losing the very phenomenon: *com*munication as *joint* action. This is so because interviewer's precise dance of gesture and speech is not just for herself: it is for Mary. In fact, if it were unambiguously apparent that the words and the gesture expose the same intelligibility, 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.[5] This coordination inherently is for the (generalized) other, who therefore may agree that the radically different communicative forms are about the «same topic». 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 is intelligible to the other unless they can assume that what they articulate is a realization of intelligibility generally. That is, they each have to presuppose that the words and phrases they utter are 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): sight (eyes) and hearing (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 (intelligibility), which always only is available through any one of its multiple, potentially innumerable concrete realizations. Thought is right here in the then and there of the situation rather than in a metaphysical «meaning». That is, the general and particular always are given at one and the same moment, where the *concrete* realization of intelligibility 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—intelligibility is constituted by the concrete plurality of all possible *concrete* singular expressions that are deemed to belong together. This is an example of the documentary method, which I present in more detail in chapter 7.

There is no end to the coordination of different expressive matter/form combinations. Therefore, 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 concrete intelligi-

[5] Any sign consists of material and, therefore, is a segmentation of the material continuum (Eco 1984). However, to be a sign, this segmentation of the continuum has to have form to be recognizable across situations. A bit of sand on the beach is not a sign unless it has a form that is cognized and subsequently *re*-cognized.

bility, which any individual concretely expresses in only a limited number of ways. Even if we accepted that an individual had a «mental model«, «mental representation», «concept», «conceptual framework», or «meaning» it would always constitute only one concrete realization rather than the full range of expressions of all the different ways in which s/he could talk that are recognized to be the «same» «idea», «concept», or «mental representation». Therefore, any singular communicative expression, in a synecdochical way, activates many other concretely possible, singular expressions so that an «idea», «concept», or «notion» never is a transcendental but always a concrete universal. This is so because

> even when we seem to be relating the word directly to the object, the word does not so much denote the object as express its practically realized essence through the whole system of language. It is not the word-name but the structure of the language that preserves the whole system of human practical actions with objects, actions, in which objects speak for themselves, with their own voices. It is the structure of the language that reproduces the structure of the practical life of society. (Mikhailov 1976: 227–228)

Thinking along this line opens up the possibility for understanding change and learning without positing that «mental representations» have to be destructed, deconstructed, or abandoned only to be reconstructed anew. 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 (statements) are not identical—even the modulation of sound changes. This non-identity among realized possibilities for expressing intelligibility constitutes a shift, a difference at the heart of the presupposed sameness. With this shift and difference, the «idea», «concept», or «notion» itself shifts ever so slightly sometimes thus allowing a presumable identity of two ways of talking to be actually different forms of intelligibility. Precisely because two statements 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 statement as a synonym, homonym, heteronym, metonym, troponym, or antonym, as the case may be.

In this fragment, the interviewer and interviewee jointly work 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. They are jointly oriented to elaborating intelligibility itself: of the topic as much as of the situation. 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 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) (see also Figure 1.1, p. 15). The intelligibility of the model therefore exceeds the two,

existing in (ephemerally) produced and marked out ways and thereby also becomes available to researchers and readers who, in listening and watching, realize intelligibility in additional but alternative forms. 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 and discursively competent person watching these videotapes featuring the interviewer and Mary. This anonymous third person possibly witnessing the situation does not tend to be theorized.

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 an approach that focuses on «mental representations», 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 the (cultural, dialectical) approach advocated here, the production itself of the concept in public space is the thing to be modeled. Do we need «mental representation», «conceptions», and «meanings»? Which case is more general? In the latter case, the participants generate a presentation in real time, with local resources. In the approach concerned with «mental representations», a «representation» has to precede the production of the presentation; and another «representation» is the consequence of the production. But do «conceptions» and «mental representations» have to precede action? Do «meanings» have to exist prior to communicative expressions? Here the now familiar instant when James Watson and Francis Crick are said to have discovered the DNA structure exemplifies an important phenomenon: The scientists "played around" with material shapes. This presented them with potential configurations for their consideration. These configurations were not produced to be retained and stored in long-term memory by means of a «mental representation». These configurations really preceded any «mental representation» that might have existed in their minds concerning the actual molecule. The two scientists produced configurations *on the table* for the taking. Once there was an interesting one, that is, the one for which they would later receive the Nobel Prize, they pursued it for building the first model of the DNA molecule. In the same way, Mary and the interviewer may produce a constellation for the first time without having had a prior «mental representation» of or about it. They produce such models without wondering about a «meaning» in the then-and-there of their situation. "It is not consciousness that determines life," say Marx/Engels 1958: 27) "but rather life determines consciousness." This segues us into the next section.

We do talk about topics that we have never thought about before

> The realization of the within-language existing possibilities of its organization and development is in this or that way predetermined by societal factors, which are correlated with the function of speech in society. (F. P. Filin in A. A. Leont'ev 1969: 21)

In this introductory quotation, the author points out that there exist possibilities within language for its organization and development. These possibilities are predetermined by societal factors and by the function of speech in society. As a con-

sequence, we do not have to have thought about something—i.e., to «construct» «meaning» or «mental representations», as constructivists want to have it—to speak about this something. Rather, there are, as a function of societal factors, possibilities that can be realized situationally in and with speech. It is out of situated speech situations that new speech capacities evolve (Roth 1996). That is, when really observing carefully at interviews with students and everyday folks alike, one can find evidence that individuals participate in conversations about topics that they have never talked about before. What they say therefore is a real-life ongoing evolution of intelligibility that surely cannot be preceded by a «mental representation». This is so because the latter requires possession of a «representation» when there never has been a presentation in the first place. This points us to the "self-givenness" as an essential dimension of all knowing (Husserl 2008; Marion 1997). The societal factors mentioned above have their starting point in the totality of a concrete speech situation, in speech activity (*rečevaja dejatel'nost'*) rather than in language as an abstract system in the way linguists tend to consider it.

People can talk about new topics, even though the topic later is repeated in different forms. 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 experience 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 5.6 from the interview Mary provides us at least twice with hints that she is thinking through the attendant issues for a first time—aloud, publicly, and therefore already realizing an inherent possibility of intelligibility.

Fragment 5.6

07 M: so the sun is in the position of thata sky ((*hand gesture*)) ↑¯position ((*looks at interviewer, makes eye contact Figure 5.5a*))
(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:: ((*Figure 5.5b*)) (0.26) in the morning ((*Figure 5.5c*)) 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; Figure 5.5). 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 appears to come as a surprise. That it likely is a surprise, we can see from the gesture that

Figure 5.5 Formulating «thinking». a. Mary has eye contact with the interviewer. b. 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 (c).

follows (Figure 5.5b), 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 may see this movement as formulating «thinking», that is, as an instant where Mary makes available that she now is «thinking about» a situationally appropriate answer to whatever the current question is. We do not know what this «thinking» consists of; but we do know that whatever Mary does, she marks it for us to be a process of «thinking». That is, following what we see as an expression of surprise, Mary not only «thinks» but also lets recipients know that she is «thinking» right now. 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 [sic] about that." That is, Mary has described the position of the sun as being "in the east" "in the morning." But in a sequence of turn pairs where the interviewer will be seen as asking her about the reason for stating this, Mary is understood to admit that she never has thought about this question or topic. That is, the fact that we do say things even though we have never thought about it dismisses claims that «conceptions», «mental representations», or «personal meanings» of something must predate or coincide with talk about this something. These concepts, therefore, are not very useful for understanding what people say and why.

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—by somehow drawing on a private model «constructed» on the fly and preceding her talk—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 what can be heard as being 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 utters the conditional "should," which, as competent speakers of English know, provides the possibility of changing one's mind without loosing face. Nevertheless, despite having stated to have never

thought about the issue at hand, Mary has been heard to provide an answer. She produces a reply 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"). In fact, her statement, in its pairing with the interviewer's preceding statement, constitutes her contribution as a reply and the interviewer's contribution as a question.

Given the preceding analysis, we may ask, what makes it possible for an intelligible reply to be produced? We have to 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 have to ask whether we (analysts) have to presuppose «meaning», «mental representations», and «conceptions» as the ground (reason, cause) for people to talk about phenomena and terms that are of interest to scientists and STEM educators? We further have to ask whether we can 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» intended to identify «mental representations» 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 the possession (and absence) of «mental representations», «conceptions», and «meanings» to which they never can have access?

«(Mis-) conceptions»: borrowed from and returning to the other

We do not own the language that we speak. Each speech act is a concrete realization of possibilities already available to knowledgeable speakers of the language generally. In fact, as a transactional phenomenon, each speech act not only belongs to two or more speakers simultaneously but also is produced by two or more speakers at the same time. What really matters is the elaboration of intelligibility that continuously occurs when people talk. 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 sun*rises* and sun*sets*. In this interview activity, the interviewer and Mary engage in speech activity, articulating words (using 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, in everyday conversation—in contrast to writing—we do not think about and select the words and sentences we

assemble (in the way we walk rather than place feet): they spring forth and become speech. There is therefore an essentially passive component to speaking: language, here English, speaks (means) through us (Roth 2013a). We do not need to know (about) 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 «conceptions» or «meanings», these are already possibilities in and of the language we receive from the other and which we produce for the other. These possibilities *are* intelligible, even to investigators who denote them by the term «misconception», which is a reason why they are so resistant to the efforts of conceptual change researchers. It is precisely because such talk is intelligible—even if a statement is said to constitute non-sense in the view of the scientific community—that STEM educators can make it the topic of their work. The intelligibility itself is the condition for STEM educators to do their work. But, to date, this condition of intelligibility has not been theorized in our community.

Fragment 5.7

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))
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) ((*Draws horizontal line, then vertical line, then moves to ends of the lines*))
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

Mary can be heard to have begun answering the question about the direction of movement by rapidly answering "from east to west" before hesitating: there is a pause. The interviewer interjects an "uh hu:." In the turn pair it functions not as an expression of something else but as an indication of 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" (Figure 5.6), but then apparently 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 (Figure 5.7). Crossing this line she draws another one beginning at a position away from her but then adds another arrowhead that is oriented away. She then points to top and bottom of the vertical

Figure 5.6 Mary begins to show how and where the sun moves, moving her eyes from the interlocutor (a) toward her moving fingertip (b).

Figure 5.7 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.

line, then to the right-most point of the horizontal line at which point she grunts a long and drawn out "u:m::." She 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." All of these movements articulate intelligibility.

On what basis is this description intelligible? A first proposal to this can already be found in my description and in what this description presupposes. Thus, although there is 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. We can see her as reading the movement of the sun off this compass, "from east to north (up) to west to south and to east again." Here, we see the reproduction of the drawing of a compass, intelligible as such once the cardinal points of a compass come to be articulated. In this reading, the directions of the compass become intelligible: there is a movement from east to west, just as Mary has stated before (turn 23). The language-in-use and the order of the compass points in particular are prefigured in the English language. Thus, although Mary may find herself in a situation of 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 is heard to provide an intelligible answer. This answer is based on 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 is inherited from those who spoke English before them, 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 evolve a statement that will have been the second part to a question|reply sequence.

Here, local resources (language, ephemeral diagram of a mariner's compass) are used in the production of an intelligible reply. This reply is not just Mary's; it is that of the interviewer alike. It is *their* conversation that we attempt to understand here in its unfolding. If the talk were not intelligible to one or the other participant, some form of repair sequence would likely be observable. The fact that the conversation continues to unfold suggests that (mutual) intelligibility underlies the situation. Under what conditions can those present use these resources as part of a communicative act (speaking, hearing)? They can do so because neither the English language nor the compass exclusively is her own to use; they have come to them as components of the community in which they participate as they appropriate its language (appropriation and membership are mutually constitutive). Moreover, Mary suggests not having thought about this question and its answer beforehand. This statement is produced for a first time in the course of the recorded activity (denoted by "interview"). The local resources provided the participants with everything they needed to exhibit intelligibility of queries and replies. It is *Mary's* reply only in the sense that she is physically producing the words using her vocal cords, hands, and other body parts so that communication is distributed across bodily resources (Roth and Lawless 2002b). But because the reply is for the interlocutor's simultaneous hearing, the resources mobilized as well as the intelligibility are inherently common to both participants. For the statement to have any effect on the listener, the sound (-words) have to make her eardrums resonate and bring about effects further up. From the perspective of the conversation, each word therefore belongs to both, involves the physical body of all participants. And here, we have not even talked about the camera recording the event, which will make whatever is happening available to an (anonymous) Other. If the intelligibility of the said could not be presupposed, then it clearly makes no sense to say anything at all! The fact that what is said is seen to be accepted as the conversation unfolds suggests that it (the said) is a possible way of marking and exposing intelligibility.

Language (here English) constitutes a virtually infinite set of resources that speakers use to describe and explain the phenomena of interest to scientists and STEM 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 the current conversation articulates the movement of the sun in the sky, all that

the participants need 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 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 considerable to attribute a sense that does not conform to the ways of intelligibly talking about 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 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 STEM educators, that is, to the ways in which many STEM educators communicate about "non-scientific" ways of talking about natural entities. That is, I address the massive body of literature that identifies itself as making a contribution to «mental representations», «conceptions», and "conceptual change," and in so doing, the familiarity and membership of readers in this form of talk is presupposed. Consistent with the present form of analysis, I understand this text to slide between the foregoing sections and the one in this and subsequent sections. From the beginning, the analysis shows that it would be incomprehensible that someone tried to talk unless the intelligibility of this talk 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» and «mental representations» are presupposed to be in and for the Self. Under what 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 have to return to texts published over 20 years ago. «Concepts» are taken to be «cognitive» entities, pieces of furniture of the conscious mind that are unlike signs. They are human inventions that "once

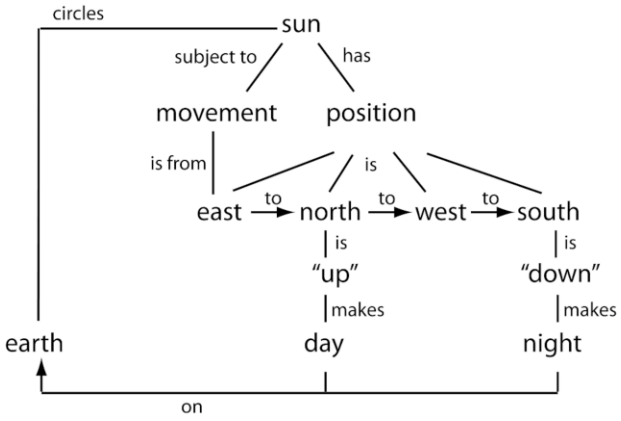


Figure 5.8 A conceptual change researcher may depict what Mary has said in the form of a concept map, said to depict her conception or conceptual framework.

labeled become communicable through the use of language" (Pines 1985: 108); the term «conception» 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" (Pines 1985: 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.

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 (Figure 5.8). 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 nonradical (simple, slight) «conceptual change», corresponding to «conceptual change» across and within ontological categories (Chi 1992). Using this framework and based on my own extensive familiarity with concept mapping research and teaching practice (e.g., Roth and Roychoudhury 1992, 1993), Mary's «conceptions» of the sun, its positions and movement, the earth, and day and night might be represented in a concept map (Figure 5.8). The problem now becomes, "Under what conditions and which presuppositions are at work in a cultural account of the production of the interview, interview text, and the «conceptions» attributable solely to Mary?"

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: there is no way back to

the original (now mythic) event in its unfolding (e.g., Ashmore and Reed 2000). This includes my own transcriptions, even though these include indications of the change in pitch and speech intensity and all measurable pauses exceeding 0.10 s. 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 (Figure 5.8), 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 fact, a «conception» may be thought of as a model of a phenomenon itself inaccessible—like the contents of and configurations within the (black) boxes that were used in "hands-on" curricula of the 1960s—and therefore characteristic of the researcher community rather than of the people to whom the structures are attributed. In the following, I articulate and discuss some of these possible reductions and abstractions that are often assumed by STEM 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 have been said, how it will have been said, and what the process is by means of which the interview becomes what it ultimately will have been. 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 approach as a paradigm. In this approach, the researcher takes as illegitimate any move to consider the saying outside of its 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 a-temporal expression of relations in a concept map (Figure 5.8).

Abstracting from real time and contingency

The present approach articulated in the course of analyzing the videotape and its transcript is transactional, which inherently leads us to constitute the talk in its historical (temporal) and contingent characteristics. Each turn, as noted 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. Each turn simultaneously belongs to the speaker, the hearer, and the speech community. Talk only is attributable to an individual if all those links and mutual contributions apparent to participants and researchers are removed. The analysis shows the conversation as contingent, and this contingency also marks its product, talk as recorded on tape. A concept map (e.g., Figure 5.8) however expresses the Said of a conversation in

an a-temporal 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 pre-existing «conception» or «mental representation» already in place. This makes it difficult to explain the change from a «misconception» to a «scientific conception», because that which is beyond the «(mis-) conception», the kind of talk between the «misconception» and a «scientific conception» has not been theorized; the in-between forms of talk, which neither can be due to a «misconception» nor to a «scientific conception» are beyond the capability of the «conceptual change» approach.[6] These transitory moments between the different forms of intelligibility («misconception» to «conception») cannot be theorized in and for themselves, because even the notion of non-intelligibility (non-sense) still is theorized in terms of intelligibility (sense).

A historical and genetic approach, however, is required in situations where participants talk about topics that they have not talked about before or have not considered before. Speakers *cannot have* a «mental representation» of something they have not thought (talked about) before. Because in this situation, as shown in and with the previous analyses, the talk about a phenomenon, drawing on available (linguistic, paralinguistic, and extra-linguistic) resources necessarily is contingent, mediated by whatever has been said and done (e.g., drawing, gestures) so far and by whatever means participants find in the social setting (configuration that make possible orientations, artifacts, materials). It thus seems reasonable to suggest that a «conception», such as the one depicted in Figure 5.8, is articulated in and through a process of talk (i.e., the *saying*) rather than driving the talk. Indeed, to go from talk to that «mental representation», 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 intelligibility. They make the topic in the process, for the purpose of realizing the interview as research activity. Thus, what participants say and here (content) and how participants say and here it (process) is produced and reproduced in an interview, which also has a topic.

A historical and genetic approach to language requires theoretical categories that embody change itself. In other theoretical approaches, commonly employed in constructivist theories, change is modeled as the transformation of an entity into another form by means of a force that is external to the entity (e.g., knowledge; see Figure 3.2, p. 59). To model the change of language, however, we need a unit of analysis that contains the change. This then allows us to understand how talk said to constitute a «misconception» turns into talk said to be scientifically accurate and, therefore, constituting a «scientific conception» (Figure 5.9). As the figure shows, there will inherently be talk in which the different forms co-occur. It is mixed, muddled, hybridized talk. Every unit of talk, therefore, contains changed

[6] One possibility would be to think of the talk as «unscientific» until the very last moment when it, all of a sudden, becomes scientific. But such sudden changes are never observed. If they existed, conceptual change researchers would be able to readily point to a particular spot in a transcript where change occurs. But I know from personal experience that these researchers tend to be unable to locate change precisely.

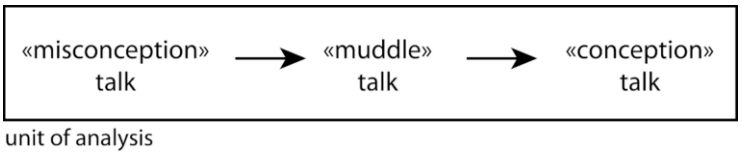


Figure 5.9 The unit of analysis of language change has change *built in*.

talk and, therefore, refers us to hybridization itself. But future forms of talk, as future forms of thought, *emerge* because these are not anticipated (Roth 2012b); speakers discover these in their own formulations. What should be of interest to STEM educators is the question of how a «scientific conception» *can* emerge from a non-scientific one (i.e., from a «misconception») in the way this is observed. What we actually observe is a linguistic change where language is tool, material, and ground. The question then concerns the transformation of something (i.e., a «misconception») radically different from itself (i.e., a «scientific conception») when nothing but the original something (i.e., «misconception») is available. The new (forms of talk, «conception») must already be possible within the old (forms of talk, «misconception»). This is precisely what Figure 5.9 depicts.

Abstracting from linguistic and paralinguistic resources

As the transcripts show, 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]). Moreover, the pitch does not always follow the customary ways, such as rising toward the end of a statement when a question is being asked—yet any competent speaker clearly hears the question realized here on the part of the recipient. 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 . . ."). Uncertainty—available to transaction participants, for example, in hesitations and pauses—thereby comes to be a resource for managing uncertainty (Roth and Middleton 2006). Leaving out these aspects from the transcription 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 totality of the situation to the verbal

In the literature on «conceptions» and «mental representations», 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 (Figure 5.8) and comes with changes of «mental representations» between ontological categories. To move from the present account, which also considers 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 presented again (i.e., *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 produce and see (recognize) gestures rather than saying something in words. The movement is precisely what the words do not reproduce and, therefore, «represent» only in an oblique manner. 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 «mental representation» or «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 statements, we might think of each expression as a singularity within a plurality (intelligibility). In this situation neither can a statement be reduced to another statement nor is the plurality as a whole given in any one singular statement. Rather, each statement (modality) one-sidedly and metonymically stands for the general intelligibility. There is then no requirement for all statements to have something in common (which the approach focusing on «mental representations» and «conceptions» presupposes as a matter of fact).[7] In this (dialectical) framing, each (synonymous) statement is different, which introduces difference into intelligibility 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 with and to the other. All of these resources contribute to constituting the intelligibility 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 (Figure 5.10). 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 intelligibility? And what is the range of error that we commit if we reduce the gesture in the particular direction and orientation is trans-

[7] In chapter 3, I present light and Schrödinger's cat as examples where two manifestations of a phenomenon are mutually exclusive and, therefore, have *nothing* in common. Light manifests itself as particle or wave and Schrödinger's cat, when we look into the box, is dead or alive.

Figure 5.10 The interviewer utters, "Do you think why the sun is over there?" while gesturing as seen here.

lated into words?

It is the competence of the listener that allows the speaker to attune to intelligibility; and it is in their subsequent joint actions that this intelligibility is further articulated. Interpretive errors enter the analysis precisely at the point when gestures and indexical terms are translated into words, literally carried from imagery and body motion into words, thereby necessarily articulating different dimensions of intelligibility; a different intelligibility is articulated even if the re-articulation occurs in the same modality—as the Italians say, "traduttore, traditore!", translation is treason—such as when something already said is said differently subsequently. Saying something in a different way clearly is non-identical with a previous Saying and therefore already constitutes an interpretation. But if conversation participants assume that two different ways of saying have said the same, there is a dehiscence of the *Saying* and the *Said*: where the former clearly differs the latter is held to be the same. This allows a conversation to continue when a person says something again following the statement "What do you mean like?" This, therefore, makes intelligible the contention that everything is untranslatable although nothing really is untranslatable; translation is the name for the impossible (Derrida 1996a). From a cultural-historical perspective, and this is where this text has been sliding into, at least by explicitly citing 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, their «meanings», and the «conceptions» being expressed by research participants do not have lives of their own but are usually taken at face value by STEM educators. Talk should instead be seen as integral to cultural activity, of statements performed by creatures acting in flesh and blood in real-world contexts and for specific purposes that are embodied in and by these contexts. And because intelligibility allows people to function in societal practices—e.g., interviewing—«concepts» are definitely not confined to the private territory of the individual human mind.

From observed talk to a cultural approach

In this chapter, I begin the analysis of a stretch of talk using nothing but 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, I 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 I ask under what conditions do we, the observers of the videotape on which the original conversation had been recorded, find intelligibility in what the participants made available for each other. In this way, I eschew anything predetermined and singled out the minimum presuppositions that enable the intelligibility of the unfolding social situation. In the course of this chapter, this form of cultural analysis leads us to a number of interesting results concerning the processes of talk that has as its topic phenomena of interest to scientists and STEM educators. These results are summarized in the following:

- 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 intelligibility articulated. The communicative act and the activity necessarily presuppose each other, as the latter exists only through concrete sympractical (joint) action by participants, which presupposes the nature of this activity that is in the very process of being realized.
- Talk between people makes use of many concrete resources other than words (sounds), which address human senses other than the auditory, and therefore possess very different intelligibility. These resources are distributed within and across speakers and listeners; they are distributed across setting particulars (e.g., spatially oriented). Each communicative act, belonging to speaker and recipient simultaneously, is concretely realized through this sequencing of these particular sounds, but the serialized production of sounds again presupposes the communicative act as a whole.
- Turns at talk are interdependent; the intelligibility of a specific statement is 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 not only synchronously across speaker and listener but also diachronically across a pair of turns (e.g., Figure 1.1, p. 15). Communicative acts therefore essentially and simultaneously are agential (has intentional and performative dimensions) and passive (in that they affect the other, and in whose actions the effect comes to be shared).
- In talking, speakers use and recipients hear 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 intelligibility as a cultural possibility, simultaneously particular and general. Social theorists often argue that language and culture speaks through the person: it is language itself that speaks in the mouth of the speaker and in the ear of the recipient.
- Talk is inherently underdetermined, full of stumbles, mumbles, malapropisms,

alternative pronunciations, inaudible sounds, metaphors, tics, prosodic variations, and pauses. Participants always say more than that they can say in so many words. When needed, this unsaid is articulated for the purposes at hand. Nevertheless, the intelligibility of the situation and talk is available to the conversation participants, who normally also draw on non-linguistic resources. Therefore, what people say underdetermines sense, they always mean other than is made available in these words.

- All recipients including the analysts bring to a situation a vast array of ordinary competencies making intelligibility possible even when (merely) synecdochically 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.
- Because it is always possible to rephrase what has been said, using different words, intelligibility inherently is open to development. The intelligibility of something maintains itself in sense, which is unfolded and explicated in being developed. Intelligibility inherently is open and unlimited because new ways of talking constitute new 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, s/he already presupposed the intelligibility of the word, and, in a group, the intelligibility on the part of other individuals. S/he presupposed forms of intelligibility, both at the moment, and developing in time. The origin of «conceptions» preceded «conceptions», preceded even the negation of «conceptions» («misconceptions»), and therefore is constituted beyond any and all «conceptions». That is, «conceptions», «meanings», «mental representations», and «mental frameworks» are *effects* of societal relations and communications that sustain them rather than their causes.

