A Cultural-Historical Perspective on Mathematics Teaching and Learning

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Eighty years ago, L. S. Vygotsky complained that psychology was misled in studying thought independent of emotion. This situation has not significantly changed, as most learning scientists continue to study cognition independent of emotion. In this book, the authors use cultural-historical activity theory as a perspective to investigate cognition, emotion, learning, and teaching in mathematics. Drawing on data from a longitudinal research program about the teaching and learning of algebra in elementary schools, Roth and Radford show (a) how emotions are reproduced and transformed in and through activity and (b) that in assessments of students about their progress in the activity, cognitive and emotional dimensions cannot be separated. Three features are salient in the analyses: (a) the irreducible connection between emotion and cognition mediates teacher-student interactions; (b) the zone of proximal development is itself a historical and cultural emergent product of joint teacher-students activity; and (c) as an outcome of joint activity, the object/motive of activity *emerges* as the real outcome of the learning activity. The authors use these results to propose (a) a different conceptualization of the zone of proximal development, (b) activity theory as an alternative to learning as individual/social construction, and (c) a way of understanding the material/ideal nature of objects in activity.

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A CULTURAL-HISTORICAL PERSPECTIVE ON MATHEMATICS TEACHING AND LEARNING

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Contents

Preface

Eighty years ago, L. S. Vygotsky complained that psychology was misled in studying thought independent of emotion. This situation has not significantly changed, as most learning scientists continue to study cognition independent of emotion. Situated in activity theory – as developed by A. N. Leont'ev and Klaus Holzkamp – we investigate in this book the mutually constitutive nature of cognition and emotion. Activity theory not only stipulates the relation between individual and culture in very different ways than any other theory, but also emphasizes the constitutive role of emotions in knowing and being.

To investigate the mutually constitutive nature of cognition and emotion we draw on data from our longitudinal research program about the teaching and learning of algebra in elementary schools. We show (a) how emotions are reproduced and transformed in and through activity and (b) that in assessments of students about their progress in the activity, cognitive and emotional dimensions cannot be separated. Second, our analysis exhibits three main features: (a) the irreducible connection between emotion and cognition mediates teacher-student interactions; (b) the zone of proximal development is itself a historical and cultural emergent product of joint teacher-students activity; and (c) as an outcome of joint activity, the object/motive of activity *emerges* as the real outcome of the learning activity. We use the results of this study to propose (a) a different conceptualization of the zone of proximal development, (b) activity theory as an alternative to learning as individual/social construction, and (c) a way of understanding the material/ideal nature of objects in activity. This leads us to outline a subject's participation in activity and its connection to all the other activities in which a subject engages in the course of its everyday life. We conclude with a proposal for a cultural-historical science of mathematical learning.

In contemporary research, intellect – thought, cognition – and affect tend to be different domains of study; the latter, at best, is thought of as a factor. An example of such thinking is the 'hot cognition' approach, which postulates that 'classroom contextual factors', 'motivational factors', and 'cognitive factors' influence learning and conceptual change from the outside. The problem with this line of theoriz-

ing is that factors remain external to the sensing subject, and 'being externalities …
are indifferent towards each other, and lack the necessity for one another that
ought to lie in the relation between an *outer* and an *inner*' (Hegel 1979: 236). This
situation has been discussed as problematic: The separation of intellect and affect
'as subjects of study is a major weakness of traditional psychology, since it makes
the thought process appear as an autonomous flow of "thoughts thinking them-
selves", segregated from the fullness of life, from the personal needs and interests,
the inclinations and impulses of the thinker' (Vygotsky 1986: 10). This segregation
is a problem because it does not allow us to understand the *immediate* – i.e., unme-
diated – influences that thought and affect have on each other. Segregating intellect
and affect closes the door on understanding *why* the learners do what they do be-
cause there is no directionality or propensity inherent in thought that would give it
a 'desire' to transform itself.

The lineage of research following Vygotsky has given rise to a different concep-
tion of the intellect-affect relation where the fullness of life, reality, is reflected
psychologically as a primary sensuousness, comprising both cognition and emotion
as irreducible, mutually constitutive moments. Understanding cognitive processes
in learning without separating them from the affective – i.e., making the affective
and the cognitive two manifestations of the same process – was a project pursued
and developed in the Leont'ev-Holzkamp lineage of cultural-historical activity
theory.[1] In contrast to the standard interpretation of activity theory, this line of
work focuses on (a) the subject of activity in relation to society and (b) conscious-
ness as a superordinate category to which cognition and emotion are subordinated.
Vygotsky had asked for 'unit analysis' of a 'dynamic system of meaning in which
the affective and the intellectual unite' (Vygotsky 1986: 10). An analysis of the
unit reveals that there is a 'transmuted affective attitude toward the bit of reality' to
which an idea refers.

In this book, we develop a conception of teaching and learning mathematics that
is very different from two available standard conceptions. On the one hand, there is
the Piagetian individual who *re*discovers through his/her own actions the rational-
ity of mathematics; on the other hand, there is the (deficient) individual as empty
vessel, who comes to be filled with the knowledge that culture makes available.
Newer conceptions combine the two but nevertheless substantialize the individual
and the collective (culture) and place them in an interactional relation. The purpose
of this book is to articulate the role of emotion in teaching-learning activity, where
it, as an index for the subjective valuation of the current state of the activity, is
both reproduced and transformed. Affect, as Vygotsky points out, is essential in an
understanding of knowing as a process that transforms itself. Similarly, we show
that the very object/motive that drives the learning activity is accessible to students

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[1] Much of this work is not available in English. But there exists a good introduction to Holzkamp's
theory (Tolman 1994) and an edited volume presents major contributors to this theory (Tolman and
Maiers 1991). The best-known member of this lineage publishing in English probably is Ole Dreier
(e.g., 2008). Mutual references in a number of works between K. Holzkamp (e.g., 1993) and J. Lave
(e.g., 1993) also suggests an affinity between the works of the two scholars.

only as an outcome of the activity, which, when it involves the teacher, also allows the zone of proximal development to emerge.

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1

Toward a Science of the Subject

> From the standpoint of the traditional bourgeois psychological approach to consciousness only what 'is found' in consciousness, or 'belongs' to it, is subject to study, i.e. separate psychological phenomena and processes and their mutual relations and connections. (Leontyev 1981: 223)[1]

In Western approaches to the mind, psychological processes, thinking, and consciousness have been generally conceived of as entities somehow lodged in an individual 'interior space'. This idea of an 'interior space' is not new. It was articulated by philosophers such as René Descartes and Gottfried Leibniz in the 17th and 18th centuries. To give but one example, let us note here that Leibniz contended that 'our ideas, even those of sensible things, come from within our soul' (Leibniz 1705/1949: 15). The contemporary concepts of the mind, thought, and consciousness as something individual are indeed elaborations of ideas that arose at the dawn of the Western modern period, right after the Renaissance. These were continued by later philosophers such as Giambattista Vico and Immanuel Kant. With more or less pronounced nuances, they have been translated into educational and psychological research. Within this context, tests and interviews serve the purpose of revealing to us what is going on *in* the students' heads. They are supposed to reveal what is found in *there*: thinking, psychological processes, self-appraisals, and even consciousness – hence, the exact kind of psychological approach to the mind that Leont'ev criticizes in the opening quote. Leont'ev found misleading in the individualistic approach the fact that it extracts consciousness, thinking, and psychological processes from the individual's mode of life and considers it abstractly. By referring to the individual's mode of life Leont'ev had in mind something that is much more than a collection of purely individual self-determining acts. His main point in fact was that our modes of life 'are built up in any set of sociocultural conditions' (Leontyev 1981: 224) so that rather than providing the external conditions for inner development they are consubstantial of the individual's modes of life.

