4 «Meaning» and the subject

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

The role of dialogue and re/writing

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

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

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

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

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

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

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

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

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

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

A *materialist* social psychology

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Activities as (language) games

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

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

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

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

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

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

The corporeal material dimension of (societal) life

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

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

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

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

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

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

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

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

Cultural history of societal life and «concepts»

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

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

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

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

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

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

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

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

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

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

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

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

Texts, subjects, and audiences

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

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

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

Discourse and/on the subject

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

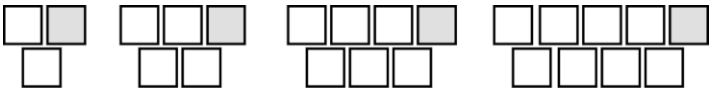
Lacan, signification, and the subject

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

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

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

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



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

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

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

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

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

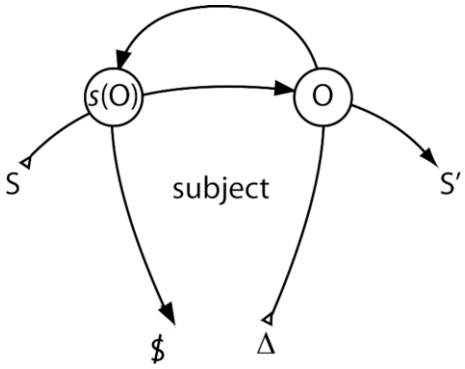


Figure 4.1 The origin and locus of the Lacanian subject.

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

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

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

Discourse, relationality, and subjectivity

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

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

Fragment 4.1

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

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

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

```
36 t: because um this one is round and this one is ap (0.48) isa
        square
37    (1.63) ((Thomas looks up to Mrs. W, as if looking for confirma-
        tion))
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The production of turn 30 can be justified after the fact, for the next turn sequence 30|32 produces what turns out to be the sought-after response. That this is the case can be found from the next turn pair 32|34. In the turn pair "feel different" | "what is different about those two edges," the different feel is accepted (at least temporarily) as a proper response and now the nature of this difference is asked about. That this is a question in this context is available from the next turn sequence 34|36, which has the structure (question|reply).

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

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

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

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

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

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

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

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

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

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

From subject to subjectification and personality

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

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

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

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

Babylonian transpositions: significations lost in translation

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Re/writing the subject: its ethical dimensions

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

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

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

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

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

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

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

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