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: 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. 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 statements and continuous transformation of ways of talking. That is, intelligibility is open to every further articulation. This openness and the indeterminacy that it implies

compel us to take a historical perspective since forms of talk change in and over time and therefore are characteristic of moments in time; even this writing here is characteristic of the historical condition we—author, readers—find ourselves in; and they are characteristic of the biographies of the author and readers. There is no indication that this, my text would or could have been produced some 20 years ago by the same or different authors; my own biography brought me to a point where such a text became a possibility, but this is not only my 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 intelligibility inherently and always is shared, intersubjective, and hence cultural.

This idea of the singular plural returns in the figure of the documentary method (see the following chapters) where any single case, for example, a way of saying something, is a singular in a plurality, all ways of saying the same with different words. The totality is a singular and a plural simultaneously; and each case not only is a singularity, but because it is constituted as part of a whole, it is also a plurality, as all other cases contribute to constituting it.

From research on «conceptions» 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. The pragmatic and cultural approach articulated here does not deal with «conceptions» other than in the way these are made available by people in conversation. This way of dealing with the talk that we record in STEM research 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 «conceptions», «mental representations», and «meanings»—which, as shown in the previous section, requires several levels of abstraction—teachers only deal with "ways of talking" as they go about their serious business of living in the world of schooling together with their students, administrators, and other relevant folk. This is the basis of the documentary approach developed in the chapters that follow.

From a cultural and pragmatic perspective—a perspective realizing the *concrete human psychology* that Vygotsky aspired to—thinking about a «(scientific) concept», of which individuals have a «(scientific, alternative) conception» should be suspicious, for there are always infinite ways of communicating some topic or phenomenon. Ways of talking change while participants talk in situation, and these ways of talking generally change in infinitesimal ways. It is not that we have to agentially change our ways of talking. Rather, we find ourselves one day talking

differently than we had done some time back.[8] 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 that is coming to us from the other. This provides not only possibilities but also constraints; and it constitutes a resource for making inferences that scientists and STEM educators deem incorrect (from "sunrise" to "the sun is moving"). That is, through each of us, the possibilities of language are concretely realized and new possibilities are created, which others or we can subsequently propagate or further modify. But language as a whole transcends us, that is, is not dependent on our individual intentions. What STEM teachers therefore can do is contribute to classroom talk with the intent to have it move towards ways of talking that are contextually more appropriate. But they have to do so without any hope of achieving a complete change of the language or even of the abandonment of a tiny part thereof. There is no definable endpoint in the development, for scientific language itself continuously evolves.

There is another advantage in the sense that we no longer have to think in terms of breaking or abandoning «mental representations» but in terms of changing forms of talk. Forms of talk, as shown here, may and do change ever so slightly. For example, articulating in alternative words what someone else or the speaker has said previously constitutes a change of statement. Thus, Mary describes and the interviewer hears the sun as going from east to north to west to south and back to east again. They orient towards an ephemeral drawing on Mary's thigh, produced by a moving hand in a circle that stops in four positions while the cardinal points are named. 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 STEM educators not only find intelligible but also acceptable from a scientific perspective. In one context, I showed how such shifts led to ways of asking questions of one teacher, after working for a while in the same classroom with a colleague, that had longer student replies as their complements (Roth 1998). «Conceptual change» no longer has to involve a radical or non-radical change of «mental representations», but occurs in ordinary talk through infinitesimally changing ways of talking. The change in speech capacity is produced in speaking itself. «Conceptions» are therefore performed as a way of getting around in the world; and this performance always is public and for the other as much as it is 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 per-

[8] The pragmatic philosopher R. Rorty (1989) makes this case for the development of cultural-historically new scientific ways of talking. These ways are not the results of conscious decisions but emerge until one day scientists specifically and cultures more generally *find themselves* talking in ways that take certain sets of related statements for granted.

spective, where performances of «concepts» is all we ever see and produce, then there are other consequences for teaching science. Taking language learning as an analogy, we can see 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. We learn the rules—grammar or rules of the games we play—after having developed some competence in the (language) game, a competence required to make any rule implied in competence intelligible.[9] Here, however, I make an even stronger claim that learning science or mathematics is simply learning to live in the world with other people by using a multitude of cultural tools, not the least of which are scientific or mathematical «concepts» and «meanings». In so doing, scientific and mathematical «conceptions» assume their position as intelligible, useful, and justifiable ways of talking for/in society and not as abstractions so predominant in current STEM discourse.

Indeed, science students are too often said to be resistant to «conceptual change» whereas the 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 STEM classrooms.[10] We therefore do not need to 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 intelligibility and because language is both from the other and for the other, speaking, as writing, is an exposition of an inherently shared intelligibility, which, in writing, literally is ex-scribed. But exposition and ex-scription occur out of (i.e., *ex*-) a particular position so that the statement inherently is singular and therefore positioned (as cultural studies and feminist scholars emphasize) all the while it is universal, inherently intelligible, and therefore 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) of the possible and a repetition of the first realization.

If the teaching of science and mathematics remains primarily the eradication of «mis/conceptions», then instruction is perpetually an exasperating chore and one that is doomed to failure. Different ways of communicating are inherently useful, and virtually infinite; communication is hybrid, heterogeneous, different within itself—we therefore never articulate only one language. This very feature that makes it possible to re/articulate sense with respect to some phenomenon in

[9] Toddlers first learn language before they later, in upper elementary school, learn grammar (grammatical rules). It is only when we learn a second language, when grammar as structure is already intelligible, that we can learn a new language beginning with grammatical rules.
[10] Pertinent to mathematics classrooms, see the examples discussed in chapter 4.

ways that scientists, engineers, mathematicians, and STEM educators approve also makes it possible to talk about this phenomenon in ways that they 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.

The *with* and passivity

This chapter could have been concluded with the previous section. However, I decided to add this section one because it contributes to thinking about «conceptions», «mental representation», and «meaning» 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—«meaning», «conception», «mental representation». Thus, constructivism presupposes the subject of the activity, the constructor, a conscious being who intentionally pursues knowledge and learning. But who, we might ask, constructed the constructor? Nietzsche (1954) tells us that the «subject» of action independent of the situated action is an ideology. It is the result of a process when everything typical of a situation has been stripped—by gross reduction we might say—until nothing is left but a cause of the action: the «subject». How, if consciousness is a function of the language we use, could the consciousness of the constructor 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 R. Descartes, I. Kant, or G. W. F. Hegel, or E. Husserl. This chapter 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).

We always presuppose the mutual intelligibility of what is said/written; 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», «meanings», «theories», and other things that we choose as topics of and for talk.

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. The traditional conception of the origin of language and «(mental) representation» has been subject to post-structural—one might say post-constructivist—critique: Thus,

> the origin of language was thought as the transparency between the representation of a thing and the representation of a cry, sound, or gesture (the language of action) that accompanied it. . . . the origin of knowledge was sought within

> this pure sequence of representations—a sequence so perfect and so linear that the second had replaced the first without one's becoming conscious of the fact, since they were not simultaneous, since it was not possible to establish between the two any difference, and since one could not experience the second as other than "similar to" the first; and it was only when a sensation appeared to be more "similar to" a previous one than all the others that reminiscence could come into play, that imagination could represent a representation afresh, and that knowledge could gain a foothold in this duplication. (Foucault 1966: 340)

We have to some theoretical work to come to an epistemology consistent with the emergence of the human being with competencies that do not presuppose the very capacities that require explanation. We cannot, for example, presuppose knowledge of grammar prior to the emergence of language that could be grammaticized and grammaticalized. That is, we have to begin cultural-historically plausible theories by considering how 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 the emergence of conscious being becomes intelligible, where a first speaker can presuppose the shared nature of the (his, her) statement. 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, which is not even a dialectic at first, is a first principle, from which all other principles derive, including culture and cultural analysis.

Some time ago, a colleague and I jokingly referred to the formula *agency| structure*, in analogy to the first principle of physics $F = m \cdot a$, as the first principle of cultural sociology. In the articulation and explications of ways of talking (conceptions) during a specific interview, I also have arrived at a more parsimonious principle for analysis. The approach articulated in this chapter allows us a redefinition of this core principle within cultural sociology for it includes a moment of passivity, without which agency could not function theoretically and practically. We speak, but in so doing, realize possibilities that precede our speaking performances; we therefore also constitute the passive means by which language realizes itself. And this was since the beginning of human 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»). This is so because a way of talking always is realized by a person, but the possibilities of

language and intelligibility always emerge from the other and are for the other. Even the triple dialectic, as framed above, arises from the possibilities of language and, therefore, is second to the self-being-with-the-other prior to any conceptualization. This redefinition further shows that «schemas» change not merely through observing someone else in talking (communicating), but that these involve 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. The «conception» therefore is *not* mine. There is an essentially passive component in «(mis-, alternative, naïve, pre-scientific, etc.) conceptions» that to date has not been theorized in STEM education.

In this way, we are able to return «conceptions» and «meanings» to where they properly belong: culture. «Conceptions», «meanings», and «mental representations» are possible because of culture and the associated societal organization. This chapter, therefore, constitutes a move to put «conceptions» where they belong. That is, in this chapter, I culture «conceptions»; in culture, «conceptions» also have been cultivated both as forms of talk and in theoretical concepts about this talk.

This way of thinking ultimately returns us to the implications of talking STEM «conceptions». To knowledgeably overhear a conversation and subject it to analysis, researchers require the same competencies that allow others to participate in whatever the societal activity is that we observe (STEM classroom, interview). As a consequence, researchers have to have the same competencies in the production of all those stretches of talk that STEM educators have come to mark as deviations from «scientific» or «mathematical» «conceptions». We cannot explicate a stretch of talk unless we are already practically competent in that form of talk (praxis). Any explication inherently is preceded, accompanied, and concluded by this praxis. To identify something as a «misconception», as the negation of a «conception», as the «meaning» of a word, 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 a way of talking.

6 The language of real life and the real life of language

> It is known that one of the most serious errors of the entire traditional psychology is the separation of the intellectual from the affective-volitional side of consciousness. Thinking thereby necessarily transforms into an autonomous stream of thoughts thinking themselves and isolates itself from *the total plenitude of real life, the living motives, interests, needs of the thinking human being.* It thereby becomes a completely unnecessary epiphenomenon, which cannot change a thing in the life and behavior of the human being, or it changes into a somehow autonomous force, originary force that participates in the life of consciousness and personality influencing it in unknown ways. (Vygotskij 2005: 678, emphasis added)
>
> Das Wesen der Sprache: Die Sprache des Wesens [The being of language: the language of being]. (Heidegger 1985: 170)

In the first introductory quotation, Vygotsky "complains" about the separation of thought and affect that is characteristic of traditional psychology. Even though there are psychological theories of affect and how it influences thought, the relation between thought and affect is always external, one factor influencing another. But thoughts, or rather the words by means of which human beings articulate thoughts for others as for themselves, are only manifestations of thinking beings (Hegel 1979). Similarly, emotions as these are considered in psychology are only manifestations external to the "*being* that is an *expression* of the inner being, the individual posited as consciousness and movement" (ibid: 234). That is, just as during Hegel's time, around the turn from the 18th to the 19th century, and just as during Vygotsky's time, in the 1920s and 1930s, psychologists continue to look not at real persons, caught up as these are in real life, with living motives, interests, and needs. Thought is treated as something that exists in and for itself rather than being a means for coping in/with the real world. Psychologists need to be concerned with "man," who thinks, who "*regulates and controls his brain*"; "*the brain does not control man*" (Vygotskij 2005: 1033). It is therefore not surprising and consistent that psychologists ask their "research subjects" to come to their laboratories, where they disconnect them from everything else in their lives—as if we could understand what a person does and says independent of the different situations where the person participates in and makes societal relations, keeping these and their connections with other societal relations alive. In this text, where

Vygotsky elaborates on the *societal* relations that are the genetic origins of "higher psychological functions," he points out that these higher psychological functions "must be explained not on the basis of internal organic relations (regulation) but in *external* terms, on the basis of the fact that man controls the activity of his brain *from without* through stimuli" (ibid: 1023–1024, emphasis added).

In a similar way, the second introductory quotation is about the relationship between being (in the world) and the being of language. Heidegger uses a colon, which means a stop and then a continuation as if there was to be an "is" or equal sign. If read in this way the phrase then states that the being of language is the language of being. There is, in the way pragmatic philosophers view it, no longer a distinction between knowing a language and knowing one's way around the world. Both are grounded in a primary intelligibility. In this chapter I therefore show that we do not need «meaning» and «mental representation» to understand and explain what is happening when people talk.

Language and life are irreducibly intertwined

These ideas may be immediately applied to our present context concerned as it is with «meaning» and «mental representation (conception)». Rather than explaining talk by seeking recourse to internal organic relations, «mental representations», «structures», and unavailable «meanings», Vygotsky suggests here that we explain phenomena in "external terms, on the basis of the fact that" we control brain activity from without. One such means of control, in fact the most important one that makes humans different from other animals, is the use of language. But rather than explaining language by drawing on inner factors, Vygotsky wants us to consider it as an external stimulus. The pragmatic approach maintained throughout this book is consistent with Vygotsky's call for a *concrete* human psychology. This psychology finds its explanation in the concrete material relations that we partake in and reproduce as members of society and that are typical for the cultural-historical situation of a particular society.[1] This then leads us to a concrete approach to language, no longer explained in terms of «mental» processes and entities—«meaning», «conception», «mental representation»—but entirely in terms of the societal relations that we entertain and, thereby, keep alive. The approach may be seen as kin to the discursive psychology outlined in chapter 5, but in fact leads us to consider activity (*Tätigkeit/dejatel'nost'*) as a broader system producing something important to the survival of society that is intelligible only in its societal relation with the remainder of society. Language is integral to this broader concern for sustaining the individual through sustaining society.

In the frontispiece, I quote Marx/Engels, who suggest that consciousness generally and the words in which it is reflected specifically is the direct consequence of material, society-sustaining activity. It is not just that we know our way around the world but this world is intelligible precisely because we engage in practical activity to change it. Imagination/representation, thinking, and mental intercourse between of people are the result of practical activity rather than the other way

[1] In German, the adjective *gesellschafts-historisch* (societal-historical) is often used as a synonymous alternative to "cultural-historical."

around. In the foundational work of cultural-historical activity theory, A. N. Leont'ev, after quoting the same passage that I present in the frontispiece, provides another quotation, which elevates the contents of the frontispiece text to a more general level: "Precisely the *changes in nature affected by man*, not nature as such and by itself, is the essential and subsequent foundation of human thought, and man's intelligence grew proportionately with his learning how to change nature" (Marx/Engels 1962: 498). The changes human beings learned to bring about, mediated by the means of production they developed, are integral to the societal relations that they entertain. The "knowing" is integral to society, its structural relations, which exist only in and through their concrete realizations rather than being external, as boxes into which human beings step. These are the societal relations that Vygotsky writes about when explaining the origin of the higher psychological functions. These functions are the refracting reflections of everyday life in consciousness. The functions cannot be understood apart from the concrete situations in which these constitute the ideal correspondence to productive material activity (*Tätigkeit, dejatel'nost'*).

We always already find ourselves in a world shot through with intelligibility. This intelligibility expresses itself as sense (Heidegger 1927/1977). When we use expressions such as "this makes sense" or "I know what you mean," then we mark for everyone to hear the intelligibility of the situation. Sense is always already structured by "fore-*having, fore-sight, and fore-conception*" (ibid: 151). It is associated with the object/motive of the current activity in view of which "something becomes intelligible as something" (ibid: 151). Sense, as intelligibility, therefore "is not a property that somehow is attached to things [*Seiendes*], lies 'behind' it or floats somewhere as an 'intermediate realm'" (ibid: 151). That is, in contrast to the metaphysical conception, whereby «meaning» exists somewhere behind are attached to words, a pragmatic approach focuses on intelligibility that arises in, with, and from our activity in the concrete material world.[2]

Some readers may think that the preceding paragraphs constitute ideological talk in its negative sense, a position they have learned to despise as a consequence of the cold war that confronted the Western allies with the countries east of the iron curtain. But we find conative expressions of the relationship between language, the "carrier" of consciousness, and everyday life in Anglo-Saxon philosophy specifically and Western philosophy language philosophy more generally—most notably, of course, in the work of the later Wittgenstein. Thus, the following quotation from the work of D. H. Davidson, subsequently taken up by pragmatic philosophers such as R. Rorty, shows that in the West, too, scholars have arrived at the conclusion of the inseparability of language and life. We may therefore characterize linguistic ability by saying that

> the ability to communicate by speech consists in the ability to make oneself understood, and to understand. It is only when we look at the structure of this ability that we realize how far we have drifted from standard ideas of language

[2] I quote from the German text, which employs the word *Sinn* (sense). The English translation, however, uses "meaning," which tends to be used to translate *Bedeutung* (signification). The English translation is this: "Meaning is . . . not a property which is attached to beings, which lies 'behind' them or floats somewhere as a 'realm between'" (p. 142 [151]).

> mastery. For we have discovered no learnable common core of consistent behaviour, no shared grammar or rules, no portable interpreting machine set to grind out the meaning of an arbitrary utterance. We may say that linguistic ability is the ability to converge on a passing theory from time to time—this is what I have suggested, and I have no better proposal. But if we do say this, then we should realize that we have abandoned not only the ordinary notion of a language, but *we have erased the boundary between knowing a language and knowing our way around in the world generally*. (Davidson 1986: 445–446, emphasis added)

In this quotation—not unlike in the case of Wittgenstein's builder asking her apprentice for the next block to be inserted in the house they are building (see chapter 3)—the ability to communicate is the ability to make oneself understood and to understand. This ability to communicate is exhibited, as I show in chapter 3, in the way the apprentice gets a  ,  , , or a  when he hears the sound /blɒk/, /'pılər/, /slæb/, or /biːm/, without being rebuffed by the builder—attesting to the general intelligibility manifesting itself in the ability of the builder to make herself understood and to the apprentice's ability to understand. Davidson points out, however, that this does not require a common core of consistent behavior, or even rules and grammar—in which we could become proficient only through the same kind of societal transactions that also lead to our abilities to communicate. People communicate efficiently even without knowing any formal grammar! Most importantly, Davidson realizes that in such a way of framing linguistic competence, we erase the boundaries between knowing a language and knowing our way around the world more generally. This, therefore, is the very way in which we may frame the relation between the language of real life and the real life of language, which is inseparable from the former (Mikhailov 1976). Most important for the teaching of a language (discourse), such as typified in the language scientists, technologists, engineers, or mathematicians speak, "there is no more chance of regularizing, or teaching, this process than there is of regularizing or teaching the process of creating new theories to cope with new data in any field—for that is what this process involves" (Davidson 1986: 446). The philosopher later continues: "there is therefore no such thing to be learned, mastered, or born with. We must give up the idea of a clearly defined shared structure which language-users acquire and then apply to cases" (ibid: 446).

How then do we learn language generally and any of the (professional) specialist languages ("Discourses") specifically? If linguistic ability is a higher-order psychological function, then Vygotsky would have a definite answer to that question: We learn and develop by participating in the societal relations where the specialist language is an integral part of real life. That is, we learn language by participating in speech activity, which simultaneously produces individual language ability and language as a cultural-historically specific but changing system (A. A. Leont'ev 1969). This immediately allows us to understand that any discourse students learn while being in school, being integral part of real life school talk, will be different than the language that is part of the real life of scientists, technologists, engineers, or mathematicians. This is so because the societal relations and language cannot be teased apart; and these relations, typical of the societal activities in which they occur and which they sustain, are different in schools, in the STEM-

related workplace, and in everyday out-of-school life where STEM-related talk is going on more generally.

Language and laboratory life

As a result of many ethnographic studies conducted within the social studies of science and sociology of science, it has become evident that science is not something special and that it is not at all in the way it may appear from the methods sections in scientific research articles. As a former research scientist and as an anthropologist having spent years working with and observing scientists at work, I know that the life of scientists in their laboratory is pretty mundane. They have the same kinds of needs as other people: They eat, drink, sleep, go to the washroom, talk about family and friends, go to pubs, attend meetings, enjoy themselves fly-fishing steelhead trout in a river, and so on. Their laboratory life, too, is very mundane. They may listen to music while waiting an hour for their eyes to adapt to the darkness of the laboratory, lit only by a faint lamp with light in the far red spectrum; they may talk about what they have done on the weekend, or about how their children are doing in school, or about the fact that the children intend to go to one of the most prestigious universities in the country. Even when scientists are working, for example, appear in transactions with their equipment to collect data or just trying to make it work, their language is not so much *about* the things in their lifeworld as it is one of the means that advances whatever they are doing right now and, in this, advances the overall activity (e.g., completing an experiment to be reported in a scientific journal). It is the activity that produces the laboratory talk;, and it is the laboratory talk that produces the activity. We can observe this in any one glimpse at the events in a real scientific laboratory, evidenced in the following instant in the concrete life of a laboratory investigating the absorption of light in the photoreceptors of coho salmon, one of the five principal Pacific salmon species.

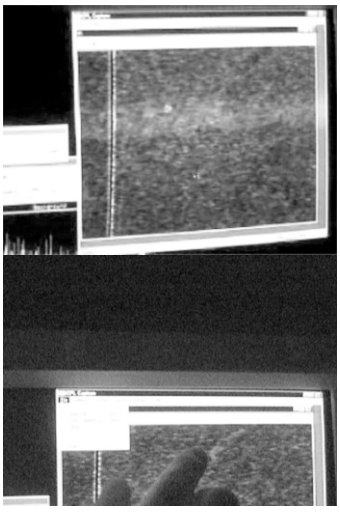
At the time, the laboratory is one of the leading ones in the world investigating, among others, life history changes in salmonid fishes by tracking changes in their perceptual systems in the course of the life cycle of the fish. The Pacific salmon that the scientists are working with at the time are anadromous fish, that is, the fish hatch in freshwater environments, where they grow to a certain size. The fish then leave the freshwater to head for the ocean, where they spend a number of years to grow to adult size, before returning to the same freshwater system to reproduce and die. Associated with the migration are physiological changes that prepare the fish for life in water with different levels of salinity. At the time of the scientific research project, the 60-year dogma suggested that the physiological changes are associated with changes in the chemical composition of the photoreceptors in the eyes from predominantly vitamin-A_2-based (porphyropsin) to a predominantly vitamin-A_1-based molecule (rhodopsin). To measure the amount of porphyropsin in a photoreceptor (cone, rod), the scientists pass light through the cell and, for comparison, through the slide but next to a cell. The difference in the amount of light measured in the two cases is attributed to absorption in the cell.

The language of real laboratory life

On that day, the scientists spent, as they did everyday when they collected data, an hour sitting in the dark laboratory, waiting for their eyes to become adapted to the situation so that they can see sufficient to get their work done. After having sacrificed the specimen, extracted the retina, macerated it, and placed a bit of the crushed material on a microscopic slide, they are ready to begin the search for the cell. But there is nothing other than a grainy image on their computer monitor that is supposed to show the contents of the microscopic slide (image next to turn 01). The scientists are flabbergasted, wondering what has happened since the night before when everything was working. They are looking, pushing buttons, and operating pull-down windows from the program that is supposed to provide them with an image of the microscopic slide. But nothing appears to work. They are literally groping in the dark. This instant presented in Fragment 6.1 constitutes a first changeover in the way the researchers are attuned to the image before them. Until this point, brightness has been the central issue that different speakers noted and therefore made salient to each another, and for which they proposed a variety of solutions or possible causal precedents. Here, there was, for the first time, a new issue: the resolution. In normal operation, the resolution of the image withdraws to be really handy. But when things are not handy, their properties force themselves into the foreground. The instrument and its constitutive parts achieve their character exactly at the moment that they do not work. We can call this the moment when the worldly character of the surrounding world makes itself known, comes and even forces itself into the clearing (consciousness) where it is accessible to our attention. The resolution issue co-emerged with the first, vague image of a cell, barely visible in the noise, but enough to be pointed to and out by means of a gesture.

Fragment 6.1a

01 T: * `okay I brighten it right here.
02 C: thats not it.
03 T: <<p>´how about this; do you see this one right here.>
04 (2.31)



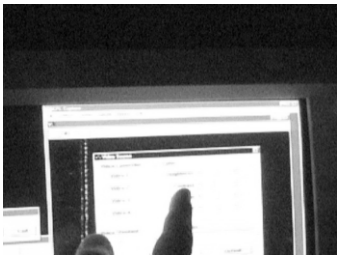
05 you see right * ⌈here.
06 ⌊((*Moves finger back and forth along screen where there appears to be something in the noise*))
07 C: `yea i know but the resolution is (0.69) really bad.
08 T: yea.
09 (1.54)
10 okay.

Let us begin by considering *what* the scientists are saying and *how* they are saying it. Fragment 6.1 begins with the formulation of an action as a change in the image by modifying brightness (turn 01); but the next turn suggests that the change made "is not it," that is, it could not have addressed the central problem. Theo says that there was something to be seen, but there is a conversationally long pause, and neither of the other two lab members present gives a sign that he has seen what has been referred to "see this one right here?" Theo then speaks again. This turn sequence, followed by the statement "yea I know," thereby constitutes the pause and lack of acknowledgment as a sign that others do not understand. The statement then not only reiterates the indexical reference "right here" but also uses a gesture to point to and move along monitor where he saw an entity (turn 05). That is, this communicative production is the second part of a turn pair, the first one being a long pause where a second turn to his preceding statement (turn 03) might be expected to occur. That is, the next turn does not treat turn 03 as a question, as the grammatical structure of the statement might lead to suggest. Rather, there is a question/invitation to see that requires an answer, something like "yes I see" or just "yea." Both words (turn 05) and gesture (turn 06) then contribute to making a statement, which constitutes a pointing out that communicates and defines.

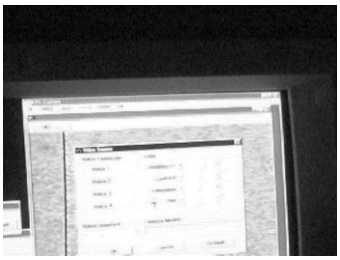
By saying, "Yea, I know" (turn 07) Craig acknowledges that he is seeing whatever "this" is; but he then articulates «the problem» in a new way: "the resolution is really bad." Theo, in turn, can be heard to «acknowledge» the comment (turn 08), and can be seen as searching for something in a pull-down menu (lines 10–11). His action selects a particular window, but the statement explains that he could not set the contrast to brighten the image—Theo's hand moves across the position where the modifications could be made (turn 12–13). Subsequently, and as if he were speaking to himself, he also describes the present situation as offering too many options to select from (turn 14). He not only makes changes but also articulates them in words: "increase contrast" and "brighten." His actions are accompanied by changes in brightness and contrast but the image behind the window remains as fuzzy as it has been. Craig now can be heard to make a statement about there being "too much noise" (turn 19), consistent with an earlier statement about a poor ("bad") resolution. The next turn accepts this statement.