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[1] The name of Alexei N. Leont'ev is spelled differently on different publications (speeled also Leontyev or Leontiev, in English, and Leontjew, in German). In the text, we use the dominant spelling 'Leont'ev', but we use the spelling from the book cover in references.

This is why Leont'ev argued that the study of the subject has to be broadened, and, in fact, that it has to be reconceptualized.

Many mathematics educators have pleaded for a new form of understanding the question of mathematical thinking and learning. There is a plea to attend to the social and cultural contexts in which students think and come to know. Some attempts have been made in order to conceive of the student as a member of her social group. Yet, often, the distinction between the individual and the collective tends to be maintained: the student's cognition and the social are kept apart (Radford and Roth 2010; Roth and Radford 2010). They remain two poles that can be explored from a psychological (that is, individual) perspective or a social one (Cobb and Yackel 1996). Apart from the problematic dualistic approach to the individual and the social, the question how the specifically cultural-historical nature that characterizes the knowledge of any era is not resolved. This approach, as Mikhail Bakhtin (1981) recognized for the study of literature, does not allow us to understand the historical evolution of writing genres, which cannot be explained if we look at the genres themselves but which requires the study of popular language itself *in the way it is realized in everyday practical activity*. Similarly, this approach does not allow us to understand the historical evolution of mathematical genres, a suitable understanding of it requiring the investigation of the historical-cultural context at large (Radford 1997). For Leont'ev – as well as other researchers working from a strictly cultural-historical activity theoretic perspective – individual development inherently means cultural development. This is why the relationship between the individual and the sociocultural cannot be investigated by means of a dualistic approach.

How does this development (both at the individual and the cultural level) occur? It is in the answer to this question that the specificity of Leont'ev's approach resides. To answer the question, Leont'ev draws on historical dialectical materialism. In so doing, he offers a new way in which to theorize the question of the subject (its consciousness, its psychic processes, its personality) in ways that are not dualistic in nature. Leont'ev's answer is this: development occurs in and through relations with others in the pursuit of collectively motivated *activity*. From this point of view, the psyche is a culturally and historically evolved form of reflection. Hence something that can exist through two *mutually constitutive* terms: an 'I' and an 'Ego' (a complex that includes subjects and the symbolic and material reality that surrounds them). Thus, we agree with Leont'ev when he says that 'any psychic reflection is the result of a real connection, of a real interaction of a living, highly organized, material subject and the material reality around him' (Leontyev 1981: 225). Psychic reflection, consciousness, mind, or abstract knowledge cannot exist or 'arise without the subject's activity. It cannot help depending on activity, cannot help being subordinated to the subject's life relations realized by activity' (ibid.: 225). These statements and the implications that unfold from them constitute the fundamental ideas that we articulate in this book.

Cultural-historical activity theory has become an important lens for learning scientists to conceptualize phenomena of their interest.[2] As the name of the theory suggests, *activity* is the central organizing category in activity theory. It is defined as 'the nonadditive, molar unit of life for the material, corporeal subject. In a narrower sense (i.e., on the psychological level) it is the unit of life that is mediated by mental reflection. The real function of this unit is to orient the subject in the world of objects' (Leont'ev 1981: 46). Activity, therefore, is thought as a 'system with its own structure, its own internal transformations, and its own development' (ibid.: 46). It is something real that we observe, not something that we make up and hypothesize in our minds.

The concept of *activity* is difficult to write and think about in English in part because it conflates two concepts that are distinct in the languages in which the theory was originally conceived. Thus, throughout this book, we use the English term in the sense of the German/Russian term *Tätigkeit/deyatel'nost'*, a system that contributes to satisfying collective needs as part of the division of labor in society, rather than in the sense of *Aktivität/ aktivnost'*, being busy with something (Roth and Lee 2007).[3] This definition has important consequences for the way in which the relation between individual and society, individual and collective consciousness, and individual and collective cognition and emotion are understood and theorized. One lineage of activity theory, which has made it from its Soviet origins to the West via the work of Yrjö Engeström (1987), emphasizes structural-systemic (static) dimensions of activity. These structural dimensions are made salient in drawings of 'mediational' triangles. Although interesting, here we do not pursue this line of work. It appears to us that its emphasis on the systemic and structural elements that organize activity limits the understanding of *inter*subjective processes and the subject's perspective on activity.[4] The Leont'ev–Holzkamp lineage that we continue here in this book emphasizes the subject and (individual, collective) *consciousness*, that is, it theorizes persons within the structures of societal practice. In the following we articulate – at greater length because it is less known – the activity theory of the Vygotsky–Leont'ev–Holzkamp lineage.

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[2] See, for example, Bartolini Bussi and Mariotti 2008, Jaworski and Potari 2009, Matos 2010, or Williams 2009.

[3] We ground our reading in the German versions of Leont'ev and Marx, which does the original more justice than the English translation. For example, the Russian and German versions distinguish between two very different nouns, *Tätigkeit* (*deyatel'nost'* [деятельность]) and *Aktivität* (*activnost'* [активность]), both of which are rendered in English as 'activity'. The Russian and German versions distinguish phenomena that are societal (*gesellschaftlich, obshchestvennoĭ* [общественной]) from those that are social (*sozial, sozial'n* [социальн]), but the English version renders both as 'social'. In English, we find the word 'meaning' that translates *znachenie* (значение)/*Bedeutung* even though the Russian/German equivalents refer to an objective phenomenon at the cultural-historical level – something that is neither culturally transcendent (as the Kantian *things-in-themselves*) nor reducible to the personal sense (*Sinn, smisl* [смысл]) that students produce as they engage in classroom activity. Our specific word choices have been made such as to promote the very different reading of Leont'ev's work that the German version allows.

[4] For critical reviews of the strengths and weaknesses of the theory see Roth and Lee 2007; Roth et al. 2009.

Activity

All contemporary cultural-historical theories that include the category of *activity* ground themselves in Marx and Engels and their conceptualization of what makes humans different from other forms of life. Although every historical analysis of present-day culture must take into account biology and the natural conditions that provided the context for anthropogenesis, Marx and Engels focus their attention on the origin of the distinction between what will become humans and other animate forms. The dividing line is a particular form of joint activity: food productive activity. Humans begin to distinguish themselves 'as soon as they begin to *produce* their food, a step that is conditioned by their corporeal organization' (Marx/Engels 1958: 21). But this joint activity that individuals make possible also produces material life: 'By producing their food, humans indirectly produce material life itself' (ibid.: 21). That is, human beings no longer are subject to their life conditions but they transform these conditions and therefore transform life itself. The production constitutes 'a specific kind of activity of individuals, a specific way to exteriorize life, a *life form* specific to them' (ibid.: 21). This form of life not only is reproduced and transformed in activity but also shapes who and what individuals are: 'Individuals are in the way they externalize life. What they are falls together with production both with *what* they produce and *how* they produce it' (ibid.: 21). The nature of the individual, which is the topic of psychology, therefore is a function of the material production of and for life.

