This book is about language in STEM research and about how it is thought about: as something that somehow refers to something else not directly accessible, often «meaning», «mental representations», or «conception». Using the analyses of real data and analyses of the way certain concepts are used in the scientific literature, such as “meaning,” this book reframes the discussion about «meanings», «mental representations», and «conceptions» consistent with the pragmatic approaches that we have become familiar with through the works of K. Marx, L. S. Vygotsky, M. M. Bakhtin, V. N. Volosinov, L. Wittgenstein, F. Mikhailov, R. Korty, 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from Plato through Kant and modern constructivism; this view of language, which already for Wittgenstein was an outdated view in the middle of the last century, continues to be alive today and dominating the way language is thought about and theorized.
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.

The purpose of this series is to encourage the publication of books that are close to the cutting edge of both fields. The series aims at becoming a leader in providing refreshing and bold new work—rather than out-of-date reproductions of past states of the art—shaping both fields more than reproducing them, thereby closing the traditional gap that exists between journal articles and books in terms of their salience about what is new. The series is intended not only to foster books concerned with knowing, learning, and teaching in school but also with doing and learning mathematics and science across the whole lifespan (e.g., science in kindergarten; mathematics at work); and it is to be a vehicle for publishing books that fall between the two domains—such as when scientists learn about graphs and graphing as part of their work.
On Meaning and Mental Representation

A Pragmatic Approach

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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. 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-

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1 The German word Bedeutung tends to be translated as meaning, and some scholars do translate the quoted passage substituting “meaning” for significations.
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 deconstruct2 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

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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 Phonetic Association that orients us toward the sound itself.

Victoria, BC
March 2013

(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 metaphorical approach from Plato through Kant and modern constructivism; this view of language, which already was an outdated 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 «meanings», «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 beleguer 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., «meanings») 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). 

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.

[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.

Based on shared understanding, members use joint intellectual efforts and resources to investigate and resolve issues, problems, or questions and to actu-

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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 + scière, 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 ethnmethodology 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). 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 “meanings” 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, practice 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 interaction and transaction 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 /ren/ 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 /ren/, 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 /ren/ 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

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1 This is a representation of the sound that we tend to hear as “rain” as per the conventions of the International Phonetic 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 /rən/, whereas the “ə” is to be sounded as the “ay” in pay, 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).

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

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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 «meanings» 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 «meanings», 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 «meanings» in his/her head or construct what «[personal] meaning» might be in my head when I say “Nice day today, a bit chilly though.”

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

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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] «meanings»—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. 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 [mysl]” and “значение [značenie]” as equivalents for the terms de Saussure uses (Vološinov 1930). The French translation of their book (Bakhtine [Volochnov] 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!” 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 «wants» to say we are already caught up in an infinite regress.
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. 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 societal 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.

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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.
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. 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.

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*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 have supposed 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 not is 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. 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 sympRactical10 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 transaction 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 «meanings», 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 «meanings», «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 «meanings» 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 «meanings» 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-
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 «meanings» 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, 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

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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.

\[
IF_{\text{Year X+1}} = \frac{\text{Number of citations Year X to journal issues Year (X-1) and Year (X-2)}}{\text{Number of articles Year (X-4) and Year (X-2)}}
\]
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. 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 PURPOSE; 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. psyche). 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 *mēnan*, 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 «meanings», 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 Saussuran 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 expressions/expressions to mark the same sense. (In this example, it is actually not a different «meanings».)

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 such 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; «meanings» 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 significance 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. 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 «meanings» from the (social) context in which it is used: “Hyper-specialization . . . 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».

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3 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”
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: 109)

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 «meanings» 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 «meanings» 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 you wanna 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 ehh
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).\footnote{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 conversation, we have to theorize the word or statement as belonging to both speaker and recipient.}

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 «meanings» 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-
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 negōtiāri, 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 soundword 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 [значения слов]). 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/attribute 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., meanings) 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 were to use the equal sign, even if not permitted, we still would find it intelligible. 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.

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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 begesture. 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.