Fragment 6.1b

11 (8.71) ((*Goes to a pull down menu, which opens a new window.*))
12 i * cant set the ⌈contrast to brighten it.
13 ⌊((*Moves hand across the window at the place where settings can be changed.*))



14 <<p>yea we have more than one to select from it.>
15 increase contrast–
16 (1.84)
17 brighten–
18 (7.39)
19 C: * nOW (0.20) there is too much noise.
20 T: yea.



In the course of their data collection, there were other moments when there was "nothing" on the screen, when there was nothing but "noise." But the scientists learned to attribute that particular part of noise to the fluid in which the retina is suspended or to some other part of the instrumentation. In the present situation, the "noise" was more like that of a television monitor when there is no signal on the cable or when the channel is slightly mistuned. The scientists do not know the source of the noise. So they cannot intentionally orient towards finding it. Their exploration, their search for something that both will change and explain the situation, is part of process of providing a clearing, in and from which entities come to emerge until one of them—hopefully—comes to make the difference.

When there are problems during the research, here as elsewhere during their research, the laboratory members never engage in the kind of searches that psychologists and cognitive scientists talk about, where the problem solver searches a known problem space for specific and specified items—similar to someone searching for a particular knife or pot in his or her kitchen. The present situation is rather different; it is a search for something that the participants do not even know what it is. As Theo says elsewhere during the episode, he does not think that they have changed anything since the previous day. Yet the image they are looking at *is* different. The process in which the researchers thereby are engaged is more like groping in the dark—they literally are in the dark where the groping is going on—when we find ourselves in an unfamiliar place in complete darkness. All we can do is move about without knowing into which direction we have to move to change our situation. At the outset, any direction is as good as any other one. There is no way that we can judge whether or not a particular movement, a particular direction, or a particular action is more or less successful in getting us out of the situation. But through our actions we clear a field, constitute a clearing, and begin to separate figure from ground. The sense that emerges is pre-figured by intelligibility as a possibility. The situation eventually can make sense because intelligibility is already a possibility. This possibility disappears as such when it comes to be realized. Realization, therefore, also means destruction of (mere) possibility as such. There is a general sense of what the overall outcome ought to be, and there are certain constraints to the actions given by the material conditions of the situation. But there is no map or gradient (as in the games where we are told "hotter" and "colder") that could help us identify if or when we are close to narrowing the gap.

Eventually Craig can be seen to be completely frustrated. Already he has "lost" an hour trying to get the instrumentation to work. The unfolding activity and with it the speech activity that participants engage in cannot be disconnected from the

larger context: that of human beings with their emotions, physical states, and so forth.

In the end, the problem suddenly disappears as one of the software settings, after being changed, brought about the desired image. Immediately prior to that instant, Theo describes for the first time the real change that has occurred since the previous day: "Maybe it's a trouble with the large screen." Here, "large screen" did not mean "large" in absolute terms. The "large screen" stands in contrast to the smaller screen that they have used on the previous day; the significance of the denotation becomes clear only in this historical perspective. Up to that point in their work, they have used a smaller computer monitor, for they only had displayed the graphs before, whereas one researcher has searched for suitable cells on the microscopic slide by looking through the ocular of the microscope. The scientists decided to replace the ocular with a CCD device, the image of which they see on the computer monitor currently connected to another computer in another lab. Articulating the large screen and thereby bringing it into the clearing—i.e., turning the ready-to-hand into something present-at-hand—changes the way in which they are attuned to the situation and quickly resolve the issue. Such attunement presupposes intelligibility: I am in tune with what makes sense, even with its opposite, non-sense; but I am not in tune what completely lies outside of sense. Once the image on the screen is in the way they want it, the scientists continue as if their problem had never existed, as if they had not spent 15 minutes struggling to find how to get their CCD image to show up on the monitor. But with the disappearance of the problem, therefore, that which had been in the foreground receded to hide itself again in its ready-to-hand everydayness.

The real life of laboratory language

The language that these scientists use is an integral part of the exploration activity; it primarily constitutes a form of action, with an intentionality of *in-order-to*, rather than a representation, with its intentionality to be *about* something. It is a resource for pointing out some things, making them salient, and aligning others to one's own ways of being attuned to the field. When speech activity appears to be insufficient, participants also have available gestures as means to point, encircle, or iconically articulate an entity. That is, we have to analyze communication rather than speech alone. The totality of ways in which the scientists exhibit to each other intelligibility, including their non-talk when things are passing by on the screen, is integral to the movement of the activity as a whole. The speech activity is part of being attuned to rather than a «representation» of a world separate from the individuals engaged in the search for the causes of the "different field." The structure and content of this communicative activity cannot be understood outside of the activity as a whole, because the research activity gives rise to and moves long the communicative activity in the laboratory; and the communicative activity gives rise to next actions and moves along the research activity. The real life of language is speech activity; it therefore is irreducibly tied to the research activity generally and to the current goals and actions more specifically.

The videotapes recorded in the laboratory in the course of the scientists' investigations also show some interesting features pertaining to communication. There

are relatively long pauses between two speakers—up to 30 seconds long. This is significant, for there is a considerable disciplinary history of analyzing conversations, particularly pertaining to turn-taking patterns, repair, function of pauses and overlaps, and so forth against which these pauses need to be seen. In the laboratory work I observed, many of the reported patterns do not hold. For example, there are long pauses when the participants do not speak, there are frequent questions and statements that arise seemingly from nowhere. Unlike other conversations often analyzed in the literature, this one here is not an activity in itself but is part of the day's work of collecting data. The temporality of language use and turn taking is subordinated to, or rather, an integral part of the intelligibility of the total situation to which the participants are attuned. The purpose of the current actions in the ongoing research activity is to produce the data for an article, and the goal for the present day is to produce such data. Talk exists in so far as it assists in moving the system toward that goal. Because the participants are co-present to each another, which gives them equal perceptual access to the material situation and to one another; and because they have a considerable history of shared collective activity, there are many things that go without saying. Words and statements contribute to moving the activity along, to bringing light to the clearing, even if these do not constitute well-formed sentences and even if these do not constitute complete representations—whatever the statements might be said to refer to. What is transforming is not the topic, as moved ahead and transformed by the verbal contributions, but the laboratory activity as a whole. Because members are attuned to the relevant aspects of the setting, those aspects that go without saying do not have to be, and in fact are not made, salient, for "statement is a pointing out that communicates in a determinate way" (Heidegger 1929/1977: 156). Not talking generally occurs when the participants have the sense that they know what is going on and that they assume it is the same for others. It is only when someone has the sense that a common ground does not exist that communicative action begins.

Communication is more than what people say. Participants are attuned to the setting and the fundamental assumption under which they operate is that others are attuned to the setting in the same way that they are. Scientists can sit in the laboratory, watch a computer monitor where images go by and know that they are in tune and that others see what they see all the while being completely silent. The changing world itself is communicating (Roth 2004b). It is only when there are discrepancies, when there is evidence that the assumptions are not fulfilled, that participants engage in repair to return the situation to be consistent with the assumption. Communication is more than what people can say in another sense as well. When Craig says, "What's *special*?," this is not just asking a question but also indicating that he does not know. One might ask, what does Craig mean? "What is special about what?" Here, *special* is a word that appeared somewhere on the screen. The two other participants in the setting are attuned to the screen in the same way as Craig. What is special can therefore be heard as a question about the word special: "What does the word 'special' that appears on the screen denote?" In fact, it is in the turns of the others that Craig's statement becomes a question paired with the reply-constituting statements of others.

Laboratory communication, verbal, gestural, or otherwise therefore has at

least two functions that we need to consider simultaneously to understand "the life of language." One is to point out something may have not been noted by another person. By the very fact that this something can be pointed out reflects the possibility of its intelligibility. With each communicative act, members to the setting make salient to and for others things. These things are already intelligible by the very fact that they can be pointed out. Things, articulated (differentiated) from their context are articulated in language—the two articulations (seeing, speaking) are the two sides of the same coin. "*Logos* [speech] lets something be seen (*φαίνεσθαι* [phainesthai]), namely that what is talked about and for the speaker (the medium), and indeed *for* the interlocutors" (Heidegger 1927/1977: 32). Second, the communicative act also functions to reassert and thereby maintain the same attunement to the situation and therefore to the current state in the unfolding of the events. The longer the individuals in this laboratory worked together, the less talk there was—which my videotapes, recorded over the 5 years that I spent in this laboratory, amply document. That is, communication cannot be seen and interpreted to constitute a momentary phenomenon but requires historical analysis. When co-workers do not talk, this does not mean that nothing is going on and happening.

The data also show how affect is deeply integrated with language production. In fact, each verbal production has both semantic and affective aspects, as we can hear in the voice when Craig gets frustrated, and we can hear in the impassionate voice of Theo that it is for him just another day in the laboratory, where things can go wrong. Craig does not have to reflect and think about what to say and how to shape the sounds that come from his mouth: what he says and how he says it is integral to the life in this laboratory, including the content of the talk, the way in which they talk, and the affective aspects that we hear them articulate simultaneously.

Language and school life

As a productive activity advances, so does the communicative activity (language game) that is an integral and constitutive part of the former; and with advances in the communicative activity, the productive activity also advances. That is, speech activity is producing societal activity, and societal activity is producing speech activity. But, as we see in the preceding section, activity is also reflected in and produces, as another form of consciousness, affectivity: emotion literally is at work (Roth, 2007). Thus, as the actions that realize the activity unfold, affect is continuously transformed into affect, sometimes shifting from elation (e.g., when a student has the sense of understanding) to frustration (e.g., when a teacher feels that what she has been doing in the attempt to assist a student has not led to the desired results) (Roth, 2013b). In the following example from school life, we see how the affective side develops together with the activity, itself developing as a result of speech activity, which, in turn, develops as the result of the advancing schooling activity. This speech activity, here, therefore does not only concern mathematics but also schooling more generally. Speech activity simultaneously produces schooling activity, societal relations, and mathematics talk.

The language of real school life

The present example has been recorded as part of an innovative mathematics curriculum, which provides fourth-grade students with opportunities for developing early understandings of algebraic notions.[3] The transcribed lesson fragment was recorded on a day when the students were working on a story-based task. The story features a girl who receives a piggybank and $6. She decides to save $3 each week. The students are asked to model the situation for the first six weeks using goblets and colored chips (a different color for the first $6 than for the subsequent $3 each week) and then to fill up a prepared table of values that the designers of the curriculum hoped would encourage the students to move from noting the dollar amounts added (3 + 6), (3 + 3 + 6), (3 + 3 + 3 + 6) . . . to a multiplicative form (1 x 3 + 6), (2 x 3 + 6), (3 x 3 + 6) . . . for each of the weeks 1, 2, 3. . . . As a way of affording this task trajectory rather than any other possible one, the table of values already contains some numbers and signs: those underlined in the preceding sentence.

The students seen in the video—Mario, Alyssa, and Thérèse—have been working for a while, but they begin to be stymied after having filled the goblets with the dollar amounts for each of the first six weeks (see goblets in offprint that goes with turn 80a) and just as they begin filling up the table. One of the three students seen on this video, Thérèse, is humming along, an expression confirming that she appears to be fine. (The other two students, Mario and Alyssa do point out that Thérèse appears to know what they are required to do.) Alyssa, however, has already come to a point where she says she does not understand and that she will never understand. Mario alternates between trying to move on and trying to get the teacher's attention. Eventually the teacher (Jeannie) comes to the table and, after Mario has said "Look, this is dumb" in response to her query how they were doing, begins to engage especially with Mario. The fragment begins after Jeannie has asked Mario about the contents of the piggybank at the end of the first week, to which he has answered "nine."

In repeating what Mario has said with a constative intonation, Jeannie's turn affirms that the amount is 9 (dollars) for the first week (turn 69) and, in continuing, her turn offers up what can be heard as a query: "Why is the three in yellow?" Mario produces an interjection, shrugs his shoulders and shakes his head as if saying, "I don't know" (turn 71). That is, in this ordered turn sequence, we observe an irreducible query|reply unit. Thérèse does state that she does not know, and Mario, who is beginning to talk simultaneously, suggests and offers as a question that it is because they are supposed to write it (turn 74). We then hear Jeannie utter a translation of the preceding query, which has concerned the reason for the three (chips?) to be yellow, to the origin of the "three" (turn 76).

Fragment 6.2

69 J: it EQuals to nine the first week. (0.78) wHY is the thrEE in yellow. whydyou think. ((*Index finger on table*))
70 (0.19)

[3] An extensive, cultural-historical activity theoretic analysis of this mathematics lesson is available in book form (Roth and Radford 2011).

71 M: um um, um ((*Shrugs shoulders, shakes head 'no', questioning look.*))
72 (0.20)
73 T: <<all>i don [no]>
74 M: [be]cause we are supposed to write it?
75 (0.44)
76 J: WHEREe does the thREE come from.
77 T: donno?
78 M: <<f>a:=u:> (0.24) u:: (0.17) u: dududu: wedding thing there?
79 (0.76)
80a J: <<exasperated>buthh * ((*turns head away from Mario*)) (0.14) the three dO:LLas? is wHAT exACtly?>
80b * ((*Mario, who has looked at her, grimaces in desperation, brings his hands up and covers face*))

As before, Thérèse states not to know and Mario suggests, switching between the French language that they have been using so far and English: "the wedding chose [thing] là [there]" (turn 78). There is a brief pause, and then we hear an exasperated "buthh"—as the "hh" shows, there literally is exasperation—upon which Jeannie turns to look straight into the camera (see offprint in turn 80a), as if she had been caught in doing something that she does not normally do (or that teachers are not supposed to do). She continues, producing another translation of the query concerning the three dollars: "the three dollars is what exactly?" (turn 80a). But Mario grimaces as if in desperation, brings his hands up to the face, which he then completely covers with the palms of his hands (see offprint in turn 80b).

In this fragment from school life, we see how participation in schooling activity, whatever the present affective state, produces affect, here with negative tonality, and changes therein. This is apparent in the exasperation and frustration that is exhibited in Jeannie's voice and in the fact that she is apparently checking on the camera and its operator who have recorded and overheard her reaction. Mario also makes available for everyone to see and hear that he noticed this frustration, his evaluative turn exhibiting what can be seen as an expression of desperation (the way he covers his face). That is, the two make available evidence of their affect and, therefore, of how what they are doing is affecting them.

We witness here an everyday situation, where the actions of the members to the setting move the schooling activity along all the while being or getting stuck. As in the saying "one step forward, two steps back," any step both moves the schooling activity ahead and retards it, because both kinds of steps realize the schooling activity even if it is in a temporarily retrograde movement. The retrograde movement is integral to the overall movement, just as the turbulent back-

ward flow in a river is part of the general movement of the river: to the ocean, a lake, or simply into the ground. Affect is integral to this movement. Affect is a reflection of this movement, and, therefore, expresses and manifests a form of consciousness of the activity—though different from the verbally mediated consciousness that is privileged in (educational) psychological and associated STEM discourses. This ebb and flow of talk and affect is integral to the realization of this mathematics-related schooling activity, which, in turn, produces the ebb and flow of talk. *This* is the language of real life in a classroom. This life is not just about the cognitive contents of talk. It is not just about ideas. Rather, it is constituted by the societal practice of doing schooling, teaching, learning, frustrations, exasperation, and so on, all playing an integral part in the schooling activity as much as the colored chips, goblets, paper-based tables of values, pens, chairs, tables, and physical classroom.

The real life of school language

We observe a transformation of the language of transaction when what has been uttered apparently does not advance the situation to whatever may be the anticipated end state. We clearly observe the movement in the talk. First Jeannie's turn states "Why is the three in yellow? What do you think?" (turn 69); then she utters "Where does the three come from?" (turn 76); and finally she voices "The three dollars is what, exactly?" (turn 80a). We note that in all three locutions, the "three [dollars]" appear thematically. In all three locution, the pitch contour points to the offering of a question, and the next-turns, all falling to Mario, accept these offers by countering with the offers of a(n) (tentative) answer. All three locutions clearly are oriented toward Mario, as per Jeannie's bodily orientation and gaze directions that can be seen as selecting him as the intended recipient; and all three are first parts of pairs in which Mario's locutions constitute the second parts. There is a change in language and in the things in the setting that are made salient in and through the talk. The first statement asks about the reason for the "three" to be in yellow. The second statement asks about the origin of the "three." The third statement asks about the nature of the "three dollars." We therefore see that although all three statements have threeness as their topic, the latter is actually changing as the situation unfolds in time. This changing language is equivalent to the life of school language in *this* situation, but, though there is not enough evidence for making a definitive statement from the current videotape, it is also important in the life of this teacher. I elaborate on this.

If Jeannie knew what the current problem is, she could have said what is required to get Mario back on track. The fact that she does not do so on the first trial but apparently has to look for a way of asking her question shows that she, too, has to figure out something, learn how to address *this* problem at *this* point in time. The changing language evidences both the search and the learning process, which both will have come to a conclusion once Mario has answered. He has to have answered in a way that will lead to the continuation of the trajectory toward eventual completion of the worksheet, on the one hand, and, hopefully, some evidence of comprehension on the part of Mario, on the other hand. This language that we observe, being the result of the current speech activity, has to be theorized

in terms of its double belonging to schooling activity and the goal of the particular mathematical task that realizes the former. The speech activity develops together with the overall schooling activity; and it does so in the form it is realized at the present instant.

This fragment contributes to the discussion about the existence and usefulness of «meaning» in an important way. We can hear Jeannie repeatedly ask about the 3 (dollars), as if Mario had said, "What do you mean (like)?" This is precisely what videotapes shot in another, mathematics classroom in another part of Canada showed, where the teacher «reframed» a question repeatedly when her student either asked "What do you mean like?" or when there was a long pause without reply, providing the teacher with another opportunity to take the floor and «ask the question» in a different way (see chapter 7). If «meaning» had been something accessible, Jeannie, as Mrs. Winter in chapter 7, could have articulated it right away. But the fact that the question "What do you mean?" or any other transactional form that has the same effect—the repeated re-framing of a question—then tells us something about how to think about «meaning», if indeed we are desperate in wanting to retain this notion. I develop one such possibility in chapters 7 and 8, where the totality of ways in which Jeannie—or my other teacher—might possibly respond to the question "What do you mean like?" constitutes «meaning». In the present instance, the student-uttered query followed the first locution "Why is the three in yellow?" We might use this as documentary evidence for (concrete manifestation of) the «meaning». The «meaning» of Jeannie's response, thereby, would exists in and of the totality of ways in which her statement may be rephrased while assuming that it is saying the same. This «meaning» is only ever available in these concrete manifestations—much like the nature of light is available only in and through its manifestations: either wave or particle. Put I return to this issue in subsequent chapters, where I give it a more extensive development.

At this point, we may also take a comparative look at the speech activity—i.e., the language games at play—in the school example and at that in the scientific laboratory. We note that there is a structural difference in the sense that the definitely ordered turn taking in school is characterized by the teacher taking the first position, in which a question appears, and the student takes the second position, where there is a reply. In this episode, the sought-for answer has not yet been produced, so the typical evaluation and change to the next topic has not yet occurred. In the fragment from the laboratory, there is no such sequentially ordered question|reply pair. Rather, there are statements, queries, propositions that move the search for the problem along. In the schooling activity, there is a definite answer. The "three" pertains to the amount of money that is saved each week. Jeannie knows it. She has designed the task together with the researcher who had planned the study. In the laboratory it is not only that the people search for an answer: they do not even know what the «problem» is. Framing the «problem» so that it can be solved is their *joint* task to be solved transactionally. In the school, it is the production of the already known answer that is to be achieved transactionally. The task appears to be clear, at least to Jeannie. But there is a problem: Jeannie and Mario appear to be stuck, as shown in their affective evaluations of the situation. The nature of the «problem», however, is not clear in the same way that the nature of their «problem» was not clear to the scientists. Thus, in each case the

case the communicative activity we observe serves to move along the activity, which in turn moves along the communicative activity (in a forward or retrograde movement). But in the two settings, there are very different, societally mediated organizations in which the transactional work is accomplished; and there are also very different object/motives to be realized. This is reflected both in the content and in the structure of the communicative activity that moves along the overall activity as it moves itself along, and which is moved along as the overall activity advances.

The real life of language is its irreducibility from the language of real life

In STEM education, there is a tendency to consider school as something different from other aspects of life. This is clearly evident in such theoretical notions as *third* or *hybrid space*, where students are said to cobble together the school-related discourses and identities—something like "second space"—and those that are characteristic of the situations around family and friend—something like "first space." We find an instance in chapter 2, where I analyze the data from an Australian chemistry classroom. There the authors focused on the fact that they observed informal language while students were completing chemistry tasks. Theorized in this way, students are then said to be boundary-crossers, moving from "home culture" to "school culture," and to be creating a "hybrid culture." There appears to be little consideration that from the perspective of the students, school is just as much part of the fullness of life as being with friends in the skate park, with family on a holiday trip, or shopping for clothing (Roth and van Eijck 2010). Students do schooling in the way they do these other things. They are likely having preferences with respect to participating in the different activities (*Tätigkeit, dejatel'nost'*); and, for some or even many, schooling may well be at the bottom of the list of common activities. Thus, although they participate in the activity of schooling, the object/motive of this activity may not be high up in the hierarchy of object/motives that make the personality of the student.

At any point in time, one activity and object/motive may be dominant, but this does not mean that the others are not equally salient. We may observe someone shopping for clothing and simultaneously talking on the telephone to a family member, friend, or co-worker/boss. That is, although a person participates as a consumer in a shopping activity, s/he simultaneously engages in the relations that maintain another activity system. A parent at work may call home where a child is staying home sick to see how s/he is doing. At any instant in time, we may think about and organize what we will do next, within one or more other activities that we commonly participate in, such as when planning to go out for dinner with a colleague who also is a friend. We well know that students not only go to school but also maintain their friendship circles, both within and between their scheduled classes. Thus, rather than conceiving of boundaries, we ought to think about the integration that occurs in everyday life, one aspect of which may be more or less favored or even be hated. Yet participating, however much one subscribes to the object/motive, means sustaining and transforming the activity.

For these reasons, I suggest that it is more useful to theorize participation in

any form of activity as connected to participation in all other activities. We always participate in *life*, though some parts may be more salient than others. That is, we do not cross boundaries but are present in and to life, parts of which manifest themselves at any one point. At any instant, we may then observe evidence that people engage in these other activities, realizing their object/motives, all the while remaining physically in the location that is characteristic of the currently dominant activity. This, then, makes for the multi-voicedness of life, where the forms of talk characteristic of one activity surface while participating in another activity. In fact, any locution has the potential to realize multiple object/motives, belonging to different activity systems, so that making reference to the leadership of a peer during the physics course using the word "Führer" (German for "leader," but also used to denote Adolf Hitler, who used the noun as a title) resonates another conversation that these students have in another place and time or in multiple places and at multiple times (Roth 2009b). This is the case in the following example, which features a fragment from a physics course.

The multi-voiced nature of life

This classroom example was recorded in a 12th-grade physics course of a private school ("college" in the British tradition), which, at the time, was for boys only. Although the activity for the students would still be schooling, in this particular case the purpose was to prepare them for college or university entry. The teachers at that school were certain that the student body was no different from those who attended the "better" of the surrounding public schools—but they tended to come from well-to-do families that could afford the high tuition and boarding fees. The particular task that the students completed was a concept map using a set of given terms printed on 1" x 4" paper slips that I, their teacher, had provided them with. The students were to arrange these terms from the most inclusive to the least inclusive, building something like an inverted tree structure, which they then transferred to a large sheet of paper (11'' x 17'') where they also drew the branches between the terms and wrote linking words along these links (see, e.g., Figure 5.8, p. 128.)

The fragment was selected such as to show that besides the concept mapping task-related talk, there was other talk going on. In fact, there is evidence of a continuing conversation that spans weeks and different occasions (dorm, chapel) between two of the protagonists, who accuse each other, part in jest and part in seriousness, of racism. At the time, I had omitted this and other bits from the transcript that I analyzed for research purposes because I considered these to be—as my colleagues elsewhere—"off-task" conversations. I realized only many years later, once I had read an analysis of F. Rabelais' novels (Bakhtin 1990), that these are forms of talk suppressed and repressed in school situations—much like the Church repressed certain forms of talk and behavior during the Middle Age (Roth 2009b). It is only under certain circumstances that the plenitude of everyday talk is allowed to come to the fore—in the Middle Age, it was during the times of the feasts, in schools it tends to be during "fun 'activities'" or during small-group work where teachers tend to be a little more lenient with the kind of topic and language that they will allow. When the fragment picks up, Miles, Ralf, and Ken (from left to

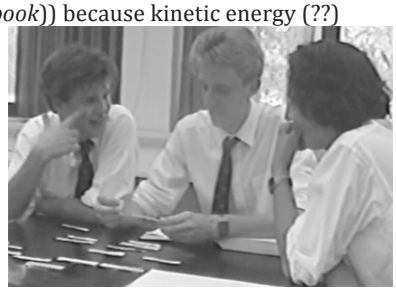
right in the offprints) are in the process of talking about where to place, in their beginning hierarchy of concepts, the term "Planck's constant" (turn 132). As the give-and-take shows, there appears to be agreement that the term is "pretty important" (turn 134), because it "practically deals with all of" the terms (turn 133). There is a proposal to place it under "complementarity," which is currently the top-most term. There is also a statement about Planck's constant being "connected" to "kinetic energy," which is "Planck's constant times frequency" (turn 136). Then, all of a sudden, Miles, who had come late to class, addresses the teacher «asking about» the recording of the lesson. And then there is a statement that in this way, "Ralf the Führer" would be recorded (turn 136a). Miles clearly is oriented toward Ken, as if waiting to see whether this statement has an effect (see offprint in turn 136a).