Activity, as a category in psychology, has been introduced and presented to psychology as one of three main concepts in a book originally entitled *Deyatel'nost', Sosnanie, Ličnost'* and translated into English as *Activity, Consciousness, Personality*. The book conceives of activity as 'a process, which contains those inner moving contradictions, differentiations, and transformations that produce the psychic, which is a necessary moment of the proper motion of activity in its development' (Leontjew 1982: 17–18).[5] It was intended to 'introduce to psychology those analytic units that carry within them the psychic reflection in its inseparability from those moments of human activity that produce and mediate it [psychic reflection]' (ibid.: 18). That is, activity is a *process*. This process contains inner contradictions, differentiations, and transformations that *produce the psychic* aspects of everyday life. These psychic aspects are a *necessary* moment of activity and responsible for the *development* thereof. Moreover, psychic reflection is *in-*

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[5] The noun *moment* in dialectical materialism generally and in cultural-historical activity theory specifically refers to an identifiable structure – e.g., tool, subject, rule – that cannot be understood independently of the consideration of the whole. A moment therefore is not an element, because different elements can be assembled to produce an atom. Two moments are interdependent because both are *manifestations* of the whole; they cannot be added up because they do not constitute independent quantities. Even the website of the Finnish Center for Activity Theory contains this error, referring to the *moments of activity* – i.e., subject, object/motive, tools, division of labor, community, and rules – as 'elements'. Vygotsky (1986) adamantly rejects analysis in terms of 'elements' and asks for 'unit analysis'. In cultural-historical activity theory, *activity* is this minimal unit.

separable from real, practical activity that both produces and mediates the production of psychic reality in the human being.

The concept of 'psychic reflection' frequently is related to the idea that underlying cultural-historical activity theory is a mirror conception of the conscious mind. Nothing could be farther from the truth. In fact, Leont'ev rejects the mirror view and points out – thereby actually coming very close to the mirror neuron research of modern neurosciences – that every afferent activity (from sensory surfaces to the central nervous system) during perception is accompanied by efferent activity (from central nervous system to the sensory surfaces); and inversely, every efferent activity is associated with afferent activity. That is, during concrete activity – whether of a material or an ideal (mental) kind – the inner and outer worlds are intimately connected and irreducible to each other. They are but manifestations of activity that sublates – does away with and keeps – the distinction.

Leont'ev's category of activity poses tremendous problems for traditional psychology.[6] This is so because Leont'ev's category of activity and the related category of consciousness aim at allowing an understanding of the 'real *transitions* that connect the psychic of the concrete individual with societal consciousness and its forms' (Leontjew 1982: 18). Societal consciousness is that which presents itself in the form of ideologies (understood as the various contrasting, conflicting implicit and explicit systems of ideas). Leont'ev agrees with other scholars, including Bakhtin, that ideologies shape the individual's consciousness of real life and social relations, without of course determining it in any causal sense.

Activity is a process in a system of relations that realizes the societal nature of human beings – it is the locus where 'the subject and the social world are connected in such a way that both are re-produced and changed' (Dreier 2008: 22). Activity therefore is a unit that cannot be reduced to inner (cognitive) or outer (material) processes. Thus, 'the production of ideas, representations, of consciousness is first immediately tied to the material activity and material intercourse of people, language of real life. . . . Consciousness cannot ever be anything other than conscious being, and the Being of humans is the real life process' (Marx/Engels 1958: 26).[7] It is not consciousness and (constructivist) thought that has given rise to human life but, rather, communal human life has given rise to consciousness and thought.

There are then two major dimensions of activity theory: (a) Human activity has instrumental (tool) structure in the satisfaction of primary and secondary needs and (b) activity is implicated in the mutual relations with other human beings. Activity mediates not only the relation with the natural world but also the relation with other human beings. There is an in-principle oneness of outer and inner activities that constitute the mediating processes relations of humans and their world. 'It is

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[6] Cultural-historical activity theorists reject all forms of psychologism and subjectivism – including those typical of constructivism – that place the 'fundamental value . . . at the head' (Bakhtin 1993: 60). Both 'subjectivism and psychologism are direct correlatives of objectivism' (ibid.: 29).

[7] Marx/Engels draw on the opportunity of the German language to write a powerful aphorism. That is, the word for 'consciousness', *Bewußtsein*, is composed of the same words as 'conscious Being', *bewußtes Sein*.

not consciousness that determines life', write Marx/Engels, 'but life determines consciousness' (ibid.: 27).

Leont'ev takes up these ideas in his psychology of the human being. He suggests activity to be the smallest unit that allows us to understand thought, consciousness, emotions, personality, subjectivity, and so on. He concludes that 'the activity of the individual human being constitutes a system integrated into the system of societal relations. Outside of these relations there is no human activity' (Leontjew 1982: 84). Activity theory therefore constitutes a systemic-analytic approach to individual thinking and consciousness. The concrete sensual nature of *symractical* (i.e., joint practical) activity not only is the source of the concrete nature of inner reflections of activity in consciousness but also the source of the concrete nature of needs, emotions, and feelings. It is precisely for this reason that 'any higher psychological function was external; this means that it was social; before becoming a function, it was the social relation between two people' (Vygotsky 1989: 56). In and with the category of activity, we therefore no longer have the divide between the two realms that Vygotsky complains about. Rather, the two are but different, irreducible moments within the same phenomenon: both are inner reflections of concrete human symractical motive-oriented activity.

Levels of Activity

For Leont'ev the chief difference in activities is to be found in the difference of their objects or motives. An object/motive (fishing, for instance) is what endows the activity with a particular *intent*. But activities involve also actions and specific contextual methods and means to carry out these operations. Actions become subordinated to *goals*, which of course are related to the object/motive but are not equal to it. 'The actions that realize activity are initiated by its motive but are directed toward the goal' (Leont'ev 1982: 103). Thus, to continue with the example of fishing, the actions of an individual may be directed to preparing the equipment for fishing; the actions of another individual may be directed to finding the bait. The goals are different, yet they are related to the same object/motive (fishing). There is still another aspect of activity that needs to be emphasized: the concrete basic constituents that make it possible to carry out the actions – something that Leont'ev calls *operations*.

This view of human activity rests hence on three interrelated levels: (a) the level of object/motive of activity, (b) the level of goals/actions, and (c) the level of operations. At each level there is a coupling of elements that accounts for a non-dissociable relationship between the subject and the activity in which it participates: activity is related to objects/motives, as actions are related to goals, as operations are related to conditions. We hence see that the first level connects activity to collective motives, which impart the activity with a certain conscious, collective teleology or end. At the second level we find actions that are oriented to realize conscious goals. At the third level we find operations that are stimulated by the

current conditions. The levels are mutually constitutive. Thus, activities are concretely realized by goal-directed actions, but goals are formed, and actions initiated only because there already is a motive and activity. That is, the sense of an action can be determined only from its relationship to the activity such that the same action may have a very different sense when the activity is changed (e.g., Roth et al. 2004). The same action therefore has a different sense when it is produced in another activity system: Taking a ball in one's hand and throwing it toward the goal is what hand-ball players are expected to do but the same action is punishable in the context of soccer. In the absence of an object/motive, an action does not make or have a determinate sense.[8] The category of object/motive therefore highlights a reflexive moment of activity, where the consciousness of the subject reflects both the outer, material productive work and the development of the psychological, inner consciousness. It emerges in the course of development:

> The object that is able to satisfy a need [initially] is not outlined sharply in the need state of the subject. Ahead of its first satisfaction, the need does not 'know' its object, it has to be discovered first. Only through the discovery is the need rendered objective and the perceived (imagined, thought) object obtains its stimulating and activity-orienting function, that is, it becomes the motive. (Leontjew 1982: 181–182)

Actions and operations, too, stand in a mutually constitutive relation. Actions are realized through the enchainment of unconscious operations, but the operations are called forth by the goal-directed actions.