Ken can be seen and heard to reply to the statement and to Miles' gaze with a chuckle, and Miles chuckles in turn. The next statement returns the accusation/insult with amplification: the addressee. Accordingly, Miles is "the biggest racist here in school," which is taken up as having already been discussed and that the preceding speaker has "been racist" (turn 136f). There is an invitation to go on, and, Ken's hand held like a dividing screen (offprint associated with turn 136f), as if separating two contestants.

Fragment 9.3

132 M: okay, where are we gonna toss plancks constant?
133 K: it deals with practically all of them.
134 M: its gonna be on top, because its pretty important.
135 K: under complementarity.
136 R: its connected, see kinetic energy is either plancks constant times frequency or electrons or ((*looks into book*)) because kinetic energy (??)

a M: ((*turned toward teacher*)) uh are you recording with this one? uh i didnt know ((*turns to Ralf*)) its like ((*hand movement as if slapping with back hand*)) this is like ((*points to microphone, then looks at Ken*)) recording ralf the * führer ((*points to microphone*)) ((*Miles and Ken both chuckle*)) ralfy the racist, now you- ralf the racist.



b R: you are the biggest racist here in school.
c M: we have been discussing this, you=ve been racist.
d R: i should=ave mentioned-
e M: ralf, who said- listen
f K: * ((*hand forward as wanting to separate them*)) <<calming>let=s go on>

g M: listen a sec. listen ((*oriented toward Ken, throwing his hand forward*)). you can decide on this. * ((*Sideward glance to Marc.*)) in my chapel speech-

h R: you are talking the whole hour about racist stuff. nothing i have said is racist; nothing racist about it.

137 K: what is pair production up there?
138 R: its the creation of matter.
139 K: where would matter waves go, though?
140 R: matter waves is, for example, an electron if it travels or even when we=re-
141 K: no, i understand now, wouldnt it be right under this? complementarity theory because thats like quantum?

However, the next turn continues, inviting Ken to whom gaze and hand are oriented, to make a decision. Moreover, as seen in the associated offprint, there is a glance at the student (Marc) sitting near the camera at the next laboratory table, as if looking for the impact that the discourse is having on the other (turn 136g). It is a literal enactment of the sideward glances detected in the double-voiced speech of some of Dostoyevsky's heroes and in polemical discourse. Thus, "internally polemical discourse—the word with a sideward glance at someone else's hostile word—is very common in practical *everyday* and in literary speech, and has enormous style-shaping significance. Here belong, in everyday speech, all words that 'make digs at others' and all 'barbed" words'" (Bakhtin 1994: 411, emphasis added). In this example, therefore, in the midst of everyday speech in the school classroom, we observe a feature "very common" in everyday speech, though, from the perspective of schooling, these students currently engage in "off-task" conversation. There is in fact no boundary or transition from talking physics concepts to talking the language of everyday life, with all of its inflections, here, the sideward glances reflecting polemical discourse of two adversaries, who mutually accuse each other—in jest and with seriousness—of racism.

Following the statement that Miles has uttered about having previously addressed racism in his chapel speech[4], Ralf's turn acknowledges that this has been the topic ("you are talking a whole hour about racist stuff") but then denies that anything he himself has said was racist (turn 136h). The episode ends with Miles' laughter while gazing at Ken as if checking his peer's expression and with a light smile on Ralf's face. As quickly as it has flared up, the topic of racism disappears when Ken offers up a question about the placement of "pair production," which Ralf takes up in stating that it pertains to the creation of matter. Ken offers up another candidate for a question|answer turn sequence, which Ralf's turn completes as a statement that apparently explains the term (turn 140). Ken states to know now, and makes a tentative (i.e., with rising pitch that marks a question) statement concerning the placement of the term "right under complementarity [the-

[4] In this school, there is an obligatory ecumenical morning service for all faiths that begins the school day and each week there is a chapel speech by one of the senior students.

ory]" (turn 141). As there is no attempt at the time to return to the topic of racism, to keep it alive by continuing to talk about it, it is de facto abandoned and, for this instant, dead. My recordings show, however, that there were at least three instances in this lesson with exchanges between Miles and Ralf concerning the issue, with accusation and counter-accusation, argument and counter-argument about who is more racist, and so on. That is, there is a continuing conversation about racisms that the two return to without any transition, as if it were a second simultaneous conversation marked by longer interruptions.

The multi-voiced nature of language

In this instance, the students move from one topic of speech to another without signaling any transition whatsoever. It is apparent that they do not require a signal that a transition has occurred or is in the process of occurring. As soon as Miles's turn offers up the possibility with his statement to enter another topic, one that they apparently have been discussing at other times, and as soon as Ralf's turn takes up this offer, the topic has switched. The two turns are part of the same unit of analysis. In its movement, it incorporates a topic *switch* and an offer. There is no boundary or border that the students would have crossed: they seamlessly move from one topic to another topic and back. The conversation is in one key at one instant and in another key at another, the transition itself undecidable, and therefore syncopic in nature. It is apparent that there is an alignment with respect to the topics and the shifts between them.

The lesson fragment shows other features characteristic of the multi-voiced nature of everyday life, the language of real life. For example, both the "accuser" (Miles) and the "accused" (Ralf) relativize the seriousness of the content of the word by means of smiles and laughter, which disrupt and undermine what on paper might be considered to be challenges to the integrity of the other. They use each other's words to charge and counter-charge, challenge and counter-challenge, and argue and counter-argue. But our competencies with everyday life allow us to experience (hear, see) the irony that is written over the entire fragment of classroom life. Together with their talk, the two make available the *how* of their speaking; and it is the *how* of their speaking that determines the *what* of their speaking: it is not a serious accusation but much of it is jest. For example, Ralf's turn offers up irony in his statement about Miles spending "an entire hour" to speak about racism based on a single comment. It appears that for the moment, this statement is accepted, as there is no counter-word that would take up the preceding statement. Whatever Miles may be thinking in private at that instant, in the public arena, there is no counter-word and, therefore, the statement is de facto accepted. This does not mean that the issue cannot be taken up at another instant to be further elaborated, discussed, or argued.

With this analysis in view, we may consider again the analysis of the episode from the Australian chemistry classroom featured in chapter 2. In their analysis, the authors do make note of the everyday talk. But they do not theorize the event in terms of the overall life of the students. The authors do not take note of the inherently affective character of talk, which, in their situation, might arise from the tension between denoting something as a grammatical issue and their presence in

a chemistry lesson, which is not normally concerned with issues that tend to belong to language-oriented courses. There may be irony, criticism, hurt, and so on; but these affective tonalities present in any situation of real life do not tend to appear in STEM analyses of classroom discourse exemplified by the study of the Australian chemistry classroom.

Irony and parody are integral parts of the fullness of life. These speech features may make use of another's speech but, even if the very same words are used, these are different, consistent with the unfolding of the theme that is in continuing development.[5] Accordingly, the words inherently are different: they are produced to convey aspirations opposite and even hostile to the previous speaker. Thus, "in the ordinary speech of our everyday life such a use of another's words is extremely widespread, especially in dialogue" (Bakhtin 1994: 93). It is precisely in dialogue that "one speaker very often just repeats the assertion of the other speaker, investing it with new value and accenting it in his own way—with expressions of doubt, anger, irony, ridicule, intimidation, and the like" (ibid: 93).

In everyday out-of-school life, there tend not to be forces suppressing full expression, which makes everyday speech in many instances inherently dialogical. In schools, however, any topic other than that pre-specified according to the official daily plan—e.g., mathematics from 9–10 am, science from 10–11 am, and so on—is suppressed, which lends school talk its monologic character, where single truths are to be developed (van Eijck and Roth 2011). Outside schools, however, abuse is common; and it does not only go one way. Between equals, there is a constant give and take. There is, in Bakhtin's sense of the word, true dialogue at work. In Bakhtin's work, the marketplace is the chronotope (i.e., time-place) where such societal relations tend to occur. But the "marketplace" could be any physical location of interest, generally where there are lots of people, and where there is a lot of come and go, such as on doorsteps, in entrance halls, in taverns, in bathhouses, or on ship decks. The marketplace is a location where words, as things, are traded. When things are traded, they have use-value and exchange-value, both being manifestations of the dialectical "value." In a similar way, when words "are traded," there is an equivalence of "value" (*značenie*): signification (*značenie*). Just as the changeover in a commodity from exchange-value to use-value integrates and distinguishes seller and buyer and pre- and post-exchange situations, the changeover in a word constitutes the different signification it has in space (for author and recipient) and in time.

The verbal as the economic exchange forms one unit that expresses itself in contradictory ways, each presupposing the other: buyer and seller, use-value and exchange-value, speaker and recipient, and the word in the mouth of one and in the ear of the other. As a result, the exchange of words occurs in a continual dialogical relation between material and ideal aspects of life and in places where others are present—like Ken and Marc, who may overhear what is being said between Miles and Ralf. In the lesson fragment, the carnivalistic marketplace where *total* life finds its expression is the classroom, co-inhabited by and with others (including the teacher), who hear what is being said. In this instance, what is nor-

[5] As pointed out in chapter 1, the theme (*tema*) is the upper limit of word-signification, the lower limit of which is dictionary sense of the word (Vološinov 1930).

mally banned from school discourse occurs: teasing and abuse. And these are not merely directed toward another person—Ralf and Miles, respectively—the recipient of the abuse. Rather, the word is also direct toward the generalized other, the Other who is witnessing the scene. It is precisely because the potential effect on this generalized third person in the scene that the abuse functions as it does, where it takes on symbolic value. This orientation toward the generalized other—who is the intended or unintended witness to the exchange that is of a type common to everyday societal relations—also is evident in the present lesson fragment.

Speech activity as irreducible part of societally motivated productive material activity

> It is through speech activity [*rečevaja dejatel'nost', Sprechtätigkeit*] that the influence of social factors on language is realized, and it is only through its mediation that these are reflected in language as such. (A. A. Leont'ev 1969: 21)

The classical approach to language and language learning—which is even accepted by those who (only apparently) subscribe to dialogical theories of language—takes speech as a form of activity designed to express some ideational content supposed to be behind the speech. A pragmatically oriented cultural-historical activity theoretic approach takes a different stance in that it considers speech activity to be an integral part of the productive activity (i.e., *dejatel'nost', Tätigkeit*) in which the individuals are involved. In this way, speaking is viewed by considering all subjective and objective factors that determine it in the totality of connections that the current activity system constitutes. In this way, "the real process of communication is not the production of an equivalence between speaking and the outer world" (A. A. Leont'ev 1969: 11). Instead, the real process is "the production of an equivalence between the concrete situation, on which the activity is based, that is, the content, motive, and form of the activity on the one side and between the structure and the elements of the verbal expression on the other" (ibid: 11). As a consequence, every act of speech always already constitutes the correspondence of two activities, or rather, the integration of speech activity (*rečevaja dejatel'nost'*) into the larger system of society-sustaining productive activity. The two aspects, the encompassing the-life-of-society-sustaining activity and speech/ communicative activity mutually constitute each other so that we can say that activity produces speech—and, therefore, language—just as speech produces activity. This speech activity does not exist as a phenomenon in, of, and for itself. There is a system of speech acts that belong to and contribute to realizing a specific activity. Nevertheless, A. A. Leont'ev suggests that it is useful to employ the term speech activity because it forces us to think about the irreducible part–whole relation of speech and societal activity.

If we now consider the three foregoing examples (scientists in the laboratory, fourth-grade students doing a math task, twelfth-grade students accusing each other of racism), we are led to ask the question about the nature of the activity that is realized and its connections to other productive activities. In the first instance, we find ourselves in a biological research laboratory. The scientists and their laboratory are integral part of research activity the motive of which is to con-

tribute to the knowledge available to society—apart from the teaching functions that the professor also has. Thus, this research activity is linked to the entire system of tertiary education with its double focus on reproducing the field of science and producing knowledge that society can use. What we hear in the laboratory—the speech and with it the language that is realized—has to be understood as an irreducible part of research activity, itself integral part of the university as institution with its role in the production and transformation of a part of society and its cultural-historically specific (scientific) knowledge.

In considering the second example, we must also identify the appropriate frame of analysis, the activity of which the lesson fragment is an integral part. Many STEM scholars—in part because of the conflation of *dejatel'nost'/Tätigkeit* and *aktivnost'/Aktivität* that the English term activity produces—would suggest that we observe "mathematics activity" that occurs in a fourth-grade mathematics classroom. However, to find the appropriate level of analysis, activity, we may better ask: "What is being produced here that contributes to meeting a societal need?" In other words, we may ask: "What is the product that subsequently is taken up in other activity systems?"[6] We then realize that the event is part of a larger system that produces grades and grade reports that constitute the keys to subsequent opportunities. For some, and as a function of the grades, these will be tertiary institutions of different reputation, but for others these will be labor as a tradesperson, and for some—those who drop out or have grades that are too low to even make it into trade school—these will be menial labor, unemployment, or welfare. Thus, when we analyze the speech activity involving Jeanne and Mario, we have to keep in mind and take into account that they are doing schooling activity rather than mathematics *in the way* mathematicians do it.

The third example exemplifies that we always need to take into account the interconnectedness of activities and that a clear separation is not possible, though depending on the particular case, the relationship between one societal activity and all the others may be invisible or negligible. Once we take this stand, we will no longer think about the students as switching between first and third space, or as crossing cultural boundaries—which are some of the current ways of theorizing such events. Ralf, Miles, and Ken do not consider themselves as crossing boundaries and traversing borders. They participate in the life of society generally, though here they are part of the schooling activity. Nevertheless, they are also talking about an issue that is the topic in other circumstances of their everyday lives: when they are in the dorm, in the chapel, or even when they are out of school where they are and have been friends long after they have left school and university. Schooling is an integral part of their lives so that the school-specific discourse, here the language of physics, only is a small part of their daily speech activity more generally.

Cultural-historical activity theory takes an integrative perspective on personality (A. N. Leont'ev 1983). This is so because it considers personality to be the result of the totality of societal relations that an individual entertains and has entertained. The relations, however, are a function of the different societal activities. In

[6] Not all activity is productive. Activity theory includes, besides production, those activities concerned with exchange, distribution, and consumption (Marx/Engels 1962). Thus, we might alternatively ask: "What is the object that is consumed [exchanged, distributed]?"

participating in these activities, the individual contributes to realizing its collective object/motives—willingly or forcedly. Personality is then understood as the ensemble or totality of object/motives, that is, personality is understood in terms of the societal functions of the activities in which we are part: we are teachers, students, scientists, researchers. However, for each individual, the relations between the different object/motives are organized into a different hierarchy and with different strengths (importance) of the connections between the object/motives. This latter part makes personality particular to each individual even though the constitutive parts that constitute the system—i.e., the object/motives—are entirely societal.

In all three fragments from the everyday life of the respective members to the setting, there is more to speech than its content. It is in and through talking that their societal relation comes about, exists, and is sustained and transformed. In the first instance, the relation is one between members of a scientific research group in the process of collecting the data for a paper that they have already envisioned. Their talk is not primarily *about* something but is integral to the attempt to get the computer monitor into the same state that it had been in on the night before. It is in and through the talk that the chief scientist and his research associate maintain their relation, here collecting data in a collaborative fashion—though there is also a hierarchical relation between them, because Craig is Theo's employer.

In the second instance, the talk involves Mario and his teacher Jeannie. Their talk, too, is not so much *about* something as it is geared to getting Mario back on track in his task following his statement that he does not understand and that "*this* is dumb." They have to talk to get the task, which realizes the schooling activity, back on track, to move it ahead. As we see, the talk itself is moving ahead, the language is changing as the schooling activity moves on without actually moving on: the student and his teacher are stuck. But this stuckness becomes apparent only in the attempt of moving on, as a part of moving on. Speaking is required to get unstuck, without assurance, however, that speaking actually gets the situation unstuck rather than getting them bogged down further in difficulties. Here the interrelation between general activity (*dejatel'nost'*) and speech activity (*rečevaja dejatel'nost'*) is quite apparent. The language used in speech changes as it apparently does not improve upon the situation. But this attempt in moving the activity along by changing language is itself integral part of the activity. That is, talk is producing activity; and activity is producing talk. The two aspects are so intertwined that we cannot take them apart.

Simultaneously, the two participants realize a societal relation (*obščestvennoe otnošenie*). It is a particular hierarchical relation within the institution (activity system) of schooling, attributing different roles in the division of labor from which issue the grades and diploma that schooling produces. The sequentially ordered turn taking, whereby one individual asks questions to which she apparently already has the answer against which the response is judged, is typical for school situations. It is in this achievement of a particular form of turn taking that the societal relation characteristic of schooling is reproduced. Each member to the setting does a particular part for this societal relation to be exhibited; and it is precisely in this practical realization of the relation that society comes to life. Speech

activity is an integral part of the realization of practical activity, both in form—the particularly institutionally ordered turn taking sequence (teacher–student–teacher), with its particular distribution of grammatical order (question–[tentative] reply–evaluation)—and content. This "language reflects societal praxis of humanity—if we grasp it not as a formalized system but as a phenomenon in the process of verbal thinking" (A. A. Leont'ev 1969: 26). That this is so is immediately evident, for schooling is a societal activity, fulfilling the need of society for guarding children, producing indicators of their differential aptitudes for subsequent studies or jobs, and, thereby, generally reproducing class society. Societal activity goes with the societal nature of speech activity, which stands with the overall activity in a dialectical/dialogical relation.

As readers can notice, throughout this explanation of practical activity and the speech activity that sustains it and is subordinate to it, there is no need for otherworldly «meaning» or «mental representation». Everything that matters is in the here-and-now of the situation in which the subjects of activity find themselves. But we can save the concept of «meaning» if we think about it in a singular plural way: as the ensemble of ways of talking about «the same thing». I develop this approach in the following two chapters.

7 The documentary method: a solution to the problem of «meaning»

In this chapter, I offer up an approach to «meaning» that does not make an appeal to ideal entities of which our this-worldly words are only shadows. The approach is called the *documentary method* and has been developed for the purpose of determining the methodological structure and the logical position of the notion of worldview (Mannheim 1921–22/2004). It has also been used to specify the common sense knowledge of social structures and the way in which interpretation operates in lay and professional fact finding (Garfinkel 1967). In this approach, a social phenomenon exists in and as of the totality of its concrete realizations, a totality that manifests itself in the concrete and particular manners of speaking. Each case of speaking is a constitutive part of the totality, and, therefore, stands not only for itself but also for all of the other manners of speaking that constitute this totality. This leads to the fact that we always «mean» more than we can say in so many words—there are always more, infinitely more ways in which "the same" could be expressed and understood. Thus,

> in the particulars of his speech a speaker, in concert with others, is able to gloss those particulars and is thereby meaning differently than he can say in so many words; he is doing so over unknown contingencies in the actual occasions of interaction; and in so doing, the recognition *that* he is speaking and *how* he is speaking are specifically not matters for competent remarks. . . . It is not so much "differently than what he says" as that *whatever* he says provides the very materials to be used in *making out* what he says (Garfinkel and Sacks 1986: 165)

An introductory example

In everyday talk among lays and professionals alike, there already exists an approach that we might extend to think about «meaning». This situation occurs, as I suggest in chapter 6, when one interlocutor asks another, "What do you mean?" In the following fragment from a second-grade mathematics, designed for the students to become familiar with and to competently communicate about three-dimensional geometrical bodies (e.g., cubes, cylinders, pyramids, prisms, hexagonal prisms, spheres, etc.) the two teachers of the lesson had planned a task (see

Figure 7.1 In this artistic rendering of the classroom situation, Mrs. Winter (right) gesticulates toward Connor (left) while offering up a question: "What did we say that group was about?"

also chapter 4). In this task, the children were to group "mystery objects," which the children pulled from a black plastic bag. At the beginning of the task, the teacher pulled an object and explained the game. Either the object would fit with other objects on an existing color pad that made a group or, if the object at hand was not like any other object, to begin a new group. Connor first placed his mystery object with a group that was tagged with the label "rectangular prism" in the course of the game (the second teacher present wrote the labels on rectangular sheets of paper and placed them next to the relevant group. Then, thereby accepting an invitation on the part of Mrs. Winter to reconsider his choice, Connor places his object with another group associated with the words "square, cube." At this point, Mrs. Winter offers up what is accepted as a question while pointing in the direction of Connor and the objects at his feet (Figure 7.1): "What did we say that group was about?" (turn 46).

Fragment 7.1a

46 W: em an ↑what did we say that group was about. ((*points to the group of cubes*))
47 (1.00)
→ 48 C: <<p>what do you mean li[ke?>]((*looks up to her, still pointing*))
49 W: [WHAt]was the (0.15) WHAt did we put for the name of that group. ((*still pointing*))
50 (1.51) ((*Still pointing, then pulls hand back.*))
51 what's written on the card.
52 (0.83)

53 C: <<p>squares>
54 W: ˇsquare an::d?
55 (0.20) ((*Cheyenne has moved forward, points to the label*))
56 J: cube
57 (0.25)
58 W: cube. does it meet the criteria of having the square or the cube? ((*Looks at Connor sternly, nods while talking.*))

There is a 1-second pause, which is in fact longer than what teachers have been reported to normally wait for a student to answer; and then, rather than a reply, there is what we can hear as a counter-question: "What do you mean like?" (turn 48). Mrs. Winter begins to speak even before Connor has finished his turn at talk, beginning with the interrogative "what" that promises a question, only to use it again following a brief pause, now to articulate what we hear as another question about the group, this time asking what had been put for the name of the group (turn 49). A long pause follows while Mrs. Winter is still pointing in the general direction of Connor and the group of objects at his feet. She takes another turn, beginning with the interrogative statement "what's," which allows us to hear her offer up another question: "What's written on the card?" (turn 51). This time Connor states "squares," which is one of the words on the white paper sheet next to the colored pad on which his object now rests. Mrs. Winter repeats the word, "square," and follows it with the connective "and," which is uttered with rising intonation so that we may hear it as a question. In repeating the word Connor has uttered previously, the turn confirms that it the word was correct. But in the production of "and" with rising intonation (turn 54), the turn offers up what is by design an incomplete statement. Such a designedly incomplete statement has a slot that the next turn is to complete (usually produced by the student) and to be evaluated by a subsequent turn. This, therefore, functions much in the way the cloze procedure functions in paper-and-pencil format. Cheyenne has already moved forward, jutting her hand with pointing finger toward the sheet bearing the inscription "square, cube" and Jane says "cube" (turn 56). Again Mrs. Winter's turn repeats the word Jane has said; and she does so, as before, in a constative intonation: "cube."

Although the words that have written on the card have now been named, that is, although the reply to the question in turn 51 has been transactionally achieved, Mrs. Winter's turn states something that what we may hear—because of the grammatical structure and the intonation—as another question. She nods while talking and looks sternly at Connor: "Does it meet the criteria of having the square or the cube?" (turn 58). There are pauses, and someone produces, with low voice, a "no" before Mrs. Winter, insistently and still sternly gazing at Connor who has gotten up from his crouching position—offers up another question evidently to be answered by Connor: "Do you think it does?" (turn 62).

Fragment 7.1b
59 (0.25)
60 X: <<p>no>
61 (0.25)
62 W: <<insistently>do you thINk it does?> ((*Mrs. Winter sternly gazes at Connor.*))

63 (0.84)
→ 64 C: like what do you mean?
65 (1.10)
66 W: ´does it match. We said THAT this group ((*points*)) was ´squa::re (0.31) or cube (0.49) ((*looks at Connor, nods*)) does it match that?
67 (0.41)
68 X: <<pp>yes.>
69 (0.48)
70 X: or::.
71 C: ((*gazes at Mrs. Winter*)) yes.
72 (0.70)
73 T: <<p>o>kay. (.) ben you wanna add? ((*nods to Connor*)) (.) thanks connor.

As in the previous cases where Mrs. Winter has offered up a question while gazing at Connor, there is a pause. And then, the return question again: "Like what do you mean?" (turn 64). Taking the next turn at talk, Mrs. Winter utters what grammatically is a question though said with the falling intonation of a statement: "Does it match?" But before an answer could come, she continues with a statement referring to what they had said before, when they transactionally named the group in which Connor's object now is located "square, cube." She then offers up another question, "Does it match that?" (turn 66). Some unidentified student states an affirmation, and eventually Connor does so too: "yes" (turn 71). Producing the affirmative interjection "okay," Mrs. Winter's turn allows everyone to hear that the expected answer has been provided. That what was to be achieved has indeed occurred is also evident from the fact that she asks, without further ado, whether Ben wanted to add and then, while nodding in the direction of Connor, thanks him.

In this brief classroom fragment, we twice hear the query "What do you mean?" And in both instances—as in many other everyday situations— Mrs. Winter offers up another way of asking "the same question" rather than providing some «meaning». That this is so we can take from the fact that in both instances, when the question has been reframed but not answered, there is a third instantiation of what we may hear to be the same question. That is, if there truly had been the possibility of stating the «meaning» of what Mrs. Winter had asked in the first instance, then there would not have been the need to provide yet another, third articulation. This, as I intimate in chapter 6, actually points us to the nature of «meaning» now understood as a singular plural. But this nature is very different from the way the term is used in the literature, which I articulate and critique in chapters 2–4.

We see in the two instances examples of what people do in everyday situations when asked the question: "what do you mean?" The respondent uses another expression, which, in the case of a question, is another question or rather, the same question asked in a different way. When this does not suffice, as seen here, we get a third instantiation of the question articulated in yet another way. This game could go on for a while, though in most instances, there is likely a point where one or the other participant will bring it to an end in whatever way situationally appropriate. For example, a teacher might be satisfied when another student produces a suitable answer or, eventually, s/he might produce the expected response.

But we note that in reply to a query "What do you mean (by . . .)?," the original speaker tends to make a different statement (produce a different sequence of words). We can think of «meaning» as the totality of ways in which Mrs. Winter may ask Connor to respond presupposing that the differing statements all «mean» the same. Each of these ways would then be a concrete manifestation of the totality. Both the totality of ways of stating the question and each actually realized way of doing are concrete and possible in this situation. There would then be no need to invoke something not actually present, like «meaning» generally or one of its adjectivally modified forms specifically. That is, rather than appealing to something that exists only in ideality and of which the actual words we use are mere shadows, «meaning» in the way proposed here exists in and as the totality of different ways of saying the same thing.

In the classical approach—which has been handed down to us through generations since Plato—this situation is taken in a different way. There is a metaphysical realm where «ideas» exist. For example, the mathematical idea of a cube is an ideal object. As other ideal objects, it does not and cannot exist in the real world, which is full of imperfections. Thus, even with the most exact machines existing today, the (perfect) cube that is the object of geometry cannot be engineered.[1] As soon as we look a little closer, using other devices such as a(n) (electronic) microscope, the very best cube that we could currently make would have rounded (rather than point-like) vertices, rounded and fuzzy rather than ideal edges, and imperfect surfaces. In this classical approach, every approximately cubical object would be taken as a pointer to, a sign of the ideal object. «Meaning», as shown in chapter 2, tends to be used in this way, as if something said were pointing to something else that existed apart from the actual word or phrase but were somehow associated, attached to, or had by it. Each concrete entity or way of stating something, therefore, would be an imperfect instantiation of something the ideal equivalent of which exists in a non-physical world somehow floating over the real world. But is this the only way in which we can think about the multiplicity of ways of expressing something? Particularly, is there a way of thinking about these ways that does not postulate the existence of something in the netherworld of ideal things but understands «ideas» and «meanings» in a very concrete way? There is. And this way consists of and in the *documentary method*.

The documentary method

The identification of the documentary method goes back to the sociologist K. Mannheim (1921–22/2004), who asked himself what kind of task was involved when cultural-historical researchers in the arts, religion, or sociology work on the problem of determining the worldview their era. The sociologist proposes that there is a worldview totality, of which philosophy and other disciplines are but particular expressions or manifestations. This worldview totality has an a-theoretical foundation, which, once the formal disciplines emerged, began to stand in a mutually constitutive relation with the sciences. Cultural-historically this

[1] Once we get to the atomic level, measurement really becomes complicated. This is why the length of the coastline, for example, of England, comes to be infinite (Mandelbrot 1983).

makes sense because at the beginning of human society, the sciences, humanities, or social sciences did not exist. These emerged, just as geometry, on the basis of everyday, common, a-theoretical experience (Husserl 1939). This common, a-theoretical experience constituted the very ground, material, and productive means for the emergence of geometry, the natural sciences, and, much later, such social sciences as psychology, sociology, and anthropology. How, Mannheim asks, can totalities such as worldview (*Weltanschauung*) and spirit of the times (*Zeitgeist*) be determined? And how exactly ought we think about each of these?

Three forms of sense (*Sinn*) may be distinguished: objective, intended expression, and documentary. The three forms of sense can be exemplified using any cultural object, such as a marble statue or painting. First, there is an objective sense, which is related to the way in which a natural scientist would approach the materiality of the cultural object. In this sense, the object is "for itself," a piece of material that stands apart from human culture and can be studied in its materiality. In such study, the shape of a statue (A. Rodin's *The Thinker* or Michelangelo's *David*) or the composition of the painting (C. Monet's *Garden at Giverny*) do not matter; for the objective sense, what matters is the marble, the chemical composition of the paint, the material and its properties of the surface on which the painting is produced. Second, the intended expression sense is concerned with the figure as figure, for example, what *David* or the *Garden at Giverny* painting are intended to convey. Finally, each piece of art, the statue or painting, also is *a concrete manifestation of the worldview* and *Zeitgeist* at the time of its creation: it is a concrete *document* of what might otherwise be taken as an abstract thing or idea.

We may also exemplify these three types of sense with an example from the social sciences. Thus, when a person is observed to give some coins to a beggar on the street corner, then this event may be considered in the light of the three forms of sense. First, it is an objective event, which can be described, for example, as the stretching out of the arm and hand of the donor, who, unmistakably and verifiably, drops some coins into the hand or hat held out towards him/her. We could also record it on videotape and, thereby, make it widely available as a (timeless) document, for example, on YouTube. From a sociological perspective, which takes the objectivity of social facts as a fundamental phenomenon of professional and lay sociology alike, the giving objectively is a form of help, assistance.

But the donation may also have an intended expression sense, for example, if the donor intends to show or is seen to show—by the person accompanying him/her, by the beggar—pity, caring. This form of sense, therefore, is inherently tied to the person, who is seen as intending to express something. The act itself exhibits or can be attributed to have an intention based on our lifetimes of experiences of acting in the world for the purpose of bringing about some change. But with the objective and intended expression levels of sense, the possibilities are not yet exhausted.

A person accompanying the donor, a friend, someone from work, might see in the act of giving something else: a form of pretense. Everything that the donor is doing, the hand/arm gesture, body movements, and perhaps the tone of voice with which the beggar is addressed—e.g., if the donor said something like "Have yourself a nice meal"—becomes a document of "pretense." In this situation, therefore, "pretense" does not exist other than in the different ways in which the phenome-

non concretely manifests itself. Here, all the objectively *different* expressive but nevertheless concrete moments are taken to be documents standing for *one and the same* phenomenon: pretense. In contrast to the intended-expression form of sense, which has to be understood from the point of view of the author, the documentary sense is an expression from the perspective of the recipient. The result is a totality that is concrete, plural, and heterogeneous in its manifestations:

> The orientation towards that which has a documentary nature, this comprehension of the homologous in totally different sense contexts is something peculiar, which must not be mistaken for an addition or synthesis, not even for an abstraction of common characteristics; it is something peculiar, because the interrelatedness of the different and the presence of a singularity in the different are circumstances that are particular to the intellectually intelligible world. (Mannheim 1921–22/2004: 127)

The core characteristic of the documentary method is that it does not constitute a phenomenon as an addition from the concrete documents available. We do not get at the phenomenon through a synthesis, which, perhaps in Hegelian fashion, somehow sublates the differences and oppositions to arrive at some abstract idea. Furthermore, the phenomenon is not the result of an abstraction as Kant describes it, where a higher-order concept is made (up) of all those features that are common to the different expressions (e.g., concept learning according to J. Bruner). This is exemplified in Figure 7.2a, where a grumpy is defined by characteristics common to the four elements in Row 1, but which do not appear in the elements in Row 2. Here, grumpiness is defined by the fact that the number of objects and the number of boundaries is the same irrespective of the shape and color of the objects. But this definition no longer retains the concrete features of the things that belong to the category. That is, there is a difference between the figures in the first row of Figure 7.2a and the generalization states as: "A grumpy has as many objects as it has boundaries."

The documentary method goes about concept definition in a different way. There are no real, independently existing parts that are waiting for some totality that gathers them together; rather, something becomes a part when the corresponding totality is comprehended *simultaneously*. For example, in Figure 7.2b, all figures together constitute a totality that defines grumpiness. Each figure is a manifestation of this phenomenon, that is, the totality. Grumpiness always manifests itself concretely, in one of the concrete ways that we can experience them—here in one of the four ways that appear in Figure 7.2b. Thus, the documentary approach views the relation between the unitary phenomenon and the totality of its manifestations as a part–whole relation. The *part–whole* relation is itself a totality integral to the whole. The documentary points us to the world as a whole in and through the *thisness* of the present situation. We never know it as something in general—like a queue in general—but we always encounter, recognize, and know something like a queue in its *thisness*, which has come to be referred to in philosophy and sociology as *haecceity*. That is, each case of a queue is a document of a queue in general, which, as a phenomenon, exists only in and as of the plenitude of ways in which a queue is and can be realized: at the supermarket checkout counter, in front of the movie ticket window, or on the freeway on-ramp.

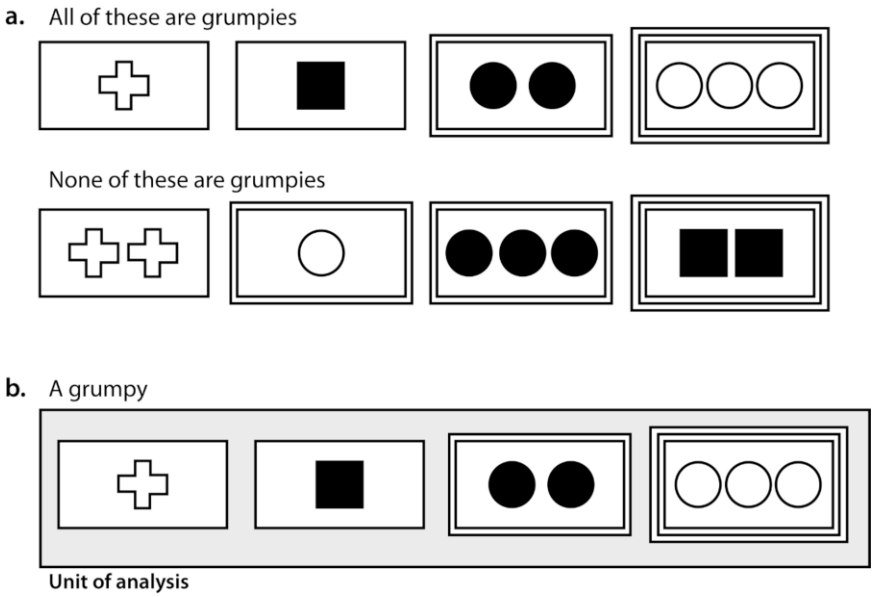


Figure 7.2 a. Traditional concept learning paradigm through abstraction: "grumpies have equal numbers of objects and borders. b. Grumpiness is defined by all the concrete ways in which the phenomenon manifests itself (here, four ways).

The difference between the classical, decontextualizing manner of defining concepts and the one apparent in the documentary evidence is exhibited in Figure 7.3. When another element is considered, the concept does not change in the classical approach, where the new object is described by the same rule: the number of objects is equal to the number of borders. In the documentary approach, however, the addition changes the totality, one that manifests itself in five different ways. Every one of the five parts now manifests a different totality; but in each and every case that this happens, the manifestation is concrete; and so is the totality.

This documentary sense, which is foundational to the a-theoretical apprehension of the world—we know queues without having a theory of queues, and we learn to point at trees in general even before we know trees in any theoretical sense—is equally foundational in the sciences. This is how an objective science such as geometry could evolve from pre-mathematical, commonsense experience with everyday objects none of which had the properties of what became the mathematical object. As the ancient Greek, children learn the geometrical properties of a cube from their concrete experiences with cube-resembling things none of which has the exact properties of the object cube that figures in geometry. The same documentary process is at work in the social sciences and their theoretical notions. Thus, for example, when sociology graduate students were asked to categorize the folder contents from a hospital for the purpose of identifying hospital procedures, the students were drawing on their familiarity with hospital proce-

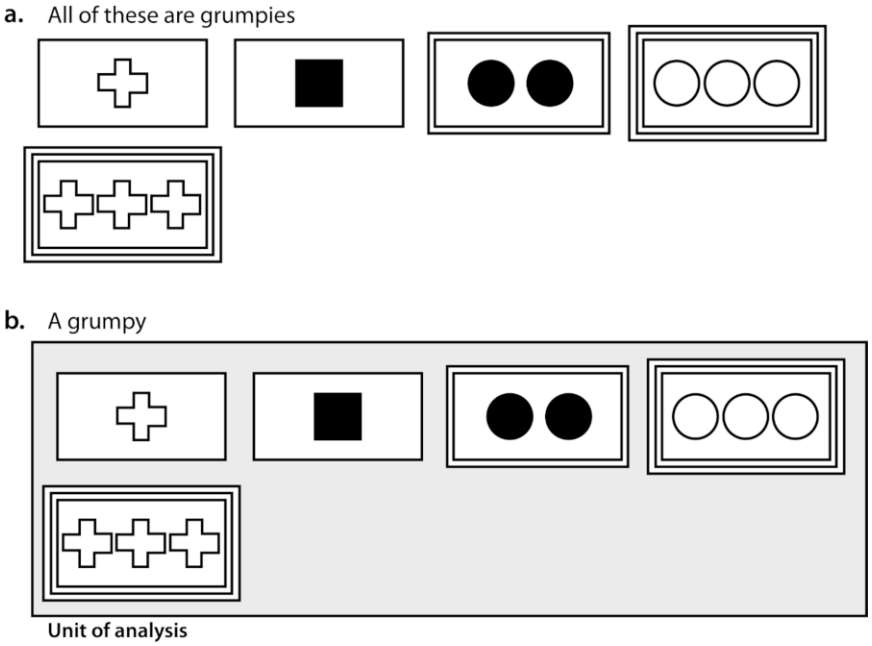


Figure 7.3 a. Adding another item does not change grumpiness in the classical approach to concept. b. Grumpiness changes in the documentary approach.

dures to organize the folder contents (Garfinkel 1967). They had made use of the documentary method whereby "the underlying pattern [is] derived from its individual documentary evidences, but the individual documentary evidences, in their turn, are interpreted on the basis of 'what is known' about the underlying pattern. Each is used to elaborate the other" (ibid: 78).

Relevant to the documentary sense of something said in words is that somebody *does* say something and how s/he says this something rather than *what* s/he says. *How* Miles made statements about racism mattered to understand his talk as (serious) joking rather than as a defamation that could be pursued in a legal case. The very fact that something rather than something else is said becomes of significance, and the different aspects of the how of the saying are taken as documents of this significance. The content (*what*) of the saying—i.e., the Said—is a function of the fact *that* something has been said and the *how* of the Saying that realizes it. "All of a sudden, what becomes important in the conversation next to the objective content is the gesture, the mimic, and the tempo: *how* question and answer are related to each other, whether they pass by each other or whether the reply [Gegenrede] literally transpierces the speech" (Mannheim 1921–22/2004: 137).

The particularity of part–whole relations is that the whole is as concrete as the parts that constitute it, each part being part of a whole that exists as the whole only because of the parts. The whole therefore is not something more abstract as we would find it in the classical, Platonic relation of real things and the ideas that

they represent. The whole exists in and through the totality of the parts. But it is not simply the sum total of the parts because of the dialectical relation between the two. Each part therefore not only contributes to constituting the whole but also contributes to the constitution of all other parts. This is quite evident in Figure 7.3, where the addition of an entity changes the phenomenon because of the whole–part relation between the manifestations and the totality they manifest. In the preceding example of the donation seen as pretense, the hand/arm gesture, the intonation of the voice, the body orientation and movement, although they are very different in nature, all are taken to be manifestations of the same. Each part, therefore, is not an element from which the whole somehow comes to be composed because the minimal unit is the whole (see shaded areas in Figures 7.2b and 7.3b). This is so because it is possible that even if one of the things we objectively perceive were different, the entire event might be perceived differently, for example, charity in the discussion of the situation with the beggar. As soon as the phenomenon is different, all the objectively describable parts also become different, now being documents of charity. That is, it is only through the whole that each part becomes *a part* of *this* unitary *whole*. If we were to take one of the manifestations away, then the whole would not just be a little less, in quantitative terms, such as when we take one apple away from a pile of five apples, but the very nature of the whole would change, as well as all the dynamic relations that interconnect the various parts.

By the time they get to this paragraph, readers may already have noted the similarities between the description of the phenomenon of the donation to the beggar and the situation from Mrs. Winter's classroom. When asked what she means in the turn after her offering of a question, she articulates what we may hear as two full and one aborted question. The question "What do you mean?" is followed by the production of different locutions, all of which are taken as documents of what she «means», the "real «meaning» of the question." This «meaning», therefore, exists in the totality of ways in asking what is taken by the transaction participants to be the same question but in different form. In the same way, someone being pointed to the first manifestation in Figure 7.3b and told this is a grumpy might ask, "What do you mean?" The interlocutor then might point to another manifestation and say, "This is a grumpy." And this might go on for a while, though in all practical cases, the question|reply sequence would come fairly rapidly to an end, though in exchanges with younger children in the process of learning the mother tongue, it might be going on for a while. In this documentary approach, therefore, the «meaning» of a word or proposition is constituted by the totality of equivalent words or expressions that could be used in lieu of it.

There is an immediate consequence: the statement "students *make* «meaning»" no longer makes sense. This is so because «meaning» is a totality, which documents itself in different concrete forms. Students do not produce this totality, because it is a supra-individual phenomenon. It is constituted by all the cultural-historical possibilities of saying «the same» in different ways. There is a sense that what is said is the same even if the words are not the same. What students do, at best, is elaborating some of these ways that can be used to say something in so many words but differently—without ever being able to exhaust all the ways. They cannot ever exhaust the possible ways because any attempt to do so would

inherently lead to a change in what is said and how it is said: Even the same word said six times in a row never «means» the same but always differently (see chapter 2).

The second upshot is the relationship between individual ways of saying and the collectively possible ways. It is not that individuals make personal «meaning», for example, in a group discussion or when responding to a teacher question in a whole-class situation. Rather, individual students concretely realize possible ways of saying that are always already directed towards the other and, therefore, inherently presupposed to be intelligible. Anything an individual says is part of the totality of ways of saying, the whole family of momentarily exchangeable expressions. Alternatively, we might say that students articulate and unfold what is intelligible. This means that some new word or expression that they encounter fits into an ongoing more or less familiar activity as part of the communicative activity that belongs to the former. There is no «meaning» involved, not if it this word is used to say that there is something expressed other than what students already say.

While writing these paragraphs, I actually came to understand in a new way the statement a chemistry professor once made: "Now, after having taught physical chemistry for 20 years, I am slowly beginning to understand physical chemistry." Today I understand that during these 20 years, he was able to talk about the same in different ways, respond in multiple ways to one or more student questions that appear to be asking the same. That is, although he might have been able to respond to tasks testing his knowledge of physical chemistry at the beginning of this long period of teaching, he had the sense that it was only at the end of the period that he *really* knew his subject matter. In fact, his «knowledge» can be said to have increased, as the many ways in which he could talk about the same «concept» changed the «concept». As a way of providing an example about how possible and suitable ways of saying something come to be established during STEM classroom tasks, I provide the following case from a twelfth-grade physics course where students evolved concept maps at the end of each curricular unit.

Finding an appropriate way of saying in so many words in place of "«meaning» making"

If we accept that there are only ways of saying and that there is no netherworld of ghostly «ideas», «meanings», «mental representations», or «conceptions» but only a multitude of ways of saying things, then we do not need to say that students "construct «meaning»." In fact, we must not say this. What students are involved in, and, when working in groups, what students transactionally achieve, at best are ways of saying things while (sometimes) eliminating ways of saying that are not to be used. Students do not construct «meaning» but establish some ways of saying or an ensemble of ways of saying, in so many words, something relevant to the field at hand. For classroom research, this would then amount to identifying which ways of talking students adopt in the course of their unfolding speech activity (*rečevaja dejatel'nost'*) and which ways they eliminate. No task in the world provides sufficient time to establish *the* definitive corpus of ways of saying, because in the course of elaborating such a corpus, the accepted ways of saying and, therefore, the corpus itself undergoes change. As a starting point for pointing research-

Figure 7.4 Miles, Ralf, and Ken (from left) are working on a concept map. The teacher can be seen on the far left, apparently oriented toward on of the paper slips on which a physics word is inscribed. When the students are done with the configuration, they transfer it onto the large, 11" x 17" piece of paper visible in the foreground.

ers in the direction of where such a form of analysis heads—one that eliminates the need for «meaning»—I provide the following description from a concept mapping session that already figured in chapter 6. The lesson fragments, which were recorded in a private school where I taught physics at the time, involve Miles, Ralf, and Ken sitting around the paper slips in a way that gives all of them access to moving the slips around (Figure 7.4).

At the end of each curricular unit at the time, I provided students with the opportunity to engage in speech activity that brought together all the key terms covered—those that were bold-faced in the curriculum guide or textbook, sometimes with terms from other chapters or units. I would print the terms on paper, which I cut into 1" x 4" slips, each containing one term. The students first worked to arrive at a structure, where the most inclusive term was to be on the top of the hierarchy and the least inclusive terms on the bottom (Figure 7.2). They then used an 11" x 17" sheet of paper, onto which they transcribed the hierarchy of terms that they have arrived at. They finished the task by drawing lines between all possibly linkable terms and by writing some linking words along these lines, mostly verbs or gerunds. Each pair, together with the linking word(s), could then be read as a statement (proposition, statement). Because the students worked in and as a

group, they had to arrive at one way of arranging the terms and of linking them. The ultimate map, therefore, was a transactional achievement: the result of their societal relation that realized the activity of schooling in this concrete task. Although there may be many ways of relating any pair of terms, which students may articulate in the course of their transactional work, they ultimately had to decide which of the possibilities they wanted to inscribe on paper.

When students come to a concept mapping session, they may have one or more ways of making statements using any pair of terms; in fact, at times, they have produced a map on their own prior to arriving in the lesson. They may have already articulated preferences for the structural relationship between the concepts under consideration. However, when they actually begin to work in the group, any proposal a student initially makes is open for discussion. Thus, even if all three or four students who participate in such a session have had preferred ways of relating two terms, at the end of the session none of these ways were ever implemented (e.g., Roth and Roychoudhury 1993).[2] Whereas many STEM researchers use the term "negotiation" to refer to the events where alternative ways of expressing something are produced, my own observations would be that negotiation, the way we normally use the term (i.e., as exchange), is inconsistent with what we actually see. The videotapes show that if the participants have evidence in the course of their task that some proposition that relates two terms is acceptable to all, the situation is unproblematic. Students then quickly move on to other pairs of terms. However, when there is evidence that different statements are favored for linking pairs of term, there is a problem that students must resolve. In the process, some statements come to be denoted as acceptable, whereas others do not lead to agreement. The totality of relations to other words that any single term may acceptably entertain evolves until it is fixed in and through the final inscription on the 11" by 17" paper sheet. I illustrate and discuss the evolution of a particular proposition—which, in the traditional approach might be taken as constituting part of each concept's «meaning»—to the point of being fixed. At this point, the participants might be said to have made a commitment to the «meaning» of a concept that they take as shared.

One important relationship in the context of early quantum theory is the discourse that relates the terms *quantum* and *photon*. In the particle view, a photon is unit of light with a specific energy. This energy is inherently quantized, that is, a multiple of Planck's quantum h: $E_{\text{PHOTON}} = \text{h}\cdot f$, where f is the frequency of the light ray. In the following, the evolution of the relationship between quantum and photon is examined as an example of arriving at an accepted way of putting together two terms in the same statement to make a fundamental proposition. Ralf speaks and simultaneously moves the two slips paper imprinted with the words QUANTUM and PHOTON so that these are at the same level in what emerges in front of the group as a hierarchical order. During this exchange, Ralf can be heard as modifying his way of talking from "exactly the same" (turn 39) to "essentially the same" (turn 41). "They (quantum and photon)," he states, "are (exactly) the same" (turn 39). This shift occurs following Miles's statement that "this one (pointing to QUAN-

[2] This relativizes those educational research studies that make claims to the contrary, that is, according to which one student dominates others to the extent that everybody else ends up with copying him/her.

TUM)" "done by Planck" (turn 40), and following a previous statement and organization of PHOTON below QUANTUM.

Fragment 7.2a

035 R: yea, okay. work function (.) if work function (.) [photon and],
036 M: [we need] something,
037 R: quantum are the same.
038 M: no; this one ((*photon*)) should be a bit lower.
039 R: why? its the same; they are exactly the same.
040 M: this one was, this one done by planck; and this one,
041 R: yea; but this is essentially the same.

As he relies, Miles co-extensively moves PHOTON so that it rested in the hierarchy below and to the right of QUANTUM. Before the group has another exchange about the relationship between the two terms, Miles moves PHOTON into a subordinate position relative to QUANTUM without explaining this choice but while referring to something I, the teacher, had said earlier: "He's saying we should pop light on top and have complementarity. And then wave and quantum and photon on the bottom, because light's general and then this describes" (turn 163). The following fragment exhibits a major exchange that subsequently occurs. In this exchange, the students propose alternative ways for the relationship between QUANTUM and PHOTON.

Fragment 7.2b

180 M: photon has a discrete energy and quantum is just saying travels in bundles so they are the same thing. basically.
181 K: but its general. this ((*quantum*)) is general; this ((*photon*)) more detailed.
182 M: a little more exact.
183 K: okay, yea, i guess.
184 M: do you understand the difference, cause [planck said]
185 T: [quantum is]
186 M: quantum, and then [Einstein said it has discrete energy]
187 R: [yea, thats right, but discrete [energy]].
188 T: [photon] is a light bundle, because you also have [phonons]
189 R: [but planck] gave a certain energy to that quantum, because he said its h times f.
190 M: but it was [einstein-]
191 T: [its ultimately] its photon that have this energy, but there are also [phonons;]
192 R: [but he used] quanta and then just einstein said its a photon, so its almost exactly the same.
193 M: but no, einstein added something to it, too, like added something; ((*turns pages of the book, pause*)) i can=t remember what it was. ((*teacher walks away, heads toward his office*))
194 R: work function.
195 M: here=s the compton effect.
196 T: ((*returns with a book in his hand*)) see, the thing is, you=ve got more quanta than just photons, then quantum would be more general.

In agreement with the earlier episode, Miles states the relation between QUANTUM and PHOTON in a different way, although, for one moment, he switches back to the same way of talking when he says that they are the same thing, basically (turn 180). However, he has another turn that constitutes a change, articulating a statement that is consistent with a turn that Ken has had: that a photon is "more detailed" or "a little more exact" (turn 181). In response, Miles first offers "a little more exact" as another way of saying what Ken has said ("more detailed"). He then turns to Ralf, selecting him as the recipient, apparently asking whether his peer understands the difference (turn 184); and Miles then invokes, as he has done before, the physicist M. Planck. He then produces a statement about Einstein, who was to have said that a quantum has discrete energy (turn 186). Ralf, on the other hand, articulates an acceptance, but, employing the contrastive connective "but" (turn 187), offers a way of co-articulating a "certain energy" with the quantum, a co-articulation made possible because "he," "Planck," said "it's h times f" (turns 187, 189). In this, a reference is made to the accepted way of relating the energy E of a quantum with Planck's constant h and the frequency f of a wave (i.e., $E = h \cdot f$). Ralf continues by saying that "he" (Planck) used "quanta," which the expression relates to the term photons by stating that Einstein subsequently ("then") "said it's a photon," which is to say that "it's," which we may hear as the two terms involved, "almost exactly the same" (turn 192). As in the previous exchange, the students move the respective paper slips on which the terms are inscribed co-extensively with their talk, pointing to groups of terms, and suggest connections by means of ephemeral lines iconically gestured into the air. I (teacher) eventually leave the group for an instant to get the textbook from my office, the door to which is less than 2 meters from where the group is sitting.