The structural approach to activity – with the pervasive triangles some scholars tend to draw – fails to capture one of the fundamental ideas of Marxian thought: the purpose of a theory of human activity must be to understand and capture the *dynamic* of life, not its structures. Just as grammar does not capture the dynamic aspect of a living language, which implies that it changes, the structure of activity theory as it is often employed neither represent nor allow us to understand why cultural historical activities continuously change. First Georg Hegel and then Karl Marx realized that to model change and movement, we have to have a fundamental unit that is itself change. Unfortunately, in the Western ways of theorizing, learning is defined as transition. Although this idea of transition evokes change and time, in the end it is a change from knowledge stage/structure at time t_1 to knowledge stage/structure at another time t_2. Most assessment approaches are based on the idea that knowledge can be assessed at some point in time so that the question whether learning has occurred can be assessed as the difference between the two assessments. The point of cultural-historical activity theory is different. Here, change is the fundamental unit, which means that this unit contains an internal *contradiction* (understood in a dialectical sense). It is *difference in itself* rather than difference *between* two identifiable states, one of which is transformed into the

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[8] In the terminology of cultural-historical activity theory, 'the object is the true motive of activity' (Leontjew 1982: 102). We therefore denote the pole of activity opposite to the subject, which provides activity with its collectively defined orienting moment, as 'object/motive'.

other.[9] This is precisely why some scholars suggest that learning is the problem in the structural approach, whereas in the activity theoretic approach, '"knowledge" becomes a complex and problematic concept' (Lave 1993: 12). In real living labor, the inner contradiction exists between the current state of affairs and the anticipated future state, the anticipated product toward which the activity is moving, realized by means of the concrete actions that the subjects of the activity produce.

In summary, therefore, we are not interested in investigating an ideal conception of activity; we are not interested in activity *in the abstract*. Rather, we are interested in investigating real, living human activity as it presents itself. When we look at any human action, it always already realizes some form of activity. Understanding this activity is our job and business. This activity is flux itself; something is *happening*; we do not see something static, which, following some event, changes into something else. But rather, we are confronted with continuous flux. Cultural-historical activity theory is an attempt to understand and describe this flux *as flux*, not as a transition between two static states. If we were to attempt the latter, then we would have no mechanism *internal* to our phenomenon and we would have to explain *why* things are in flux, why change is occurring. This would require us to introduce an external force – akin to the motor of a movie projector that brings the contents of the reel 'to life'. Our task is precisely the other way around: Everything around us is changing, including the language we use, culture, thought, even if we are not thinking about it. There is an inner force to life itself that makes living things change. Therefore, if there were anything that requires an explanation, then it would be the presence of static structures.

Vygotsky wants to understand thought *process*, not as something autonomous, 'segregated from the fullness of life, from the personal needs and interests, the inclinations and impulses of the thinker' (Vygotsky 1986: 10). He suggests that this requires a special form of analysis, *unit analysis*, which is capable of capturing a *dynamic system*. The attempt is to have a theory where the change process is *inherent* rather than imposed from the outside, a theory where change, development, and learning are the norm. For Vygotsky, therefore, thought, language, and the relation between these two processes are *the result of* developmental processes; that is, process is the beginning of this way of theorizing.

Activity changes activity – as a whole and in any of its irreducible parts. Irreducible here is the same as saying that if one part is taken away, then there is a different activity altogether. But as an integral part of activity, any part changes with the activity and all the relations change as well. A simple analogy may help. As a river flows, not only its bed changes but also any neighboring parts of the river: it is in constant change, changing itself in the very instant of its Being. Vygotsky conceives of the integral unity that ties together thought and language in the

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[9] Within classical Western forms of thought, thinking *difference in and for itself* is difficult because it no longer allows us to make the logical statement '$p = p$'. Difference in and for itself cannot be modeled by the difference between p and $\neg p$, because both p and $\neg p$ are self-identical, whereas *difference in and for itself* constitutes the non-self-identity of a thing with itself. In a strict sense, this idea of difference would have to be written as '$p \neq p$', which goes against all classical logic though it is consitent with dialectical logic. We elaborate this idea further in the section entitled 'Contradictions'.

same way. Not only are thought and language processes that mutually affect each other but also their relation, itself a process, changes. Activity through and through is process, from the global dimension of the unit as a whole to its tiniest identifiable but inseparable moment. Like a river, activity *is* a flux and *is in* flux at the same time. It is in flux even if we may not notice it. Thus, we could show that even the most boring task in a fish hatchery – using a scoop to throw 200 kg of feed into a pond to nourish the salmon smolt in it – changes the person doing the job both physically and mentally (s/he has a better understanding of the task), changes the fish, changes the stock of feed, and so on (Lee and Roth 2006). This becomes an important aspect of our analyses in the later chapters of this book, as it means that we may not assume either that a student is a constant aspect or that learning is only occurring when we somehow 'measure' it using a test. This is so because material processes constantly occur, entailing real changes in the world. Thus, chemical energy is consumed as a student sits, writes, talks, or simply is; material resources such as graphite and ink are used as students use their pens and pencils. As students' bodies change, their physiological, structural, muscular, hormonal make-ups, and so on change, as do their momentary emotive states. Finally, the awareness of getting or not getting closer to the end results, some material product, finds its reflection in the changing emotional state of the individual subjects.

The Material Plane: A Subject Perspective on Human Activity

As note above, we do not follow here the approach to cultural-historical activity theory that emphasizes its identifiable components ('elements'). We rather focus on the subject of activity and its relation to object/motive of activity and the way in which it realizes collective intersubjective consciousness in a concrete way monitored by and reflected in emotion. However, the reader must not think of the subject or object/motive as separate from the activity. Who the relevant subject is and what its object/motives are can only be determined in the concrete analysis of concrete, real-life instants of human activity, that is, living praxis of people at work. Our purpose, therefore, is to bring to the fore real life and real praxis, in the way humans live, feel, and experience it.[10]

Subject

In our elaboration and expansion of the Vygotsky-Leont'ev-Holzkamp line of cultural-historical activity theory we are mainly concerned with understanding cogni-

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[10] On the difference between living/lived mathematical work and verbal accounts of mathematical work and on the related difference between ethnomethodological and other forms of research see Roth 2009c, 2011b.

tion generally and teaching-learning particularly *as they occur in real life*. This life can be comprehended only concretely, in the form of what *is* rather than what *ought* to be. The world that makes this life is unitary, unique, and experienced concretely: 'it is a world that is seen, heard, touched, and thought, a world permeated in its entirety with the emotional volitional tones of the affirmed validity of values' (Bakhtin 1993: 56). Here, the role of the individual subject and what is apparent to it in consciousness in sympractical activity is of primordial importance. What is apparent to the subject is important because this constitutes the condition of its decision-making and its being rather than what theorists might see in the situation. 'This work is given to me, from my unique place in Being, as a world that is concrete and unique. For my participative, act-performing consciousness, this world, as an architectonic whole, is arranged around me as around that sole center from which my deed issues or comes forth' (ibid.: 57). The approach to activity from the position of the individual subject, however, is not the same as the one chosen in psychological and subjectivist approaches. Thus, 'subjectivity at the level of the sensual reflection must not be understood as its subjectivism but rather as its subjectivity that belongs to an active subject' (Leontjew 1982: 59).

In cultural-historical activity theory, the subjects of activity are not the Piagetian/constructivist individuals that make discoveries and construct knowledge on their own; subjects are subjects of *collective* activity. In the course of participating in cultural-historically formed relations with others, individuals become cultural-historical beings through unending processes of *subjectification* (Radford 2008a), that is to say, processes of *be*coming through cognitive, emotional, ethical, political reflexive and critical differentiations, and identifications. Of paramount importance in the making of the subject – in the formation of this unique in-flux subject that is continuously *be*coming – are those cultural-historical significations it engages in and in which it finds itself immersed. Cultural-historical significations are those generalized forms in which the individual appropriates the generalized and reflected/refracted human experience (Leontjew 1982). For example, when Aurélie – a fourth-grade student to whom we shall come back later – says 'I don't understand. And I will never understand' (turn 029), she is describing a subjective experience that is nonetheless articulated in a form that is consonant with and understandable to others. Such a description is possible within her culture, and is understood by other members of the culture. It therefore is not really simply describing the experience of an individual; her description is not subjective. It is a generalized form of experience that Aurélie opts for and articulates here. She thereby subsumes her singular experience in a generalized expression. It is important to note in this respect that this expression embraces an inner contradiction in that a *generalized* expression also is a *particular* expression, both describing and not describing the real lived experience of a student at the instance. Similarly, if we point with the index finger and say, 'This is a pine tree', then there is an inner contradiction, because we use the name of a general concept – we can point to many entities PINE TREE and our utterance is true – and use it for a particular entity. The same applies to mathematical expressions such as 'This is a circle'. Expressions such as the one Aurélie uses to describe her personal sense have come to her from

culture, which, as language, changes in time. Each expression therefore is cultural and historical simultaneously, so that the way in which we express ourselves, and our personal sense inherently is cultural-historical. Students and teachers in different times and cultures will articulate their experiences in different ways. Their subjectivities, therefore, also are different and entirely mediated by their culture and its historical condition at the instant that is analyzed. Thus, it was only after some time – *Le Petit Robert*, a standard French dictionary suggests 1952 – that French people began using the adjective 'cool' for people and things. Thus, prior to that people would not describe others – or feel and describe themselves – as 'cool'. That is, the way in which reality is reflected for us is a function of culture and time and the *inherently shared* resources that culture makes available to articulate oneself. Thus, 'it is not so much that the expression adapts itself to our internal world but that our internal world adapts itself to possibilities of our expression, to its possible ways and orientations' (Bakhtine [Volochinov] 1977: 130).

The difference between (culturally relative) objective, collective significations and individual sense is captured in the relation of the universal (general) to the particular rather than in the contrast between the logical and psychological. *Individual sense* therefore is a concrete realization of *collective signification*, which, as a general (universal), exists only in and through all concrete realizations and the possibilities that these enable. It is only in and through collective cultural significations that the world can become an object of individual consciousness, itself enabled by those significations. Significations are mediated by language, which constitutes a practical consciousness for others and constitutes one of the main contents of collective consciousness. As such, linguistic signification 'becomes the "real consciousness" of individuals, objectifying in itself the subjective sense of the thing reflected for them' (Leontyev 1981: 226). Signification is the generalization of a collective experience of reality, crystallized and fixed in the sensuous semiotic vehicles used as part of communication. That is, 'signification does not lie in the word or in the mind of the speaker or in the mind of the interlocutor. Signification is the effect of *the interaction of speaker and receiver, which imposes itself on the material of a sonorous complex*' (Bakhtine [Volochinov] 1977: 146–147, original emphasis).

Language is the vehicle of consciousness. In fact, 'language is a practical consciousness-for-others and, consequently, consciousness-for-myself' (Vygotsky 1986: 256). All consciousness therefore is connected to language generally and words particularly. In practical use, in any instant that we may analyze videotapes recorded in and as (classroom) interaction, words constitute aspects of consciousness. As such, 'the word is a thing in our consciousness . . . that is absolutely impossible for one person, but that becomes a reality for two' (ibid.: 256). In any concrete analysis, we must not take the word as a property or the reflection of the inner life of the person uttering it. This is so because 'the word addresses itself to an interlocutor; it is a function of the person of this interlocutor' (Bakhtine [Volochinov] 1977: 123). The word therefore will not be the same when the interlocutor is of a different social group, when 'he is inferior or superior in the social hierarchy, according to the more or less tight social links that he might have with the

speaker (father, brother, husband, etc.)' (ibid.: 123). When we look at any actual exchange, therefore, we *must not attribute it solely to the speaker*. In the following exchange, when Mario utters 'Tresa, you're on camera', it is not just his inner self, his subjectivity that is expressed in the utterance. Because it is addressed to Thérèse, the function of the utterance is irreducibly a function of the social interaction.

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025  M   <<p>tresa, you=re on camera; >
026      (1.19)
027  T   <<len>i=know, i=m not writing anything. >
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Moreover, the understanding of the utterance *in this situation* is to be taken from the response, which is an expression of the situation that Thérèse makes available to Mario and all other members to the setting and anyone overhearing, such as those who watch the video camera that is recording the lesson (Roth 2009c, 2011b).

The subjective reflection of objective reality can be understood only as the product of those relations and mediations that emerge and form in the course of human history; any subjective reflection is but a concrete realization of a culturally possible reflection. Every higher order cognitive function and structure is therefore the result of interactions – which we understand here to be interaction rituals (Collins 2004) – with others; every one of these functions and structures is the result and reflection of outer, material, sympractical activity. Thus, inner, ideal activity cannot be separated from outer, material activity; the two are mutually constitutive processes. 'Outside of these relations (and outside the societal consciousness), the existence of an individual psyche – in the form of conscious reflection, in the form of conscious processes – is impossible' (Leontjew 1982: 127–128). 'Meanings', in the (radical, social) constructivist tradition, are the psychological product of individual constructions, a 'product of the association and generalization of impressions in the consciousness of the individual subject, the results of which are attached to words' (ibid.: 123).[11] This contrasts the cultural-historical activity theoretic perspective, where concepts are the result of the objectification (i.e., the process of becoming active and critically conscious) of historically achieved significations ('meanings'). In individual development (ontogenesis) critical reflexive processes of objectification occur as part of the child's activity in communication with others in its surroundings. Objectification is not a simple appropriation of

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[11] After having established a referential theory of language, Wittgenstein spent the remainder of his life dismantling this perspective. Categories such as 'meaning' belong to a referential theory of mind. The author therefore is quite explicit in rejecting the category as one useful in understanding language and mind. Thus, he suggests that the 'philosophical concept of meaning has its place in a primitive idea of the way language functions. But one can also say that it is the idea of a language more primitive than ours' (Wittgenstein 1958: 3). Pragmatist philosophers tend to abandon the term 'meaning'. Thus, 'I urged at the end of the entry on IDEAS that there is no place in science for ideas, and under KNOWLEDGE that there is no place in the theory of knowledge for knowledge. Now we find me urging that there is no place in the theory of meaning for meaning' (Quine 1987: 131). Richard Rorty and Donald Davidson are other philosophers who do not have use for the category 'meaning', for in their approach, there is no difference between learning language and finding one's way around the world.

significations. The coming in contact with historical significations renews and transforms these historical significations. Without this renewal, cultures would be static and lifeless. The significations are *integral* to and characteristic of sensuous sympractical activity rather than entities attached to words that are owned by individuals. Or, to state it in yet another way, by reflecting the concrete life of individuals words *accrue to* always already existing, cultural-historically formed significations in and through sensuous practical activity.

Linguistic significations ('meanings') are idealizations of real, concrete relations in the world; in communication, these significations structure and become integrated into individual consciousness. That is, in individual consciousness societally achieved significations obtain a second life. The difference between the collective significations and those of the individual is captured in the differentiation of (collective) signification and 'personal sense'. The difference between the two may be given in the example of school grades, which have a particular, objective function in the activity system of schooling, the signification of which is understood by all students. But, for the individual student, a grade may constitute the possibility or obstacle to entering a career whereas for another, it may be a form of an ego-boost. Individual signification (personal sense) and objective, collective signification cannot be studied independently, for the latter depend on the concrete realization through the former, and the former are enabled by the possibilities inherent in the latter. Thus, individual significations are inherently societal-historical and culturally objective in nature. They refract the political, ethical, economical, social and cultural variants, conflicts, and oppositions of the world we live in. In concrete sympractical activity, individual significations return to the sensual objectivity of the multifarious world and its contrasting and often incommensurate ideologies.