When I initially join the group, I can be seen and heard to make several advances to get a turn at talk (turns 185, 188, and 191)—where my overlapping another speaker constitutes the not-always-successful attempt (see the abandoned statement in turn 185) to contribute substantially to the unfolding topic. As anyone else present, I can hear Ralf steadfastly holding onto describing quantum and photon as one and the same. Miles and Ken, equally hearable by all others present, do not articulate distinctions between the two terms. As seen above, even Miles has said at one point that photons and quanta are the same thing. When I finally get a turn, I state that there are more quanta than just photons (turn 196). And, if there are more quanta than photons (e.g., phonons), then quantum is a more general phenomenon (turn 196). However, the students apparently do not attend to my remarks—we do not see them, in the transcript, take up my words and respond to them. At the beginning of Fragment 7.2c, I reiterate the existence of something other than electromagnetic waves that are quantized: Phonons, I state, are elastic waves in matter, are quantized (turn 203). There is the beginning of an elaboration of the nature of phonons, elastic waves in matter inside a crystal, (consisting) of molecules that move in harmonic ways. Ken's turn apparently takes up the word I just introduced, and, following my ever-so-brief turn at talk, completes making a statement about a phonon as a form of quantum energy (turns 204, 206). In saying "that's right," my turn provides what can be heard as an affirmation of the appropriateness of this statement, which Ken can be heard to affirm in his turn.

Fragment 7.2c

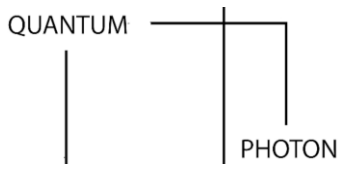
203 T: ((*points to a page in the book*)) you also have phonons which are elastic waves, which are quantized, but its an elastic wave in matter, its not like, its inside a crystal, but the molecules they can move.
204 K: so a phonon,
205 T: move-
206 K: is a form of quantum energy;
207 T: thats right.
208 K: yea; thats it,

The subsequent transcription shows that I do not further engage Ken, which can be heard as an acceptance of the description he has uttered: the quantized nature of other forms of waves. Neither Miles nor Ralf offer up queries to ask Ken for an explanation or elaboration of his statement. Ken's "Yeah, that's it" concludes this stretch of talk, flagged as being an end end by the fact that they go on to talk about the relation of other terms. Although the three students subsequently articulate further propositions including the term "photons," it is always in relationship to terms other than "quantum." Only when they get to the point of transcribing the configuration before them onto a 14" x 17" sheet, thereby making a permanent record of the results of their transactional achievement, does the talk return to the pair of terms at hand (i.e., PHOTON and QUANTUM) to finalize a statement that links the two. The figure provided in the transcription of Fragment 7.2d shows how the two terms were integrated in the structure that their joint action had accomplished before.

Ken, who has uttered a phrase earlier that others apparently accepted as the statement to be used in the map, offers up a question that asks the others to remember. Pointing to QUANTUM, he can be heard to propose words to be inscribed above the line linking QUANTUM and PHOTON: "it [quantum] has" "photon." Ralf, however, utters in constative form another statement, which can be heard as alternative to what Ken has said. The latter repeats the same words dropping only the indefinite article "a," which in effect makes the resulting statement shorter. He writes the words on the link and adds an arrowhead pointing from PHOTON to QUANTUM (turn 465). This action completes the part of the speech activity concerned with the relationship between the terms photon and quantum.

Fragment 7.2d

463 K: has; because remember, it ((*points to* QUANTUM)) has photon;
464 R: photon is a form of ((*points to* QUANTUM));
465 K: is form of; ((*writes "is form of" on the pencil line connecting* PHOTON *and* QUANTUM))



During all these exchanges, the students accompany their talk by corresponding moves of the concept labels, thus producing a form of communication that includes verbal and gestural forms. This communication not only produces what emerges in front of them but also their relation in this societal schooling activity.

They deictically refer (point) to the inscribed words, and thereby arrive at a form of *public talk* that resembles the brevity of inner speech (Vygotskij 2005). In this sense, communication cannot be usefully separated into different levels, one verbal and the other one gestural/pictorial. Simultaneously, we cannot reduce one of these modalities to another by expressing in words the pointing, moving of inscriptions, and body orientations. We cannot ever know what the verbal equivalent is that *this* student would have chosen had he been forced to. But in the end, they transactionally achieve—in irreducible *joint* action—a form of text consisting of propositions, the hierarchical relation of which is made visible in a spatial way.

The foregoing illustrates the evolution of a proposition, and with it, of one aspect of the physics discourse involved. This evolution is the result of a process, whereby the activity provokes and moves ahead the communicative activity, and communicative activity, in turn, moves the activity ahead so that—having started with a pile of paper slips with words—they arrive first at a hierarchically ordered organization of paper slips and, subsequently, at a map in which the arrived at order is augmented by pencil lines onto which students inscribe words relating pairs of terms. To understand the process of the emergence of this map, we do not require «meaning», a term that was using when I first published papers on the "social construction of scientific knowledge" in the context of this concept mapping task. At the time of the original research, I concluded:

> With this construction, the students also limited the *meaning relationships* which these two concepts could have taken for them. And they established with it their own *meanings* which each of them *took-to-be-shared* with the others. For the students, the issues surrounding a concept were not resolved at once. The discussion returned repeatedly to the same pair of concepts, dropped them, only to pick them up again at a later point. As the discussion proceeded, the relative positions of concept labels changed, thus changing the pairs of concepts under discussion. In retrospect, with the knowledge of the final concept map, one might be inclined to see evidence that *concepts were slowly evolving*. During the event, however, it was far from evident what the final map would be, in spite of the teacher's presence to provide assistance. One may want to think of the various attempts at linking two concepts as seeds for the later construction of the proposition. However, although these seeds were part of the construction process, there did not seem to exist a cause-effect relationship with the final product. (Roth and Roychoudhury 1992: 541, emphasis added)

As the emphasized words and expressions exemplify, at the time I make use of «meaning» to explain what I have observed. Here, «meanings» come in two varieties: personal and taken-to-be-shared with others. The two aspects of this explanation, as outlined in chapter 2, are in fact related. Because in the constructivist position that I was taking at the time, we postulate «ideas», «meanings», and «mental representations» inaccessibly existing in the head of others, we can only take-as-shared the theoretical position that may exist in a group of people. Alternatively, we can indeed be certain about and establish that there are commonly accepted ways of talking. In the quotation, there is also the supposition that there are «concepts» that the students *have*, which, in the course of the task, evolve. At the same time, the quotation is evidence of another, pragmatic way of approaching

such classroom events. In the statement that the discussion returned repeatedly to the same pair of «concepts», dropped them, only to pick them up again at a later point, we have an entirely phenomenologically based description of the observations that any actual or vicarious participant could have used. What the participants say, in public, is all anyone ever has access to.

The documentary approach allows us to re/write the issue of "«meaning» making" by entirely focusing on the concrete manifestations of talk. Each manifestation, each expression, is a manifestation of a totality of possible expressions—rather than some abstract «idea» or «meaning». In other words, the totality of concrete expressions that can be used as alternatives constitutes a particular «meaning» in the same way that all the parts of Figure 7.3b can be used as alternatives to point to the phenomenon of grumpy. This immediately implies that «meaning» is not something abstract but is as concrete as any of its manifestations that is taken as a document of the totality. Any one expression, always already intended for the other and therefore never only belonging to one person, is part of this totality. That is, this «meaning» always is shared, because each expression points to the entire family of equivalent ways of saying "the same (thing)." This «meaning» therefore *is shared* rather than personal because the particular expression points to the *same* family or it *is not shared* because it points to another family of equivalent expressions. In this way, «meaning» is entirely this-worldly rather than belonging to a metaphysical world, which could not be ours because we all exist in flesh and blood.

We know that if there were any doubt about an expression and its belonging to a family, then someone might say something like "What do you mean (by)?" This and similar statements tend to have as their consequence transactional sequences of turns in which other ways of saying the same come to be proposed until some such point that whatever has been said is sufficient to indicate the nature of the family to which the first, questionable expression was to have pointed everyone. That is, whenever there is trouble, the members to the setting produce a sufficient number of equivalent ways of saying the same thing in so many words to establish a subset of the entire family that gives participants some assurance that they can move on because all are aligned to the same family of expressions.

8 The documentary method and «mental representation»

In chapter 7, I present a way in which we can understand what STEM researchers have come to call "«meaning» making" to denote the increasing familiarity and appropriateness with which learners use certain words and expression that relate to an academic field. I suggest that the term «meaning» may be retained in a post-constructivist approach when it refers to the entire family of words or expressions that can be used in lieu for each other. A related aspect is the usefulness of this family of words or expression in talking about and within a form of activity. That is, the family of words or expression has become integral to the speech activity (*rečevaja dejatel'nost'*), which is, in turn, integral to and constitutive of the ongoing productive human activity (*dejatel'nost'*) as a whole (A. A. Leont'ev 1969). For school students, this activity is schooling; and this activity is realized, within different school subjects, by means of the ensemble of tasks that students have to complete. In that situation, therefore, the participants themselves ask each other what they «mean» until there is a point when they can or do continue with an apparent sense that they are "on the same page." STEM educators—and I have been no exception in the now somewhat distant past—might denote what is happening in this case as the "«co-construction» of «meaning»." But as I show in the preceding chapter, it is not so much a process of «co-construction» than a way of evolving ways of talking, where the verb "evolving" highlights the fact that the students in fact do not intentionally «construct» something, as they never know whether their speech activity is going to produce something that is useful. The new always is in excess of the intended. Many of the statements that the physics students have tested in their mouths, they subsequently discarded or, to use more literary language, "spat out." In this chapter, I pursue this line of argument with respect to the concept of «mental representation» or its alternative, «conception».

Toward a linguistic turn on «mental representation»

«Mental representation» is a researcher construct, whereby what a research participant or learner says is used to make inferences about what might be in their minds. But the (intellectual) contents of the mind cannot ever be accessed other than by means of verbal and other (inherently material) sign forms. In a strong sense, therefore, what STEM, learning science, and cognitive psychological re-

searchers do is take what participants say and do as documents (manifestations) of something else that in itself is inaccessible (see chapter 2). That is, these scientists are using the same documentary approach that we see at work when people in the everyday world take to «meaning» or to any other phenomenon that they know only in and through its concrete instantiations, like a "queue." My proposal here is that we may retain the concepts of «mental representation» or «conception» by qualifying them as a family of expressions or statements that pertain to a particular topic. Thus, rather than thinking about «mental representation» as being something *actually* in the heads of people, it is used to denote the culturally possible ways of talking and making statements about a pertinent phenomenon. Just as each part in Figure 7.2b (7.3b) points to the totality of things within the unit—rather than to something beyond this unit—ways of talking about a phenomenon point to all other ways of talking. In any concrete situation, these ways cannot ever be exhausted, because in the attempt to articulate them, statements may be retracted, elaborated, developed, changed, and so on. For example, in chapter 5 I present the person Mary in a conversation with an interviewer. Rather than attributing the statements that emerge from her mouth to some actual, physical or other structure or «representation» in the mind, we can classify what she says as documents of the ways of talking about sun and moon or day and night. Such a way of talking comes with a range of advantages.

A first advantage lies in that we do not have to reduce talk to contributions of individuals. Thus, because Mary talks to the interviewer in an intelligible way and for the latter's benefit, the ways of talking employed are actually cultural-historically specific ways always and already possible. In talk, spoken and heard, intelligibility itself comes to word. If it were not in this manner, then neither the interviewer nor the analysts of the interview transcript would be able to make sense of what has been said. What the interview samples show, therefore, is nothing that is particular to Mary but always already is something particular to the culture at a point in its history. A «mental representation», thereby, inherently is a «societal representation» that comes to be articulated in an intelligible way. As «societal representation», it does not have to be reduced to individual speakers. Rather, it always already is a societal phenomenon: It takes form in speech activity (*rečevaja dejatel'nost'*) that realizes the activity at hand, which, in the case of the interview, is research activity. Mary participates in a research activity; and in and through her participation in the collective speech activity, she contributes to the actual production of research data and research results (i.e., to the activity).

This approach, therefore, fits with the proposal that all higher order psychological functions are societal relations (Vygotskij 2005): Mind is in society to the extent that society is in the mind. Thus, even though Mary has not thought about a particular phenomenon before, and, therefore, could not have constructed a «mental representation», the societal relation with the interviewer is sufficient for her to participate in what might subsequently attributed to her alone: a particular «conception». The « mental representation», because it is a «societal representation», however, is available in speech activity that produces and is produced in the societal relation and by means of the language that comes to be articulated in the process. All the possible ways of talking or writing about sun, moon, and earth or day and night constitute families that Mary might produce if she were left alone

are nothing but realizations of the possibilities already inherent in language, which, in turn, themselves are, from a Vygotskian perspective, the result of all the societal relations Mary has entertained in the past.

From this perspective, then, all research does is to collect ways of talking about some phenomenon of interest and, from the domain of interview-based texts, to take these as documents of a «mental/societal representation». My proposal is to view this «mental/societal representation» as a family rather than as an individual thing that is denoted by, and generating the ways of talking. The difference between the two approaches is that in the family perspective, a «mental/societal representation» exist only in and as concrete realization. In the traditional perspective, these are abstractions, which, as abstractions of the type Kant theorized, lose some of their situational characteristics. Related to Figure 2a, we noted that the abstraction is actually very different from the images that we can see: It is a *verbal* statement about the equal number of objects and borders that characterize a grumpy. This changes in the documentary approach. Here, «mental/societal representations» are not mere sum totals of independent elements. Because of the part–whole relation that binds together the different manifestations and the whole these constitute, any change in one or more parts will ripple through and change the family as a whole (e.g., change from Figure 7.2b to 7.3b): we end up with continuous change that at some point will be recognized as a qualitative difference.

Theorizing «mental representation» in this way leads us to another advantage: we can easily model change, which comes about through the change in any of the parts. That is, it comes about through the addition of something that not only changes the whole but also all other parts that are transformed in the process. This means that we get to a model of «conceptual change» where there are no discontinuous changes in some «mental structure», «mental representation», or «conception». Rather, quantitative changes may lead to qualitative changes in processes easily modeled with the catastrophe theory where the emergence of qualitatively new states (morphogenesis) is the result of quantitative changes in one or more parameters.[1] What is important is that the «mental representation» not only manifests itself in a concrete manner but also exists in this manner. That is, «mental representation» exists in the concrete speech activity that people mobilize in the course of this or that activity, some of which may be interview or research activities for the purpose of eliciting talk on particular topics.

Transitions—i.e., when there is a more or less substantial «conceptual change» within or between ontological categories—might then be expected to manifest themselves in something like "muddle." In this situation, the different ways of talking would not be consistent with each other so that there would be logical inconsistencies within the different forms of talk. The family of talking as a whole contains contradictory statements. This would be equivalent to the situation in Figure 7.2b if there were some parts accepted for the moment to be grumpies, which

[1] Elsewhere I show how catastrophe theory can be used to model the emergence of the human psyche generally and the emergence of new psychological functions more specifically (Roth 2009a). Others have shown more than 2 decades ago how Piagetian, stagewise cognitive development can be modeled using the catastrophe-theoretic approach (e.g., van der Maas and Molenaar 1992).

would subsequently be eliminated from this group because speakers recognize that these do not belong here. Only when a new «conception» has emerged will the family of talking be consistent again within the scientific community. That is, we have a continuous change in ways of talking from an instant where all possible statements appear to be consistent with one «conception» to another instant where all statements appear to be consistent with another «conception». In between, we still have ways of talking, but individual statements may be consistent with one or the other «conception». But when we are in the midst of changes, we have no way of making decisions about where all of it is heading. Thus, in describing the Copernican revolution,

> we did not decide, on the basis of some telescopic observations, or on the basis of anything else, that the earth was not the center of the universe, that macroscopic behavior could be explained on the basis of microstructural motion, and that prediction and control should be the principal aim of scientific theorizing. Rather, after a hundred years of inconclusive muddle, the Europeans found themselves speaking in a way which took these interlocked theses for granted. Cultural change of this magnitude does not result from applying criteria (or from "arbitrary decision") any more than individuals become theists or atheists, or shift from one spouse or circle of friends to another, as a result either of applying criteria or of *actes gratuits*. We should not look within ourselves for criteria of decision in such matters any more than we should look to the world. (Rorty 1989: 6)

From the perspective presented in this book, rather than dealing with ephemeral, because metaphysical «mental representations», we are actually dealing with ways of talking about astronomical phenomena. These ways of talking, during a "scientific revolution" are not entirely consistent with each other. There are contradictions within the larger family of talking about these phenomena. Because ways of talking inherently change—language would be dead otherwise—so do the ways of talking about astronomical phenomena. As a result, we get an evolution. In the end, there may be a new, relatively consistent family of ways of talking about these phenomena. But this new way is not something that has been decided upon or that scientists have a set of criteria for arriving at—just like my physical chemistry professor did not make decisions about changing his ways of talking about physical chemistry. Precisely because scientists do not know what the new family of ways of talking will look like, they have no way of making a decision about which descriptive theses will be maintained and which ones will be abandoned.

The proposal here is that if we thought «mental representation» or better »societal representation» along the lines of the documentary approach, then our theoretical descriptions would map or fail to map onto the empirical descriptions, which would always be descriptions of the ways in which people (scientists, science students) actually talk. Rather than being something abstract, a «societal representation» always is something concrete, a family of possible ways of talking about a phenomenon. Inherently, talking about a phenomenon, a speech activity or language game, also maintains the relation between the interlocutors in the process of accomplishing the activity at hand. When scientists produce the talk—e.g., those who communicated during the time of the Copernican revolution—then

the activity concerns the production of new collective knowledge; when the talk involves students and teacher in school science, then the general activity is schooling, which produces grades and grade reports.

The production of a «conceptual reconstruction»

In 1995, I had an opportunity to work together with a well-known group of researchers working from a «conceptual change» perspective. It provided me with an opportunity to see such research from the inside; and it provided opportunities for relating to and challenging (being challenged by) researchers who take a different theoretical perspective. During the actual research process at the time, I was recurrently asking my colleagues to show me in the transcripts where the «conceptual change» was occurring. I literally asked them "to put their fingers on conceptual change (in the transcripts)." But during the discussions about the data, none of my collaborators was prepared to do so. At the time, this contributed to my unease about «conceptual change» as a useful category for the analysis of what is actually happening when students are in a process of what subsequently comes to be known as a process of learning. This reluctance (or inability) to point to the «conceptual change» where it was thought to occur suggested to me—already at that time when we conducted the research and regularly met to interpret the lesson transcripts—that some gross reductions have to occur before researchers can claim that such a process has indeed happened. All I could see was classroom talk in which students completed the curricular tasks; and there was no evidence that they were not genuinely engaged. When watching the videotapes from the study and when following any participant in her conversations with others, then one can hear/see intelligible verbal intercourse and participation in speech activity that accomplishes the task at hand. In fact, from looking at the conversations, my colleagues could not even predict where the topic development might lead and whether a «conception» or a «misconception» was in the making (e.g., Duit et al. 2001; Roth and Duit 2003).

In part to see what alternative theoretical frameworks yield and how these might be combined to provide new insights, we conducted an empirical study. The colleagues had developed a unit on chaos theory in which they had produced a set of materials that might be seen as analogical to each other. For example, a ball rolling on a mountain ridge or on a earth wall will move in unpredictable ways given certain conditions (Figure 8.1a). Similarly, the movement of individual steel balls in a Galton board—a device, also called "quincunx" or "bean machine" consisting of an upright board with evenly spaced nails or pegs in staggered order—is stochastic (randomly determined), though the result of many steel balls moving through the system will be a predictable distribution (Figure 8.1b). The unit begins with an investigation of a magnetic pendulum, which consists of a steel bob suspended above three magnets placed on the corners of an equilateral triangle. After being released, the steel ball will come to rest above one of the magnets. But students soon find out with repeated release of the pendulum that they cannot predict above which magnet the pendulum bob will end up even if they were trying to hold the starting point constant. When iron filings are sprinkled on a sheet

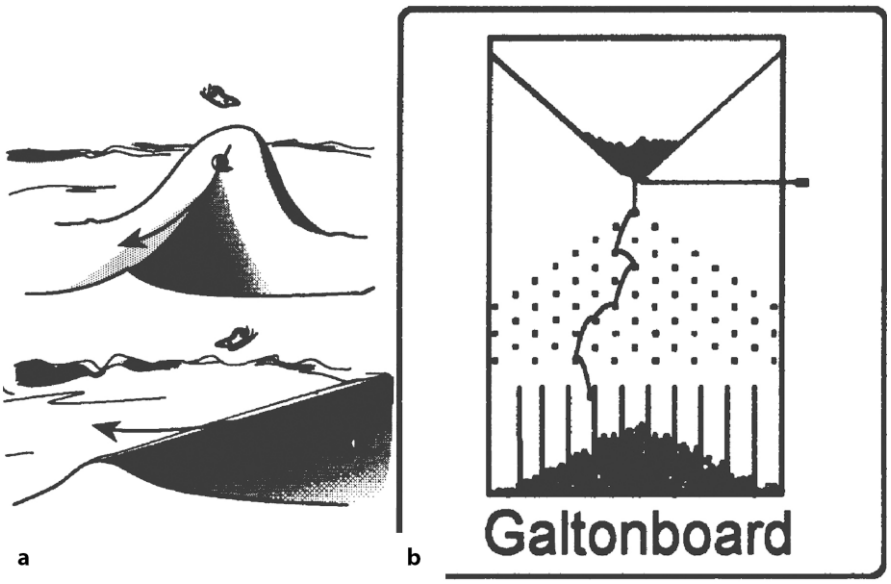


Figure 8.1 Two of the diagrams used during the unit on chaotic systems and interviews. a. The ridge makes the trajectory of a ball unpredictable when minor influences make it go down left or right. b. A Galton board consists of many rows of nails that deflect the steel balls moving from top to the bottom. When many balls are sent through the system, a distribution of steel balls will result on the bottom.

placed above the magnets, the form of a star becomes visible. In our empirical work, one student called this visible configuration "the Mercedes star."

My colleagues and I presented our work in a variety of contexts, among others under the title "Analogy-induced conceptual change during a unit on chaos theory." The key theoretical issue was the linkage between analogies and «conceptual change». This change was to occur between two «schemata» or «conceptual frame[work]s». These theoretical issues were presented in a section entitled "Conceptual change and analogical reasoning":

> Analogical reasoning is a key feature of learning processes within a constructivist perspective: every learning process includes a search for similarities between what is already known and the new, the familiar and the unfamiliar. In Rumelhart and Norman's theory of learning, which echoes the Piagetian schema theory based on the notions of assimilation and accommodation, analogies play a key role. New schemata (conceptual frames) arise either through continuous development of already existing schemata or discontinuous reconstruction of already existing schemata. New conceptual frames are developed transferring structures from familiar to new domains, that is, by establishing an analogy between the familiar and the unfamiliar. Rumelhart and Norman's distinction between continuous growth and discontinuous change has been adopted by recent conceptual change researchers. Conceptual change perspectives have

> shown to be fruitful particularly in science education where everyday views of phenomena are often incommensurable with canonical views. Learning processes therefore often require major restructuring of students' already existing conceptions. Analogies can play a central role in this restructuring of students' conceptual frameworks. Sometimes, the base domain is as unfamiliar to students as the target domain. Students' understandings of the base domain therefore also require major restructuring. (Duit et al. 1997: 2)

The paragraph shows that from the perspective we presented, what had happened was a change in «conceptions» and the processes underlying our observations could be thought of as «conceptual change» or «change in conceptual frames». Two forms of change are proposed: continuous and discontinuous. The following shows that the reports from the research neither showed the presence of a «schema» («conceptual frame») nor the unfolding of an actual «conceptual change» in the making. Our reports also did not exhibit precisely where in the transcripts evidence of a continuous or discontinuous change is observable. Moreover, we did not comment on the fact that the teacher and researchers were integral part of the conversations so that anything a student said was for someone else and, therefore, had to be intelligible inherently rather than constituting some abstract «mental framework». In fact, to be able to say that a particular expression *derives from* a misconception, my colleagues actually had to understand what the expression said (its content). That is, the form of talk *was* intelligible. The best we arrived at to combine the two approaches, «conceptual change» and discourse analysis, was to propose the latter as a means to analyze "minute shifts in students' language games" (Duit et al. 1998: 1059) that might occur during their engagement with the curriculum. But we had not dealt with the problematic reduction of interviews to what was denoted to be a «conception». The following reproduces some of the descriptions and claims we made at the time about learning that occurred in terms of the conceptual change paradigm modified and mediated by my own contribution to the collaborative work.

One of the problems that become apparent in our texts from that time is that the researchers introduced new devices as topics in the interviews that had chaotic systems as the overall topic, for example, the die and the Galton board. Thus, students could not have constructed a «conceptual framework» concerning these devices. In addressing the students, here Kirstin, the researchers actually set up the speech activity (language game) in a particular way, "biasing" the conversation to take certain turns. We might better express what happens in terms of the irreducible joint action (transaction), so that any aspect, any turn, actually belongs to both researcher and student. Thus, in the following there is no mention that Kristin did not "try to explain the die" but that the researcher (interviewer) sets up the language game to be played and the topic: the die.