Object/Motive and Motivation

Practical (material) activity is oriented to transform existing materials into some outcome. The difference between the current state of affairs and the anticipated outcome is reflected psychologically in consciousness as the motive of activity. Leont'ev refers to Marx/Engels in his definition of the object[12]: *The object of activity is its true motive*. As mentioned previously, motive is related to activity as goal is to action. The motive of activity is concretized as the transformation of existing materials into an outcome (product). This is referred to as the dual appearance of the object, in the material world and in consciousness (Leontjew 1982). The two aspects of activity, its inner and outer form, constitute a *single* unit. This unit, ac-

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[12] The trouble arises to a large extent because English does not distinguish between material object (Ger. *Objekt,* Rus. *objekta* [объекта]) and an object that can have both ideal and material nature (Ger. *Gegenstand*, Rus. *predmet* [предмет]). Thus, in instances where Leont'ev uses both words – *objekta* and *predmet* – the English translation simply drops one, whereas the German translation retains both.

tivity, *is irreducible in principle*. This is so because when we look at and analyze any concrete activity, humans are involved in transforming something into something else. They do so *in order to* achieve something, and this *in-order-to* is as much an aspect of concrete reality as the *for-the-purpose-of,* the *what-with,* the *who/what-for*, and the *for-the-sake-of-which* that characterize everyday circumspect attention to the world as it offers itself to the subject of mundane activity (Heidegger 1977). The motive concretizes the *orientation* of activity toward its specific outcome. In standard psychology, objective significations ('meanings') are concretized in a personal sense, whereas for Leont'ev, sense concretizes itself in significations. Personal senses and cultural signification have different origins, are differently grounded, and follow different laws. Sense is produced in and through life, not by significations. Sense, because it is a relation of the person to the world, can be fostered in its emergence but it cannot be taught (told).

There is some inconsistency in the literature with respect to the use of 'object'. For some, the term only designates the material, object-sensory aspect of practical activity, distinguishing it from the 'ideal object', which is the object reflected in consciousness during activity (e.g., Davydov 1990). Others use the term 'motive of activity' to denote its ideal dimension, its 'inner' reflection, thereby bringing into play the motive forces that underlie the continuous change of activity. These motive forces are the results of inner contradictions – or, expressed in other words, because the category of activity theorizes living, inherently transformative processes, there are inner contradictions that also describe the transformative forces. Therefore, activity, the unit (of analysis) that comprises current materials and future anticipated outcomes, contains inherent contradictions of two kinds: between the material reality and its ideal reflection in consciousness and between current and future material/ideal states. As a way of avoiding the reduction to the material or ideal dimensions of activity, we use another way of denoting this category sometimes used in the literature: 'object/motive'.

Object/motives reflect collective interest, the interests of the collective, and therefore are general. They reflect generalized needs satisfied in and through the network of collective activities. '"Motivation" comes about as the emotional regulative of "autarchic" learning by exploration and is the orientation of activity via learned anticipation of a situation with higher (compared to the present) emotional value to be reached by means of activity' (Holzkamp 1983: 298). Thus, motivation is not a separate analytic category; rather, it constitutes the emotional dimension of the difference between present and future orientation in activity. The motivated nature of an activity does not depend on the anticipation of concrete results but on the subject's enhanced (material, cognitive, spiritual, etc.) quality of life that can be achieved by means of the activity. The motivated nature of activity is the result of considerations that concern the totality of action-embedding connections (significations) from the perspective of the individual; in this sense, it constitutes the '*"emotional aspect" of thought*' (ibid.: 299). Motivation is the '*emotional-anticipatory aspect* of the *real action planning and execution*' (ibid.: 300). Together with the higher emotional valuation of the anticipated quality of life at the

end of the activity, the agential subject also has to anticipate the emotional value of the way by which the activity is realized, that is, future effort and risk.

The question therefore is not whether or not a student is 'motivated' to engage in and complete the mathematical task that the teacher posits for the day. The real question is which activity students engage in, and, therefore, which object/motives they take up and pursue. Thus, a student who orients toward getting good grades does not actually have to take up the object/motive of knowing algebra some point down the road. Grades may be achieved by other means as well, including copying homework and copying from others or from notes during an exam. Leont'ev provides a compelling description of the role that the object/motive plays in the orienting activity and, thereby, in bringing about particular kinds of actions.

In the pioneer palace of Kharkov, organizers offered a workshop on building model airplanes.[13] Although the children were very interested in building the models, very few actually showed interest in understanding the theoretical aspects of flying that are relevant in a *conscious* construction of the planes. There were posters and knowledgeable adults, but the children were only oriented toward building beautiful models, leaving aside any considerations of what makes a plane fly or why the wings might be in a particular orientation. The psychologists were interested in organizing the task such that the students, on their own, would see the advantage in accessing theoretical information for advancing their own interests. This was achieved by framing the task as one of building model airplanes that were capable of flying a given distance. The students took up this new object/motive just as they had the earlier one. But as soon as they tried their models, they found out that the models they had built did not cover the desired distance. At that point, to expand their possibilities for redesigning the model planes, they did indeed read the available posters and books or asked available personnel. That is, the children engaged in learning loops not because the adults had told them to do so but because they anticipated an expansion of their own room to maneuver toward the ultimate object/motive they had taken up – building a plane that would fly the given distance. In addition to the significant increase in attending to theoretical issues from a few minutes to nearly half an hour, the total number of children signing up for the workshop also increased from an average of about 6 or 7 to an average of over 40 children per day.

In concrete activity, the ultimate outcome aimed at does not yet exist. It can therefore regulate activity only when it presents itself to the subject as an image that makes it possible to compare the current state with its starting materials and its intermediate forms: 'The psychic reflection of the target product has to exist for the subject in such a form that it can *work* with this image, can modify it under the existing conditions' (Leontjew 1982: 123). Consciousness, too, is the subjective product, the transformed appearance of the societal relations that are realized through human activity in an objective material world. This has consequences for

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[13] Leont'ev writes about these experiments in an appended chapter 7 that follows his concluding chapter 6. This appended chapter, entitled 'Psychological Questions of the Consciousness of the Learning Process' (Leontjew 1982), though referenced very infrequently in the literature, actually contains a lot of material that ought to be of interest to educators.

theorizing learning activity, where learners, because of the very nature of the activity, cannot know the object/motive: The object/motive itself has to be the outcome of the learning activity so that others – e.g., teachers – have to take on the regulative function that in other productive human activities exist in the known object/motive.

This aspect of the object/motive places particular constraints on what we can expect to happen in mathematics classrooms. Leont'ev suggests that the target product has to 'exist for the subject in a form that it can *work* with this image'. Now, when we expect a student to learn algebra, which they do not yet know, what image can we expect the student to have? When a student is to solve some novel problem, what is the concrete image that the student can have of the outcome – which s/he does not yet know because knowing it is precisely the reason for the curriculum – that exists in a way so that s/he 'can *work* with this image'? This precisely is a contradiction in learning activity. The present book is an opportunity for us to articulate the contradiction and how it is resolved in practice. In anticipation of chapter 4, we suggest that an integral part of the learning activity is for students to recognize the object/motive in their own actions. That is, the object/motive *emerges* in the course of, and therefore also is the *product* of, the activity. Because students cannot recognize this on their own, there is a central role for the teacher in the function as the representative of the current cultural-historical conditions. But it will not be that the teacher can *tell* students what the object/motive is of *their* activity; rather, it is through joint actions with the teacher and other students that the object/motive of the current activity emerges for any particular student from his/her actions.

The Ideal Plane: Reflecting Concrete Reality

The fundamental difference between activity theory and other contemporary theories consists in the way human thought is theorized. Thought is considered as a cultural and historical evolved form of reflection, that, although it always remains enmeshed in sensation and perception, goes beyond the sensed and the perceived. Signs in general and language in particular endow the particular with general attributes that overcome the 'here' and 'now', that is to say, the limits of local spatial-temporal experience. Thus, 'generalization is a verbal act of thought and *reflects reality in quite another way than sensation and perception reflect it*' (Vygotsky 1986: 6, emphasis added). As a result, human thought does not merely mirror the external world in front of us, but refracts it in myriads of subtle and complex manners that seem to be beyond the reach of other species.

One way in which living activity is reflected is in the conscious awareness of the subject; the other way is in the form of emotion. Unit analysis 'demonstrates the existence of a dynamic system . . . in which the affective and the intellectual unite' (Vygotsky 1986: 10), and this includes material reality, for 'every idea contains a transmuted affective attitude toward the bit of reality to which it refers'

(ibid.: 10). Consequently, all unit analysis includes material sympractical activity, on the one hand, and the two manners that reality is reflected, namely consciousness and emotion, on the other hand. 'The true nature of psychic sensual images exists in their object character, in that these images are produced in activity, which relates the subject with the external, object-world' (Leontjew 1982: 134).

Consciousness

What is it that matters to our deliberations about what we do next? What matters precisely is what is salient to us in our consciousness. It is not an abstract world, a world described by all physicists after Galileo; it is not some abstract thoughts and concepts that are supposedly in our mind. What we do next is determined by what is salient to each of us in our conscious awareness of the actual, practical conditions and circumstances. It is this aspect of human reality that is of importance to a cultural-historical activity theoretic perspective. Thus, the 'psychic reality that immediately opens itself for us is the subjective world of consciousness' (Leontjew 1982: 122). In all its immediacy, consciousness reflects the world as it is given to the individual. As Marx/Engels (1958) suggest, conscious Being and being conscious are but two aspects of the same sensibly sensuous human life.

An often-used example of the difference between theoretical cognition and practical consciousness is that of hammering. Because the 'totality of useful things is always already discovered *before* the individual useful thing' (Heidegger 1977: 69), the hammer, which is a tool used *for some purpose* and *in order to* achieve something, does not appear in consciousness in the way rationalists and cognitive scientists tend to theorize it. The hammer is *not* represented. Rather, the hammer is subordinated to the activity at hand. 'The less we just stare at the entity called hammer, the more actively we use it, the more original our relation to it becomes and the more disclosed it is encountered as what it is, as useful stuff' (ibid.: 69). That is, the hammer as hammer is not apparent in consciousness. Rather, it is the thing or state that is to be achieved. Thus, our association with the hammer, as with other useful things, 'is subordinate to the manifold of references of the "in-order-to"' (ibid.: 69). What is apparent in consciousness and what a (practically knowledgeable) person is attending to is placing a nail to hang up a picture or to fasten a loose board in the chicken coop. Active attention to the hammer occurs only when something goes or has gone awry. We then notice that the hammer we have been using is too heavy or too light, that its handle is broken or that there is a splinter in the handle that hurts the hand. What we do next depends precisely on what appears in consciousness.

Activity theory differs from other theories of knowing and doing concerning the true nature of the focal concepts in the consciousness of the subject. Consciousness, rather than knowledge, becomes of primary interest because 'consciousness, as relation, is not characterized by comprehension, not by the knowledge of the significance of the subject matter, but by the personal sense that the subject matter

obtains for the child' (Leontjew 1982: 279). Confusing the two aspects produces intellectual formalism. Traditional psychology has not taken consciousness as its central problem. In this field, consciousness is a derivative of knowledge rather than the relation of humans with the world. Kantian/Piagetian approaches conceive of consciousness in terms of formal knowledge. But this creates the problem of the relationship between formal knowledge and the world. Activity theory, on the other hand, theorizes consciousness in activity as the *relation* of a person to the world: 'The inner movement of the individual consciousness is produced by the movement of the objective activity of the person' (ibid.: 150). In this, our approach also differs from others who claim to ground their work in cultural-historical activity theory yet continue to focus on knowledge as the starting point for understanding the way in which individuals act in the world. Human consciousness therefore is neither a plane nor a space filled with images and processes, but is the inner movement part of the total movement of activity that concretizes the real life of the embodied, living individual in society.

Consciousness plays a much greater role in cultural-historical activity theory, than in any other theory. Ontogenetically speaking, individual human consciousness is possible only when there is collective, societal consciousness. Without collective consciousness, individual consciousness does not develop beyond the realms of the sensorial and perceptual as shown by the various cases of the so-called 'wild children' (Newton 2002). In society, language and material culture are the substrate for consciousness at two levels: the individual and the collective (Vygotsky 1986). Individual and collective consciousness are mutually constitutive so that there can be nothing available to the consciousness of the individual that is not already a possibility configured in collective consciousness – as, for instance, possible conceptual or artistic emerging combinations from established ones that nonetheless need to be articulated in intelligible ways to produce a resonance in the forms of known social canons: it is precisely in this way that the well-known sociologist Norbert Elias (1993) explains Mozart's genius. Reciprocally, creativity supposes individual consciousness as the possibility for new forms of collective consciousness. Consciousness is thus the place where individual subjectivity and collective subjectivity come to be irreducibly intertwined, for '[t]he appearances of reality can become conscious only by means of "ready-made" significations appropriated from the outside – the knowledge, concepts, perspectives that the individual obtains in intercourse, in individual and mass communication' (Leontjew 1982: 149). That is, rather than being merely taken-as-shared, an understanding of reality is inherently enabled by collective cultural-historical forms, most important among these language (considered, of course, not as a simple 'tool' but as a conveyer of forms of life).

In activity theory, the role of consciousness changes. It is the reflection/ refraction of the world in the course of human engagement in sympractical activity. When consciousness is thought of in terms of knowledge (structures), then the role of emotions cannot be understood. For example, the effect of experience on emotions has to be understood in terms of experiences that require interpretations in terms of knowledge before it can affect emotion (the 'telegram effect'). The prob-

lem changes when consciousness is understood as the relation of the person to the world, as that which reflects his/her real life, his/her being in the world. This requires an entirely different approach from the one that considers Gnostic problems only, a change from the lifeless treatment of thinking processes.

By its very nature, *con*sciousness is something that we share with others. The etymology of the word points us to knowing (Lat. *sciēre*, to know) that we have in common, with others (Lat. *con-*, with). Vygotsky therefore insists on the fact that consciousness *never* is the consciousness of an individual, who is always but an 'inhabitant of the social edifice of ideological signs' (Bakhtine [Volochinov] 1977: 31). Consciousness realizes itself in the form of *participative (unindifferent) thinking* (Bakhtin 1993) that interaction participants make available to each other. If we are interested in understanding the unfolding of an event as an irreducible aspect of social life, we must focus on the various forms of signs that speakers make available for others as much as for themselves. These signs comprise words, pointing and iconic gestures, body positions and orientations, prosody (speech intensity, pitch, speech rate), rhythms, and so on – that is, anything that people use as a resource in the conduct of social life that both reproduces and transforms the activity at hand.

Emotion

The function of interest, boredom, inclination, remorse, *exhilaration*, or *frustration* is to signal to the subject the personal sense of events that occur in and as part of its real life. These affective forms constitute valences of the events as the individual subject experiences them and the activity that they constitute. Emotions reflect the relations between motives (needs) and the success in – or the possibility for a successful realization of – the corresponding activity of the subject. It is not the intellectual reflections on these relations that matter but the unmediated, sensuous, lived experience thereof. They emerge prior to any rational valuation of the activity. Emotions are relevant at the level of activity, not at the level of operations or actions. The same actions and operations may receive emotional colorings as a function of the emotion such that a successful action may be colored negatively and hardship may be charged positively – as long as it is perceived as getting the subject closer to realizing the motive (e.g., hardship and training for athletes in the face of the pay-offs that come with a victory).