> Without major difficulties, Kirstin deciphers the wall and ridge analogies (Figure 8.1a) and uses it to interpret the movement of the pendulum. But Kirstin's problem was that, initially, she could not find a "Mercedes star" in the drawing of the ridge. After a short while she points to the ridge with her finger, moves the finger along the ridge and then completes the figure of the Mercedes star by pointing to the two lines into which the ridge divides (Figure 8.1a). When trying

> to explain the behavior of a die, the image of the Mercedes star impedes. During instruction, one student had proposed the term "Mercedes star" as a label for the key feature of all chaotic systems denoting the zones of unstable equilibrium. Whereas the ridgeline is such a zone, the other two lines that follow in the drawing are not. It is perhaps for this reason that she cannot interpret its stochastic behavior. For Kirstin the dominating feature of the descriptor "Mercedes star" was not the "sensitive zone of unstable equilibrium" but a mere geometrical appearance. This interpretation is supported by Kristin's apparent difficulties to explain how a dice works. Here too, she searched for something that could be described with the label "Mercedes star" (I = Interviewer; comments in brackets; figures in brackets give wait time in seconds):
>
> 01 I: What about the die? You know what a die is? You throw it, and you cannot predict which number will come.
> 02 K: Yes ((hesitant)).
> 03 I: Do you know why this is the case?
> 04 K: No, but in some way for me that has nothing to do with the Mercedes star. ((2 sec)) Sure, there are six permutations and then it has to decide.
> 05 I: Okay, let us try not to think of the Mercedes star. Why is it not possible to predict which number will come?
> 06 K: Well, also because of influences. And because one does not start in the same way and
> 07 I: Why is this of importance?
> 08 K: Well, why not?
>
> Although Kirstin began to reconstruct her knowledge of chaotic systems in mentioning characteristics of them besides the mere geometrical symbol Mercedes star (such as the impact of influences and the starting point) she did not explain, at this point, why the die demonstrates stochastic behavior. (Duit et al. 1997: 6)

In this instance, the researcher "sets up" Kristin; or, rather, as a result of the joint action, Kristin comes to find herself in a set up that she herself contributes to creating. She is not familiar with the relationship between a die and the stochastic systems that have been among the topics of the foregoing lessons. She is unfamiliar with the situation so that we should perhaps expect her talk to reflect this unfamiliarity, just as we would expect a person to show more hesitation when arriving in an unfamiliar airport or city. In the latter case, we do not know where to find the (shuttle) bus or even where we could go and ask for the departure of the (shuttle) bus. We would have difficulties finding our way around this part of the world. We would exhibit apparent difficulties locating relevant resources just because we are unfamiliar. In «conceptual change» research, however, such unfamiliarity is taken as evidence for problems, difficulties, or misconceptions. The interpretive text preceding the transcription is quite abstract, stating, for example, that Kristin "cannot interpret" without actually pointing to the evidence for an inability or an interpretive effort on Kristin's part. In the paragraph following the transcript, our conference presentation text can be understood as claiming that Kirstin is in the process of reconstructing her knowledge. Again, no evidence is

provided that there is a knowledge display, in what the knowledge consists, and precisely where the «reconstruction» is happening.

The case analysis of Kristin continues. The text provides evidence of the disjuncture between the claims, on the one hand, and the data (transcription), on the other hand. For example, there is a statement about the Galton board (Figure 8.1b) providing Kristin with insights. But there is no index to point readers to the place in the transcript where the insight does occur. There are also assertions about intentions—such as that the interviewer "decided to find out"—that are not obvious from the transcript.

> But her explanation of the Galton board (Figure 8.1b), which was not used during instruction, provided her with insights that turned out to become a key element for constructing the features characteristic of all chaotic systems. On the Galton board, small balls are released and roll down through an arrangement of nails. Kirstin suggested that the nails are the "points of decisions." Very small differences of starting position and minute disturbances of the ball's trajectory determine whether a ball passes to the left or right of a nail. At this stage of the interview the interviewer decided to find out whether Kirstin would employ this insight also to understand the other chaotic systems discussed previously during the interview.
>
> 01 I: To put it into other words, do they have something in common that makes it such that small differences of the starting position have such a large impact?
> 02 K: Well, yea, for all of them there is this decision between right and left.
> 03 I: Uh hm.
> 04 K: Don't know.
> 05 I: There in the case of the magnetic pendulum, where is this decision?
> 06 K: Yea, between the magnets.
> 07 I: Yea. And here? ((Points to chaos bowl.))
> 08 K: On this line. ((Points to the ridges in Figure 8.1a.))
> 09 I: And here? ((Points to Galton board.))
> 10 K: On the nails.
> 11 I: Do you know them in the case of the die, do they exist also for the=
> 12 K: =Yes, the edge. So when it, one could throw the die so that it comes to stand on the edge, but that's not possible, a breeze comes and it goes to the right and I only have a one although if it would have gone to the left there would have been a six or so. (Duit et al. 1997: 6–7)

My colleagues suggested to me at the time that this example illustrates complexity of the processes of analogy formation, which are endangered by «idiosyncratically entrenched representations» to such an extent that the analogy construction is moving in a wrong direction. They noted that this phenomenon is obvious at the beginning of the interview. As the subsequent passage shows, our text claims that Kirstin "had reconstructed her framework of understanding" though readers are not provided with evidence where this «reconstruction» is occurring or where any «(cognitive) framework» is made visible. Moreover, we can find evidence of a claim of a "change of perspectives" and another one concerning Kirstin to "work out that the key characteristic of all chaotic systems possess sensitive zones."

> Kirstin relates the notion of the chaotic system with the image of the Mercedes star, which was strongly reinforced during the lessons. This image, however, is marked predominantly by the geometrical figure and not by what the Mercedes star is standing for, that is, the zones of labile equilibrium.
>
> The example also shows that Kirstin explained the behavior of a die although she had not done so earlier. She had reconstructed her framework of understanding. It appears that the frequent change of perspectives allowed Kirstin to work out that key characteristic of all chaotic systems to possess sensitive zones of unstable equilibrium. She could retroactively use the observational description of sensitive zones to characterize the die as a chaotic system. (Duit et al. 2001: 296)

The narrative then suggests that Kirstin "could retroactively use the observational description of sensitive zones to characterize the die as a chaotic system" (turn 12).[2] But the transcript shows that the interviewer re-introduces the die as a topic and whether "they," the decisions, occur in this situation. Here the question that is offered makes a connection between the die and the decisions. In her reply to and for the interviewer, Kristin takes up this connection introducing the "edge" as a crucial point where the influence of a "breeze" would sway the die such as to show a one rather than a six.

In our research meetings, my colleagues present the case of Kirstin with respect to the talk about the Mercedes star in this way:

> Kirstin sees the lines of the Mercedes star as points of decision, where it [the moving part of the system] decides where to go on. When the two analogies are presented to her, and she is asked what these point out, she says:
>
> > Kirstin: Well, like in the picture it is for example the Mercedes star here ((points to the analogy of the mountain ridge; moves the finger along the ridge and then points to the two lines in the image that it joins further below, which in fact complement each other to form a triangle similar to the Mercedes star)), like, and the ball rolls down here, this is the pendulum, it arrives like this ((points)), yea, and then it is like the pendulum or ball has to decide whether to go right or left.
>
> Without doubt, she searches in the drawing a similar geometrical figure. When it comes to the wall, however, she notes that the geometrical similarity no longer holds:
>
> > Int: Hm. Given a very small influence. And this, you now have both, is there something like a Mercedes star? ((points to the wall analogy))
> > Kirstin: Hm. ((moves the finger along the ridge)) so, well ((laughs)), fundamentally yes, but it is not a star, somehow just here on the line, I would say, like here ((shows to the ridge))
> > Int: Why do you believe this?
> > Kirstin: Yea, because it has to decide on the line where to go.

[2] I had offered the term "observational description" drawing on the work of W. O. Quine (1995). The relation between students' embodied experiences and the observational descriptions that arise with it shaped my own account of the event. The observational descriptions might give rise to observation categoricals and, thus, to theoretical descriptions (Roth 2005).

> We see that similar to Svenja that for Kirstin, too, the search for geometrical similarities comes into play when she is looking for similarities between the given situations and the Mercedes star. But like Svenja, she identifies concordances beyond geometrical similarities, even when there are no geometrical correspondences. (Research notes)

Here, the authors take the term "Mercedes star" as "an abstract symbol" for the sensitive positions where there is a labile equilibrium. We suggested at the time that this symbol initially pertains only to the concrete magnetic pendulum that the students were experimenting with and the plaster bowl in which they actually rolled a steel ball. It subsequently goes through a range of gradations up to becoming an «abstract idea» or «abstract representation».

The materials from this part of my research career provide evidence for the distance that exists between the claims about «mental frameworks», on the one hand, and what can actually be observed in the transcriptions, on the other hand. In fact, such a distance has to occur because we have the real talk depicted in the transcription, on the one hand, and a claim about a non-present «schema», «mental representation», or «conception», on the other hand. These *cannot* be pointed to precisely because, by their very nature, these phenomena are not physical. These phenomena are abstractions in the Kantian sense, which, in the case of research such as the one presented here, are abstractions from the interview or classroom transcripts that leave behind contextual particulars. As I suggest in chapter 7, these abstractions *cannot* be seen in the concrete world precisely because they belong to some ideal world—in contrast to the documentary approach that only deals with this-sided manifestations.

It may not come as a surprise, therefore, that practitioners—including teachers—find such abstractions of little use in their work, where they are faced with concrete ways of talking. This is what happened to me when I returned to the classroom following my PhD studies, where I had investigated the possibility of predicting cognitive development and learning on the basis of various measures of short-term memory. In the classroom, however, I had no access to the short-term memory of students apart from the fact that I did not have abstract data points in a graph correlating short-term memory and achievement. I was confronted with real persons participating in real conversations with their peers and myself (e.g., such as those transcribed and analyzed in chapter 7). This may lead us to ask, "Are there other ways of thinking about «mental representation» that are more closely related to what we *actually* are confronted with in praxis?" The short answer to this is, "Yes," if we take the documentary approach to «mental representation» or rather «societal representation». In the following section, I exhibit how this works and why.

The documentary approach and «societal representation»

In this section I suggest moving the discourse from «mental representation» to «societal representation» because the only evidence we can ever gather about the hypothetical former comes through language-in-use, which inherently is a societal phenomenon. The «representations» are societal rather than social because soci-

ety is the proper unit of analysis when it comes to language. Although it is possible to make a pitch for using "cultural" as adjective, there are differences in languages between countries and culture such that certain expressions may exist in French-French but not in Québécois-French, in Portuguese-Portuguese or Spanish-Spanish but not in Brazilian-Portuguese or Mexican-Spanish, and so on—even though there may be considerable family resemblances between each pair. But linguistic research does show that there are differences in national languages and new features in one national language may diffuse into other national languages but lead to different distributions of ways of talking in the different countries. In this section I return to one of the transcriptions in the preceding section and, based on the analysis, articulate the documentary approach to «societal representation» as an alternative to the going (socio-) cognitive approaches.

The fragment begins with an offer of a question; there are actually two offers of questions and, before there is time for a reply, an articulation of the particularity of an object that appears in the locution (die) (turn 01). The next turn constitutes a completion of the second offering as the pertinent question, "Do you know what a die is?" Not only is the statement offered as a question about a die but also, as the descriptive statement that follows suggests, it is a device that can be thrown and when it is done so, one cannot predict the number that will be exhibited on its top face. The interviewer thereby offers up not only a question but also a particular form of language game in which is figured such a thing as a die. What is being said is directed toward Kristin and, therefore, inherently anticipated to be intelligible not only to her but to others within the language community. The statement offers up intelligibility itself. It is therefore not merely a «mental representation» that allows the interviewer to introduce the die as a topic and to refer to the game of rolling the die, where the number that will come to lie on top cannot be predicted. If anything, there is a «societal representation» at work, which draws on the die as a feature of certain games with which others are already familiar with. Together with games involving dies, there are die-related language games.

Fragment 8.1

01 I: What about the die? You know what a die is? You throw it, and you cannot predict which number will come up.
02 K: Yes ((hesitant)).
03 I: Do you know why this is the case?
04 K: No, but in some way for me that has nothing to do with the Mercedes star. ((2 sec)) Sure, there are six permutations and then it has to decide.
05 I: Okay, let us try not to think of the Mercedes star. Why is it not possible to predict which number will come?
06 K: Well, also because of influences. And because one does not start in the same way and
07 I: Why is this of importance?
08 K: Well, why not?

The interviewer then offers—the question mark indicates that the transcriber heard it as a question—another question which has "this" as its content: "Why is this the case?" (turn 03). That is, from the perspective of the conversation as an unfolding process, the interviewer's turn presupposes familiarity with the die and

with the fact—which he introduced—that one could not predict the outcome of a throw. The student turn states that no and continues to unfold a reply, which states that this has nothing to do with the Mercedes star. That was the topic of their earlier talk. The turn explicitly articulates the absence of a relationship between "the Mercedes star" and "that" (turn 04). Kristin produces a statement about the six possible outcomes ("permutations") and about the "it" "having to decide" something.

As the next turn shows, the offer of bringing the Mercedes star into the discussion comes to be declined: "let us try not to think of the Mercedes star" (turn 05). That is, there is a proposal not to use the Mercedes star language in the present context (interview game), which has the die as its stated topic. That is, there is not some abstract game at play, for which the rules are somehow given, but the rules to be played by are made up and provided to players as the game unfolds. As the interviewer continues, the interviewer's turn offers up another question concerning the impossibility of predicting the number that the thrown die will show (when it comes to rest). If anything, the description of the entire situation of the game of dice is asymmetrically distributed: articulated by the interviewer but for (the benefit of) Kristin. Not only does the interviewer articulate the impossibility of predicting the outcome of a die throw but also the question about the reason for it. The offered reply raises two possibilities: influences and the start as not being in the same way. Again, a turn offers up a question about the importance of "this," which, rather than being paired with a reply, is paired with a counter-question: "Well, why not?" (turn 08). That is, two candidate reasons that fill the reply position to the antecedent why-question come to be questions as to their importance followed by a questioning of the question. In any case, whoever is speaking at the time, we see intelligibility itself at work, which speakers would have to presuppose in and with every verbal articulation. To understand the dynamic of the conversation, researchers, too, have to draw on intelligibility, because speakers would not be able to respond to each other unless intelligibility was presupposed.

For this interview to unfold, no individual turn can be attributed to the person who actually articulated it with his or her speech apparatus. Inherently, to be able produce an intelligible reply or next turn, the corresponding interlocutor has to have ears to hear. Each locution, therefore, is both said and heard. It is said *to be heard*, that is, it is said for the hearing. Each locution is therefore inherently assumed to be intelligible on the part of the author and on the part of the recipient. We are therefore not dealing with an individual «mental representation» that the talk points to, even if we were to take the classical perspective on this category, but a «societal representation». The words and expressions point in both directions simultaneously, to author and recipient. For one interlocutor to hear an offered question in a certain way presupposes its intelligibility and a «representation» of precisely the same kind as that which is at the origin of the locution.

In the preceding section, I show how we used this excerpt from the interview transcript to make claims about the change in «conceptual framework» that Kristin has undergone or rather, the change observable as a consequence of her reconstruction of the «frame». However, the present analysis shows that if any attribution is to be made concerning a «representation» then it is to the interviewer. Otherwise we would be in the same position of attributing Socrates' knowledge to

the slave whom he asks questions such that the previously arrived truth comes to be articulated in words and expounded (Bakhtin 1994). The truth, knowledge, clearly appears with the words of the "teacher" and the dialogue is a mere form in which this knowledge is displayed.

The second important lesson we can draw from the transcript is that even though the excerpt is short, we do observe a number of different expressions that contain the word "die" or that bring it into the conversation by means of the indexical "it." The interviewer's turn uses the word in the first two parts of turn 01 and then reintroduces it as topic using the pronominal "it." Kristin's turn also uses this pronoun when it refers to the fact that "it has to decide" (turn 04). That is, the speech activity is about a feature of the games played with a die or with dice. And all those games with dies involve language games as well. The interview appeals to familiarity with such games and introduces the topic with words and expressions that would appear in the course of such games. That is, the interview does not merely appeal to familiarity with the games but also to the familiarity with the language that is used in and about such games. The interviewer also offers up constraints as to the words not to be used, which, in the short excerpt that the researchers presented, are accepted: Kristin's turns do not bring the Mercedes star (term or perceptual image) to bear on the present topic. That is, the interviewer proposed the delimitation of the discourse rather than it coming from Kirstin. If anything, the non-appearance of the Mercedes star in the discourse about the die is due to the researcher. Kirstin accepts the proposal not to use the word, as exhibited by the fact that she does not bring it into the conversation. She thereby plays by the rules of the game that were developed on the fly. Again, if we were prepared to make an attribution about the «schema» at work in this situation, it is to be made to the interviewer rather than to Kirstin.

Rather than attributing the operating «schemata», «mental representation», or «conceptual framework» to one or the other interlocutor, I propose focusing on all the concrete uses of the word die or its plural form dice, the possible expressions in which these occur, and the content of explanations concerning their behavior. These concrete ways of using die and dice and explanations of the behavior of the physical devices constitute a family of talking in a particular language game. This entire family constitutes a «societal representation». Because this is a family of ways of talking, the «societal representation» is not an abstraction but a concrete way of pointing to the ensemble of ways of talking about (games with) dice. The nature of the family changes with the appearance of a new member, the disappearance of an old member, and the changes in the relation between members. The analogy with a human family immediately shows why this is so. When a male (husband) leaves or dies, for example, then we are left with a single parent family. Such a change may entail changes elsewhere in the society, for example, when the mother now receives forms of support that she would not have had access to otherwise. When there are behavioral changes observable in her child or children in school, the whole discourse employed concerning any "problems" may be attributed to the current "single-parent" status of the mother. Changing relationships also lead to changes in a family, which outsiders or therapists may signal in a conversation by referring to change from a "happy family" (with or without "small problems") to one of a "dysfunctional family." That is, the change is denoted as a

qualitative one from one state to another when in fact the change may have been a quantitative one in the relation between members.

Returning to the games of dice and the language games associated with them, we do not have to mobilize changes in abstract categories to explain what is going on. Rather, a «societal representation» changes along with any concrete change that is produced in actually talking (about) games of dice. This talk is indistinguishable from knowing to play the game of dice. It is precisely because of the constitutive nature of the part (a way of talking) and the whole (family of ways of talking) that change is continuous—even if unnoticeable in the short run. That is, we do not need to appeal to abstraction and abstract constructs but may use observational constructs—exemplified in the documentary approach to «societal representation»—that directly map onto the theory. Each way of talking is taken as a manifestation of the totality of ways of talking that it contributes to constituting. As the examples from the second-grade mathematics classroom in chapter 7 show, when it is unclear which family is being invoked, transaction participants tend to ask for further members from the family of expressions until there is sufficient material provided for going on. In other words, going on is equivalent to a provisional identification of the pertinent family (i.e., for «meaning»). This family tends to be reified in subsequent talk, such as when it becomes apparent that Connor provides a (partially) satisfactory answer to the question initially offered up on the part of the teacher.

The transcript also points us to another game. The interlocutors do not merely talk about a game of dice and the unpredictability of the number that will come out on top when the device comes to rest following a throw. These things are the topic of the speech activity (*rečevaja dejatel'nost'*). With the very same words, the interlocutors also produce the relation that makes, and which is made through, interview talk. The interview was one aspect of the research activity (*dejatel'nost'*) the concrete outcomes of which were our research team's conference presentations and journal articles. Without the words that produced the topic, the *relation* would not have existed. This points to the integral nature of speech activity to activity. The words, therefore, also are accomplishing the interview game. We may in fact say that the words and expression producing the societal relation *also* have a content that the talk is about. In other words, the speech activity does not only have content but also realizes and primarily is *for* the research activity. Without this activity and the societal relation, no topic is possible. Thus, not only does speech activity realize the interview, but also it evolves the topic, bringing it to points where some questions are enabled and others become less suitable or likely to occur. Thus, when the interviewer's turn offers up a question about the die (turn 01), he could not anticipate what Kristin would say in turn 08 or even what he would subsequently ask in turn 07. The speech activity therefore evolves together with the activity. As a result, this description is consistent with the content of the quotation from Rorty, which orients us towards the evolutionary nature of activity.

9 Epilogue

> *Meaning:* A word so confused that it is best never used at all. More direct expressions can always be found. (Try for example, speaking in terms of "is," or "involves.") The transactional approach does away with that split between disembodied meanings and meaningless bodies for meanings which still enters flagrantly into much discussion.
>
> *Mental:* This word not used by us. Usually indicates an hypostatization arising from a primitively imperfect view of behavior, and not safe until the splitting of existence into two independent isolates has been generally abandoned.
>
> (Dewey and Bentley 1949: 194)

More than six decades ago, Dewey and Bentley suggested abandoning the words "meaning" and "mental" because they are confusing and of little use for understanding how human beings conduct their everyday affairs, whether this be in everyday situations or in the scientific laboratory. I fully agree with these philosophers. In this book, I present a perspective on «meaning» and «mental representation» that differs radically from the currently dominant ways of thinking about and theorizing knowing and learning. There are two major differences between existing and this new way of thinking about and theorizing «meaning» and «mental representation»:

1. Rather than constituting abstractions to which the language of students and just plain folks points, the documentary method allows us to understand «meaning» and «mental representation» in entirely concrete ways. Thus, the «meaning» of a word or expression consists in a family of words or expressions that can be used in lieu of each other for talking about the same thing. Because each word, expression, and statement is concrete, the ensemble or family of expression is equally concrete.
2. Because «meaning» and «mental representation» exist in and as families (ensembles) of the concrete ways in which people concretely talk and talk about certain phenomena, the relationship between individual and collective perspectives changes. In traditional approaches «meaning» and «mental representation» inherently point to something in the individual mind (see chapters 2–4). There is therefore always the question about how the contents and structures of one individual mind relate to that of all other individual minds. Thus, for example, «meaning» can only be "taken-as-shared," for there is never a way

> of ascertaining that the contents or structures of two minds are the same or aligned. On the other hand, if «meaning» and «mental representation» exist in the concrete ways of talking, inherently available to any competent speaker addressing other competent speakers, «meaning» and «mental representation» are *inherently* common to all who make specific statements or use words and employ expressions in the same way: they are part of the same family. «Meaning» and «mental representation» inherently are cultural, possible ways of articulating an issue in a given language game sufficiently intelligible for others to take up and engage with it.

The first consequence is that students do not "make" or «construct» «meaning» or «mental representations». In the language available to them they find ways of talking that are more than others appropriate, useful, or familiar. When their ways come to be by-and-large consistent with the ways that scientists might use in their communication, then an evolution has occurred from plain, everyday ways of talking to scientifically acceptable ways of talking. Or, rather, students have learned to recognize the kinds of settings in which the latter forms of talking are to be employed without ever having to abandon their everyday ways of talking—just as physicists and astronomers continue to talk about sunrises and sunsets. That is, everyday ways of talking have not gone out of fashion. Rather, the scientifically acceptable ways now constitute new possibilities of talk, in certain contexts; these are new ways that others in these contexts find acceptable and consistent with existing ways of talking. This also implies that new ways of talking may emerge without that previous ways of talking become wrong or inappropriate. We may think of such shifts in ways of talking in terms of the history of science, where the discourse, for example, about electromagnetic phenomena has changed over the years. Thus, when J. C. Maxwell initially proposed a new way of talking about the relation between electrical and magnetic phenomena that are related, it took him an entire book to make his case. Today, electromagnetic phenomena are summarily presented in the form of four equations that appear in introductory physics textbooks or Wikipedia. Just as the field of physics experiences the evolution of its discourses, so do students experience evolutions in the kind of conversations and language games in which they can knowledgeably participate.

A second consequence is that «meanings» and «mental representations» are not personal. These consist of families or ensembles of ways of talking a topic—and all ways of talking are inherently collective—so that anything we may say in response to "what do you mean (by)?" is inherently shared. This is so because nothing can be said in response to this question without already addressing the other and, therefore, being *shared* rather than being *taken-as-shared*. The individual may be more or less familiar with a world, but the lifeworlds that we inhabit inherently are collective worlds populated with others; and signification always implies collectivity. Activity theorists—Vygotsky, Leont'ev, and those who follow(ed) in their footsteps—are adamant about the *societal* nature of anything that is characteristically human: forms of thought, personality, consciousness, and psychological functions. Thus, both emphasize that that which sets humans apart from other animals, the human essence, is not something abstract. The human essence is, according to ideas first set forth by Marx, the totality of *societal* rela-

tions. This includes what we have come to attribute to the innermost characteristics of human beings, thought, personality, consciousness, and psychological functions. Any of these characteristics *are* societal relations; and we know about them precisely because the manifestations thereof are available in public and to everyone. The different tack taken in this book is to suggest that there are no abstract and metaphysical entities like «meaning» and «mental representation» but that these are but names for the ensemble (totality) of concrete ways of talking.

The third implication is that there cannot be an argument about the difference between theory and practice, knowing something but being unable to apply it. Speech activity, as all activity, occurs in and is constitutive of praxis. «Meaning» and «mental representation» are names that denote alternative forms of speaking, evidenced in speech activity. That is, human thought and consciousness always evidences itself in concrete ways of speaking. The reality of thought and consciousness proves itself in the this-sidedness of our concrete ways of speaking. Any argument about the reality of thought and consciousness or «meaning» and «mental representation» becomes academic. Societal life essentially consists in praxis; this praxis is oriented to the control over the human condition and the provision for human needs.

Families of ways of talking do not tend to be articulated in their entirety. In fact, in most conversations the interlocutors tend to take one or two ways of talking to be sufficient documentary evidence on the basis of which they go ahead. Thus, in the course of most conversations, people do not have to ask even once "What do you mean?" to have the sense that they can proceed. From a perspective of feasibility, the elaboration of all ways of talking (about) a particular issue in so many ways is unnecessary and undesirable. Conversations go on with the provision of an etcetera clause, which means, that there are other ways of talking not actually articulated. There is an implicit assumption that there are other ways of talking until some point where for one or the other person there is a sense of "losing ground," that is, where the topic of the conversation treads unfamiliar terrain ("You lost me!"). When the question "What do you mean?" or some equivalent *does* occur, then participants readily engage in elaborating other ways, so that they recognize, for example, that someone is asking "the same question" in a different way to assist the intended recipient to "understand," a situation that would be indicated when a suitable response is articulated.

Especially in the latter part of the 20th century, STEM researchers have focused on the «misconceptions» that students and just plain folk alike are said to "have" about some STEM phenomenon. The approach presented in this book allows us to better understand some of the surrounding issues. One of the more important issue is the very idea of a «misconception». Despite being a classified as a «misconception», a particular way of talking about a phenomenon is sufficiently intelligible for the researcher to understand what a research participant has said and sufficiently intelligible to evaluate it as a way of talking that would not fall within the same family of statements that a natural scientist would use, find acceptable, or deem consistent with the domain. That is, the talk is sufficiently intelligible for the STEM researchers to identify it as lying outside of the family of acceptable ways in a particular domain. But because of this intelligibility, it is a form of possible talk; and because it is a form of possible talk, it is also a cultural form.

The standard forms of talking current *within* a particular discipline always are set against and in relief of the forms of talk that negate it. Acceptable forms of talking are figure against a ground, the latter being required for the figure to become figure in the first place. That is, any disciplinary talk is a subset of possible ways of talking. In a strong sense, this implies that we cannot ever "eradicate" «misconceptions». This is so because, evident from the way in which I present the case here, these constitute the very ground against which "correct" «conceptions» stand out as particular to the scientific community.

This commonality of disciplinary talk—a subset in the family of talking about a phenomenon, and the broader family of talk—also allows us to understand what we might want to do in STEM education to assist students in separating situations where some forms of talk are less or not acceptable (desirable). Thus, just as students learn to distinguish those situations where certain words (e.g., 4-letter f-words) are banished and inappropriate, they will learn that certain ways of using groups of words such as energy, heat, and temperature or speed, velocity, impulse, and force are inappropriate in some situations (games) although they might be appropriate in other situations (games). But there is continuity: as they talk and participate in speech activity, their ways of talking change (slowly), and situations are distinguished according to their appropriateness for particular ways of talking.

The latter point takes us back to the description of language learning, which, from a pragmatic perspective, amounts to coming to know one's way around the world more generally. Engaging in speech activity (*rečevaja dejatel'nost'*) so that it is useful to move along and to be produced by, and in the context of, some activity (*dejatel'nost'*) or game that fulfills a collective need amounts to learning the relevant language (game). In most school situations, students do not have sufficient time—time of the order that we know it takes to become familiar with a language and a new setting—to become familiar with situations and associated speech activity. Moreover schooling, as it currently operates, is in the business of producing grades and grade reports rather than in the business of contributing to the development of people who can navigate different parts of this world (other than that of schooling itself). Students learn whatever is required to become familiar with this world; and their speech activity develops accordingly. For example, students do talk about how they "crammed" the night before or how they "pulled an all-nighter" and how, only one day after an exam, they "have forgotten everything." This kind of talk, and the kind of learning that is made a topic therein, does not tend to improve familiarity with and competence in the speech activity associated to whatever STEM discipline that they have taken the exam in. But it is indicative of their knowledgeable navigation of the world of formal schooling and its reversal of a well-known Roman insight according to which we learn for life rather than for school (*non scholae sed vitae discimus*).

Focusing on languages and the games in which they are played allows us to be consequential in implementing Vygotsky's program of the higher psychological functions as societal relations. Thus, for example, this social psychologist suggests that outer speech dies off because whatever can be thought is inherently speech and therefore something specific to and irreducible from society at its particular point in cultural history. He therefore can come to the conclusion that *all* forms of

verbal intercourse of the adult with the child later become psychological functions (Vygotskij 2005). But this insight also shows that we must never reduce the inner to the outer or the outer to the inner. Responding to his own question "What is man?," Vygotsky notes that it is the totality of societal relations, embodied in the individual. (Also: "The person = a heap of societal relations.") This is so because to participate at all in verbal intercourse, the inner of the child must be active. Later the same inner is active even without the adult or another present, which *must not* be used to suggest that the inner speech is somehow the person's own and not always already collective. This is quite clear in the analysis of writing, which is first for the other before it becomes something individuals do for themselves: when writing notes, diaries, reflections, and so on. For Vygotsky everything cultural is social: all signs, outside the organism, are social tools. All higher functions therefore have a soci(et)al rather than biological origin. As a result, the entire structure of personality is *societal*: the individual personal is the highest form of what is societal in nature. Thus, «meaning», «mental representation», or «conception», as psychological functions, cannot be anything other than societal; and, because all of these are mediated by language, we need to investigate the concrete forms of talking and speech activity that. It is therefore "ridiculous to search for special centers of higher psychological functions or to search for highest functions in the cortex" (Vygotskij 2005: 1023). The function of the word, Vygotsky says, initially is distributed across several people. In the mind of the individual, this would be impossible. He contrasts his approach, which situates the origin and presence of the individual behavior in collective behavior, to all those approaches that derive social from individual phenomena and behaviors. And he concludes that development therefore consists in the individualization of *societal* functions rather than the socialization of the individual. Development is *not* a question of how the child behaves in society but how society generates in the child the higher functions required in the maintenance and transformation of society. It is not that children argue because they have different ideas about something but that argument leads to reflection.

Appendix

The transcription conventions for most transcripts are those of standard conversation analysis enhanced for the transcription of prosodic features (Selting et al. 1998). Unless modified, all words are written with small letters.

Notation	Description	Example
(0.14)	Time without talk, in seconds	okay. (0.24) OH
(.)	Period in parentheses marks a hearable (micro-) pause less than 0.1 seconds long	NO. (.) <<assertive>you
(??)	Question marks in parentheses indicate (approximate) number of undecipherable words	and (??) the square
((*turns*))	Verbs and descriptions in double parentheses are transcriber's comments	((*head sideward*))
::	Colons indicate lengthening of phoneme, about 1/10 of a second per colon	U::M:::
[ ]	Square brackets in consecutive lines indicate overlap	J: wa[xes.] C: [wAX?] (0.93)
<p> >	Piano, lower than normal speech volume	<<p>like we get hot air from.>
<<f> >	Forte, louder than normal	<<f>whAT> (0.23) makes
<<ff> >	Fortissimo, much louder than normal	<<ff>[no].>
<<pp> >	Pianissimo, a lot lower than normal speech volume, almost inaudible	<<pp>kay.>
<<all> >	Allegro, words are uttered with faster than normal speed	<<all>okay?>
<<dim> >	Diminuendo, decreasing speech intensity	<<dim> just; just lay this one down>
<<len> >	Lento, slower than normal	<<len>and what do you mean by the same.>
<<rall> >	Rallentando, slowing down	<<rall>are the same>
<<acc> >	Accelerando, speeding up	<<acc>they look a lit-

		tle bit like cubes>
<<plain- tive> >	Transcriber's glosses are provided for ways of speaking	<<plain- tive>i=just=found= out=a=way=to='dO=`it.>
JAne	Capital letters indicate emphasized sounds.	T: ANd (2.92) bENs group says
—,?;.	Punctuation is used to mark movement of pitch (intonation) toward end of statement, flat, slightly and strongly upward, and slightly and strongly downward, respectively	T: so can we tell a shape by its col- or? T: does it belong to another group (0.67) O:r.
=	Equal sign indicates that the phonemes of different words are not clearly separated	loo::ks=similar

References

Ashmore, M., & Reed, D. (2000). Innocence and nostalgia in conversation analysis: The dynamic of tape and transcript. *Forum Qualitative Sozialforschung/ Forum Qualitative Social Research, 1* (3). http://www.qualitative-research.net/index.php/fqs//article/view/1020/2199

Augustine. (1860). *Confessions*. Andover, MA: W. F. Draper.

Bakhtin, M. (1981). *The dialogic imagination*. Austin, TX: University of Texas.

Bakhtin, M. M. (1990). *Tvorčestvo Francua Rable i narodnaja kultura I renessancia*. Moscow, Russia: Khudožestvennija literatura. (L'œuvre de François Rabelais et al culture populaire au Moyen Age et sous la Renaissance, Paris, France: Gallimard, 1970.)

Bakhtin, M. M. (1994). *Problemy tvorčestva poètiki dostoevskogo.* Kiev, Russia: Next. (Bakhtin, M. M., Problems of Dostoyevsky's poetics. Minneapolis, MN: University of Minnesota Press, 1984)

Bellocchi, A., & Ritchie, S. M. (2011). Investigating and theorizing discourse during analogy writing in chemistry. *Journal of Research in Science Teaching, 48*, 771–792.

Bourdieu, P. (1992). The practice of reflexive sociology (The Paris workshop). In P. Bourdieu & L. J. D. Wacquant, *An invitation to reflexive sociology* (pp. 216–260). Chicago: University of Chicago Press.

Brown, T. (2011). *Mathematics education and subjectivity*. Dordrecht, The Netherlands: Springer.

Chi, M. T. H. (1992). Conceptual change within and across ontological categories: Examples from learning and discovery in science. In R. Giere (Ed.), *Cognitive models of science: Minnesota studies in the philosophy of science* (pp. 129–186). Minneapolis, MN: University of Minnesota Press.

Davidson, D. (1986). A nice derangement of epitaphs. In E. Lepore (Ed.), *Truth and interpretation* (pp. 433–446). Oxford, UK: Blackwell.

Derrida, J. (Ed., Trans.). (1962). *Edmund Husserl: L'origine de la géométrie* [Edmund Husserl: The origin of geometry]. Paris, France: Presses Universitaires de France.

Derrida, J. (1967). *De la grammatologie* [Of grammatology]. Paris, France: Les Éditions de Minuit.

Derrida, J. (1985). Des tours de Babel [Towers of Babel]. In J. Graham (Ed.), *Difference in translation* (pp. 209–248). Ithaca, NY: Cornell University Press.

Derrida, J. (1990). *Le problème de la genèse dans la philosophie de Husserl* [The problem of genesis in Husserl's philosophy]. Paris, France: Presses Universitaires de France.

Derrida, J. (1991). *Donner le temps. 1. La fausse monnaie* [Given time 1: Counterfeit

money]. Paris, France: Galilée.
Derrida, J. (1993). *Khôra* [Khôra]. Paris, France: Galilée.
Derrida, J. (1996a). *Le monolinguisme de l'autre ou la prothèse d'origine* [Monolingualism of the other or prosthesis of origin]. Paris, France: Galilée.
Derrida, J. (1996b). *Résistances de la psychanalyse* [Resistances of psychoanalysis]. Paris, France: Galilée.
Dewey, J., & Bentley, A. F. (1999). Knowing and the known. In R. Handy & E. E. Hardwood, *Useful procedures of inquiry* (pp. 97–209). Great Barrington, MA: Behavioral Research Council. (First published in 1949)
Duit, R., Komorek, M., Wilbers, J. & Roth, W.-M. (1997, March). *Analogy-induced conceptual change during a unit on chaos-theory*. Paper presented at the annual meeting of the American Educational Research Association, Chicago, IL.
Duit, R., Roth, W.-M., Komorek, M., & Wilbers, J. (1998). Conceptual change cum discourse analysis to understand cognition in a unit on chaotic systems: towards an integrative perspective on learning in science. *International Journal of Science Education, 20,* 1059–1073.
Duit, R., Roth, W.-M., Komorek, M., & Wilbers, J. (2001). Fostering conceptual change by analogies: Between Scylla and Charybdis. *Learning and Instruction, 11*, 283–303.
Eco, U. (1984). *Semiotics and the philosophy of language*. Bloomington, IN: Indiana University Press.
Edwards, D., & Potter, J. (1992). *Discursive psychology*. London, UK: Sage.
Foucault, M. (1966). *Les mots et les choses* [The order of things]. Paris, France: Gallimard.
Franck, D. (2008). *L'un-pour-l'autre* [The one-for-the-other]. Paris, France: Presses Universitaires de France.
Frege, G. (1892). Über Sinn und Bedeutung [On sense and reference/signification]. *Zeitschrift für Philosophie und philosophische Kritik, 100,* 25–50.
Freud, S. (1999). *Gesammelte Werke Band XVII* [Collected works vol. 17] Frankfurt a/M, Germany: Fischer-Verlag.
Garfinkel, H. (1967). *Studies in ethnomethodology*. Englewood Cliffs, NJ: Prentice-Hall.
Garfinkel, H. (1988). Evidence for locally produced, naturally accountable phenomena of order*, logic, reason, meaning, method, etc. in and as of the essential quiddity of immortal ordinary society, (I of IV): An announcement of studies. *Sociological Theory, 6*, 103–109.
Garfinkel, H. (1996). Ethnomethodology's program. *Social Psychology Quarterly, 59*, 5–21.
Garfinkel, H., & Sacks, H. (1986). On formal structures of practical action. In H. Garfinkel (Ed.), *Ethnomethodological studies of work* (pp. 160–193). London, UK: Routledge and Kegan Paul.
Hegel, G. W. F. (1979). *Werke Band 3* [Works vol. 3]. Frankfurt/M, Germany: Suhrkamp.
Heidegger, M. (1977). *Sein und Zeit* [Being and time]. Tübingen, Germany: Max Niemeyer. (First published in 1927)
Heidegger, M. (1985). *Gesamtausgabe. 1. Abteilung: Veröffentlichte Schriften 1910–1976. Band 12: Unterwegs zur Sprache* [Complete works. Part 1: Published works 1910–1976 vol. 12: On the way to language]. Frankfurt/M, Germany: Vittorio Klostermann.
Holzkamp, K. (1983). *Grundlegung der Psychologie* [Founding psychology]. Frank-

furt/M, Germany: Campus.
Husserl, E. (1939). Die Frage nach dem Ursprung der Geometrie als intentional-historisches Problem [The question of the origin of geometry as intentional-historical problem]. *Revue Internationale de Philosophie, 1*, 203–225.
Husserl, E. (1980). *Vorlesungen zur Phänomenologie des inneren Zeitbewußtseins* [Lectures on the phenomenology of inner time consciousness]. Tübingen, Germany: Max Niemeyer. (First published in 1928)
Husserl, E. (1995). *Cartesianische Meditationen* [Cartesian meditations]. Hamburg, Germany: Felix Meiner. (First published in 1950)
Husserl, E. (2006). *Collected works vol. xii: The basic problems of phenomenology. From the lectures, Winter Semester 1910–1911*. Dordrecht, The Netherlands: Springer.
Husserl, E. (2008). *Husserliana: Gesammelte Werke Band XXXIX: Die Lebenswelt. Auslegungen der vorgegebenen Welt und ihrer Konstitution. Texte aus dem Nachlass (1916–1937)* [Husserliana: Collected works vol. 39: The lifeworld. Interpretations of the given world and its constitution. Texts from the estate 1916–1937]. Dordrecht, The Netherlands: Springer.
Ilyenkov, E. (1982). *Dialectics of the abstract and the concrete in Marx's Capital* (Transl. Sergei Kuzyakov). Moscow, Russia: Progress.
Johansson, A.-M., & Wickman, P.-O. (2011). A pragmatist approach to learning progressions. In B. Hudson & M. Meyer (Eds.), *Beyond fragmentation: Didactics, learning, and teaching* (pp. 47–59). Leverkusen, Germany: Barbara Budrich.
Krange, I., & Arnseth, (2012). Students' meaning making in science: solving energy resource problems in virtual worlds combined with spreadsheets to develop graphs. *Cultural Studies in Science Education, 7,* 585–605.
Lacan, J. (1966). *Écrits* [Écrits]. Paris, France: Éditions du Seuil.
Leont'ev, A. A. (1969). *Jazyk, rec', recevaja dejatel'nost'*. Moscow, Russia: Prosveščenje. (*Sprache, Sprechen, Sprechtätigkeit,* C. Heeschen, Trans. Stuttgart, Germany: Kohlhammer, 1971.)
Leont'ev, A. N. (1983). *Dejatel'nost'. Soznanie. Ličnost'*. [Activity, consciousness, personality]. (Leontjew, A. N., Tätigkeit, Bewußtstsein, Persönlichkeit. Köln, Germany: Pahl-Rugenstein, 1982.)
Levinas, E. (1971). Le dire et le dit [The saying and the said]. *Le Nouveau Commerce, 18/19*, 19–48.
Levinas, E. (1978). *Autrement qu'être ou au-delà de l'essence* [Otherwise than being or beyond essence]. Paris, France: Dordrecht, The Netherlands: Martinus Nijhoff.
Livingston, E. (1986). *The ethnomethodological foundations of mathematics*. London, UK: Routledge and Kegan Paul.
Magga, O. H. (2006). Diversity in Saami terminology of reindeer, snow, and ice. *International Social Science Journal, 58,* 25–34.
Mandelbrot, B. B. (1983). *The fractal geometry of nature*. New York, NY: W. H. Freeman.
Mannheim (2004). Beiträge zur Theorie der Weltanschauungs-Interpretation [Contributions to the theory of worldview interpretation]. In J. Strübing & B. Schnettler (Eds.), *Methodologie interpretativer Sozialforschung: Klassische Grundlagentexte* (pp. 103–153). Konstanz, Germany: UVK. (First published in 1921–22)
Marion, J.-L. (1997). *Étant donnée: Essaie d'une phénoménologie de la donation* [Being given: Essay on the phenomenology of givenness]. Paris, France: Presses Universitaires de France.

Marx, K./Engels, F. (1958). *Werke Band 3* [Works vol. 3]. Berlin, Germany: Dietz. (Written in 1846.)

Marx, K./Engels, F. (1962). *Werke Band 23* [Works vol. 23]. Berlin, Germany: Dietz.

Merriam-Webster Online Dictionary. (2012). http://www.merriam-webster.com/dictionary/

Mikhailov, F. T. (2001). The "other within" for the psychologist. *Journal of Russian and East European Psychology, 39*, 6–31.

Mixhailov, F. T. (1976). *Zagadka čelovečeskogo ja* (2nd ed). Moscow, Russia: Politizdat. (Mikhailov, F. T., The riddle of self. Moscow, Russia: Progress, 1980)

Nancy, J.-L. (2000). *Being singular plural*. Stanford, CA: Stanford University Press.

Nietzsche, F. (1954). *Werke in drei Bänden* [Works in three volumes]. Munich, Germany: Hanser.

Nöth, W. (1990). *Handbook of semiotics*. Bloomington, IN: Indiana University Press.

Ogden, C. K., & Richards, I. A. (1923). *The meaning of meaning: A study of the influence of language upon thought and of the science of symbolism*. London, UK: Kegan Paul.

Pines, A. L. (1985). Toward a taxonomy of conceptual relations. In L. H. T. West and A. L. Pines (Eds.), *Cognitive structure and conceptual change* (pp. 101–116). New York, NY: Academic Press.

Potter, J. (2003). Discursive psychology: Between method and paradigm. *Discourse & Society, 14*, 783–794.

Quine, W. V. (1995). *From stimulus to science*. Cambridge, MA: Harvard University Press.

Radford, L. (2006). The anthropology of meaning. *Educational Studies in Mathematics, 61*, 39–65.

Radford, L., & Roth, W.-M. (2011). Beyond Kantian individualism: An activity perspective on classroom interaction. *Educational Studies in Mathematics, 77*, 227–245.

Rancière, J. (1995). *La mésentente* [Misunderstanding]. Paris, France: Galilée.

Rorty, R. (1989). *Contingency, irony, and solidarity*. Cambridge, UK: Cambridge University Press.

Roth, W.-M. (1996). The co-evolution of situated language and physics knowing. *Journal of Science Education and Technology, 5*, 171–191.

Roth, W.-M. (1998). Science teaching as knowledgeability: a case study of knowing and learning during coteaching. *Science Education, 82*, 357–377.

Roth, W.-M. (2000). From gesture to scientific language. *Journal of Pragmatics, 32*, 1683–1714.

Roth, W.-M. (2004a). Activity theory and education: An introduction. *Mind, Culture, and Activity, 11*, 1–8.

Roth, W.-M. (2004b). Perceptual gestalts in workplace communication. *Journal of Pragmatics, 36*, 1037–1069.

Roth, W.-M. (2004c). Vagaries and politics of funding: Beyond "I told you so." Forum Qualitative Sozialforschung / Forum: Qualitative Social Research, 5 (1). http://www.qualitative-research.net/index.php/fqs/article/view/661

Roth, W.-M. (2005). *Talking science: Language and learning in science classrooms*. Lanham, MD: Rowman & Littlefield.

Roth, W.-M. (2007). Emotion at work: A contribution to third-generation cultural-historical activity theory. *Mind, Culture, and Activity, 14*, 40–63.

Roth, W.-M. (2008). Bricolage, métissage, hybridity, heterogeneity, diaspora: Concepts

for thinking science education in the 21st century. *Cultural Studies in Science Education, 3*, 891–916.

Roth, W.-M. (2009a). Cultural-historical activity theory: Toward a social psychology from first principles. *History and Philosophy of Psychology Bulletin, 21* (1), 8–22.

Roth, W.-M. (2009b). *Dialogism: A Bakhtinian perspective on science and learning*. Rotterdam, The Netherlands: Sense Publishers.

Roth, W.-M. (2011a). *Geometry as objective science in elementary classrooms: Mathematics in the flesh*. New York, NY: Routledge.

Roth, W.-M. (2011b). *Passibility: At the limits of the constructivist metaphor*. Dordrecht, The Netherlands: Springer.

Roth, W.-M. (2012a). *First-person methods: Toward an empirical phenomenology of experience*. Rotterdam, The Netherlands: Sense Publishers.

Roth, W.-M. (2012b). Mathematical learning, the unseen and the unforeseen. *For the Learning of Mathematics, 32* (3), 15–21.

Roth, W.-M. (2013a). Technology and science in classroom and interview talk with Swiss lower secondary school students: A Marxist sociological approach. *Cultural Studies of Science Education*. DOI: 10.1007/s11422-012-9473-4

Roth, W.-M. (2013b). Toward a post-constructivist ethics in/of teaching and learning. *Pedagogies: An International Journal.*

Roth, W.-M. (in press). At the intersection of text and talk: On the reproduction and transformation of language in the multilingual evaluation of multilingual texts. *Semiotica.*

Roth, W.-M., & Duit, R. (2003). Emergence, flexibility, and stabilization of language in a physics classroom. *Journal for Research in Science Teaching, 40*, 869–897.

Roth, W.-M., & Gardner, R. (2012). "They're gonna explain to us what makes a cube a cube?" Geometrical properties as contingent achievement of sequentially ordered child-centered mathematics lessons. *Mathematics Education Research Journal, 24,* 323–346.

Roth, W.-M., Goulart, M. I. M., & Plakitsi, K. (2013). *Science during early childhood: A cultural-historical perspective*. Dordrecht, The Netherlands: Springer.

Roth, W.-M., & Lawless, D. (2002a). Science, culture, and the emergence of language. *Science Education, 86*, 368–385.

Roth, W.-M., & Lawless, D. (2002b). Scientific investigations, metaphorical gestures, and the emergence of abstract scientific concepts. *Learning and Instruction, 12*, 285–304.

Roth, W.-M., & Lee, Y. J. (2007). "Vygotsky's neglected legacy": Cultural-historical activity theory. *Review of Educational Research, 77*, 186–232.

Roth, W.-M., & Middleton, D. (2006). The making of asymmetries of knowing, identity, and accountability in the sequential organization of graph interpretation. *Cultural Studies of Science Education, 1*, 11–81.

Roth, W.-M., & Pozzer-Ardenghi, L. (2006). Tracking situated, distributed, and embodied communication in real time. In M. A. Vanchevsky (Ed.), *Focus on cognitive psychology research* (pp. 237–261). Hauppauge, NY: Nova Science.

Roth, W.-M., & Radford, L. (2010). Re/thinking the zone of proximal development (symmetrically). *Mind, Culture, and Activity, 17*, 299–307.

Roth, W.-M., & Radford, L. (2011). *A cultural-historical perspective on mathematics teaching and learning*. Rotterdam, The Netherlands: Sense Publishers.

Roth, W.-M., & Roychoudhury, A. (1992). The social construction of scientific concepts or The concept map as conscription device and tool for social thinking in high school science. *Science Education, 76*, 531–557.

Roth, W.-M., & Roychoudhury, A. (1993). The concept map as a tool for the collaborative construction of knowledge: A microanalysis of high school physics students. *Journal of Research in Science Teaching, 30*, 503–534.

Roth, W.-M., & Thom, J. (2009). Bodily experience and mathematical conceptions: From classical views to a phenomenological reconceptualization. *Educational Studies in Mathematics, 70*, 175–189.

Roth, W.-M., & van Eijck, M. (2010). Fullness of life as minimal unit: STEM learning across the life span. *Science Education, 94*, 102–1048.

Russell, B. (2009). *Human knowledge: Its scope and limits*. London, UK: Routledge. (Originally published in 1948)

Saussure, F. de (1995). *Cours de linguistique générale* [Course in general linguistics]. Paris, France: Éditions Payot. (First published in 1916)

Selting, M., Auer, P., Barden, B., Bergmann, J., Couper-Kuhlen, E., Günthner, S., Meier, C., Quasthoff, U., Schlobinski, P., & Uhmann, S. (1998). Gesprächsanalytisches Transkriptionssystem. *Linguistische Berichte, 173*, 91–122.

Smith, D. E. (1990). *Conceptual practices of power: A feminist sociology of knowledge*. Toronto: University of Toronto Press.

Tobin, K., & Roth, W.-M. (2006). *Teaching to learn: A view from the field*. Rotterdam, The Netherlands: Sense Publishers.

van der Maas, H. J. L., & Molenaar, P. C. M. (1992). Stagewise cognitive development: An application of catastrophe theory. *Psychological Review, 99* 395–417.

van Eijck, M., & Roth, W.-M. (2011). Cultural diversity in science education through novelization: Against the epicization of science and cultural centralization. *Journal of Research in Science Teaching, 48*, 824–847.

Vološinov, V. N. (1930). Marksizm i filosofija jasyka. Leningrad, Russia: Priboj. (Vološinov, V. N., *Marxism and the philosophy of language* (L. Mtejka & I. R. Titunik, Trans.). Cambridge, MA: Harvard University Press, 1973; and Bakhtine, M., *Le marxisme et la philosophie du langage: essai d'application de la méthode sociologique en linguistique* (M. Yaguello, Trans.). Paris, France: Les Éditions de Minuit, 1977).

Vygotskij, L. S. (2005). *Psixhologija razvitija čeloveka* [Psychology of human development]. Moscow, Russia: Eksmo.

Vygotsky, L. S. (1971). *The psychology of art*. Boston, MA: MIT Press. (First published in 1922.)

Vygotsky, L. S. (1997). The historical meaning of the crisis in psychology: A methodological investigation. In W. R. Rieber & J. Wollock (Eds.), *The collected work of L. S. Vygotsky vol. 6* (pp. 233–343). New York, NY: Kluwer Academic / Plenum Publishers. (First published in 1927.)

Waldenfels, B. (2006). *Grundmotive einer Phänomenologie des Fremden* [Founding motives of a phenomenology of the alien]. Frankfurt/M, Germany: Suhrkamp.

Wittgenstein, L. (1977). *Philosophical grammar* (A. Kenny, trans.). Oxford, UK: Basil Blackwell.

Wittgenstein, L. (1997). *Philosophische Untersuchungen / Philosophical investigations* (2nd ed.). Oxford, UK: Blackwell. (First published in 1953)

Wittgenstein, L. (2000). *Bergen text edition Ts-213: Big typescript*. Accessed April 4,

2012 at www.wittgensteinsource.org/tetxts/BTEn/Ts-213
Zuckerman, G. (2007). Child-adult interaction that creates a zone of proximal development. *Journal of Russian and East European Psychology, 45* (3), 43–69.

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