Psychology and the learning sciences have tremendous difficulties in explaining the fact that consciousness is active and engaged rather than a disinterested calculating mechanism – in the way a central processor is in a computer. The computer processor works because of outside forces, whereas the human mind moves by itself. Affect and cognition tend to be theorized as external to each other, affect

often as a factor that diminishes cognition.[14] Kant (1956) did his part to expel affect from cognition, arguing that strength of the emotion constitutes the weakness of the mind. True strength and inner freedom come when the mind becomes the supreme master, subjugating all the affects to rule over them. In more recent constructivist thought, too, emotion is something external to cognition: emotion is to cognition what fuel is to the motor (Piaget 1981). After several decades of doing without emotion as a category, suggestions emerge only now in the constructivist conceptual change movement, that affect has to be included as another factor that mediates cognition and learning. In cultural-historical activity theory, however, affect generally and emotions specifically are theorized such that they have become *integral to cognition*, as a second form in which reality is reflected in the (individual, collective) subject. This was achieved as part of a categorical reconstruction of the human psyche on evolutionary grounds.

This reconstruction posed as its main question the origin of the relation of affect and cognition (Holzkamp 1983; Leontyev 1981).[15] It was recognized that affect is tied to life itself so that the question about affect has to be reconstructed from the beginning of organic life itself. Holzkamp and Leont'ev posit some originary situation where a one-cellular organism floats in brine with sufficient food to sustain it. To initiate anything like cognition, a number of internal and external conditions have to exist that lead to contradictions. On the outside, changes have to occur whereby the brine no longer contains plentiful food but has gradients. The organism needs to be able to 'experience' these gradients as a lack, which constitutes a state of *negative valence* to its life. Moreover, the organism needs to have an originary sensibility, which allows it to sense the food gradient or some other signal, such as light, associated with the food gradient. The organism has to have some mobility, which initially is random and arbitrary. The 'cognition' required for *voluntary, intentional* movements to be produced toward greater food availability presupposes that the organism correlates the movement, which it has to have some sense of, with increase in available food as mediated by the signal (e.g., light). The organism has to be able to assess the increase in food availability in some form of 'satisfaction', some measure of 'improvement' of its situation. That is, some form of mechanism has to exist that provides a negative valuation when there is a lack of food and a positive valuation if the motive of activity is realized and needs are satisfied. The final link required is that between (a) the intentional movement toward food gradients and (b) an associated change in the organism's valuation of the situation from negative (original state) to positive (final state). Here then, 'affect' (sensibility, valuation) and 'cognition' (movement mediated by sensibility) become part of one and the same mechanism. The organism moves, mediated by the signal, because doing so 'promises' a pay-off in terms of higher food availability and better conditions, and the organism *experiences* the change from negative to positive

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[14] Besides cultural-historical activity theory, phenomenological philosophy treats affectivity (emotion) as a phenomenon *integral to* cognition, cognition and emotion as two sides of the same coin (e.g., Henry 2000; Sheets-Johnstone 2009).

[15] A short version of the way in which this reconstruction is conducted and its results can be found in Roth 2009a.

valuation, which also has to leave a 'trace' so that the organism 'remembers' the relation between originally arbitrary movement and change in the organism's condition.[16] In this approach, therefore, gnostic and affective moments are combined in an originary sensibility. Both moments are reflections of the situation and both are integral to the changes therein through active, intentional movement, of which there is a trace so that the organism immanently knows that it can move and bring about change.

In their reconstruction, Leont'ev and Holzkamp show how from these original conditions, given a combination of internal and external developments, changes, and developmental contradictions, there is a development from single-celled organisms to the hominid species from which Homo sapiens emerged in anthropogenesis. At this point, the control over life conditions is transferred from the individual to the collective, as the division of labor and the active and intentional production of food, the social organization, the handing-down of practices, and so on is selected in evolutionary processes to become the dominant form of life for this species. That is, emotions 'emerge in objective situations and "mark" in their own language these situations and individual objects, and sometimes enter these by chance or indirectly' (Leontjew 1982: 190). Changes in activity are reflected in changed affective tonalities of the situation as a whole and of individual objects. It is important to retain that in relation to the analysis of activity, 'the objectivity of activity generates not only the objective character of the images but also the objectivity of the needs, emotions, and feelings' (ibid.: 90). Here, emotions are 'the result of and the "mechanism" of its movement' (ibid.: 188). These reflect the relationship between object/motives and the levels of success that are anticipated as the outcome of a set of actions that concretely realize the activity. They therefore constitute, besides consciousness, a second mode in which the activity is reflected in the subject. Their import derives from the role they play in orienting activity rather than the action. Thus, as mentioned previously, a particular action may be associated with negative valuation (e.g., athletes put up with hardships on the way toward a victory) as long as the anticipated outcome of activity is associated with a positive valuation.

Affective valuation and movement are integral moments of the same phenomenon. It relates, now at a human level, 'a given lived-experience *to me* as the one who is actively experiencing it' (Bakhtin 1993: 36). This self-relation of the individual who not only acts but also experiences the action and its result has a 'sensuous-valuational and volitional – performative – character' (ibid.: 36). The different moments, that is, the sensuous-valuational and the volitional (intentional) form, are given in/as, a unity.

The emotional valuation (assessment) of relations with the environment is the basis and first step of any cognitive process, that is, of thinking and acting, questioning the existing relations. Emotional valuation reflects knowledge of these relations. But while they mediate orientations and goals of action, they tend to remain

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[16] The resulting *immanent* memory arises from a self-affection of the living/lived body, which phenomenological philosophers refer to as 'flesh' (e.g., Henry 2000).

subconscious and unaddressed in the conscious orientation toward and selection of future actions (Holzkamp-Osterkamp 1978). That is, actions are not the result of cognition, but inherently mediated by emotional valuations that arise from, and reflect/refract the assessment of the current relations and mediate selection of goals and actions that move the activity further along. Emotions and volition are integral and mutually constitutive moments of the same unit so that it comes as little surprise when cultural-historical activity theorists use the adjective emotional-volitional to characterize the relation of the subject to its activity. Thus, 'everything that is actually experienced is experienced as something given and as something-yet-to-be-determined, is intonated, *has an emotional-volitional tone*, and enters into an effective relationship to me within the unity of the ongoing event encompassing us' (Bakhtin 1993: 33, emphasis added).

> The emotional-volitional tone, encompassing and permeating once-occurrent being-as-event, is not a passive psychic reaction, but is a certain ought-to-be attitude of consciousness, an attitude that is morally valid and answerably active. This is an answerably conscious *movement* of consciousness, which transforms possibility into the actuality of a realized deed (a deed of thinking, of feeling, of desiring, etc.). We use the term 'emotional-volitional tone' to designate precisely the moment constituted by my self-activity in a lived experience – the experiencing of an experience as *mine*: I think – performed a deed by thinking. (ibid.: 36)

The emotional-volitional tone is an integral aspect of the *movement of consciousness*, which, for Bakhtin as for Leont'ev, reflects the transformation of the current state into a future state already present in consciousness as anticipation. We also note the importance that the 'experience as *mine*' has to the thinking of Bakhtin, which will require our research to take into account lived experience and an adequate method to access, describe, and theorize it.

The emotional-volitional tone is central to activity. It is 'an inalienable moment of the actually performed act, even of the most abstract thought' (ibid.: 33). Moreover, and precisely in the way that Leont'ev frames the issue, the philosophers states that the 'function of the object within the unity of the actual event encompassing us is *its actual, affirmed value,* i.e., is *its emotional-volitional tone*' (ibid.: 33). That is, everything experienced has an emotional-volitional tone, most importantly, the object of the activity, which is its true motive.

From the above-said, we should therefore expect that (a) there is an emotional-volitional tone in every mathematical situation that we might study in school classrooms, (b) this emotional-volitional tone is changing in/with activity (an outcome, result), and (c) the emotional-volitional tone is itself a 'mechanism' of the movement of activity. In the episode made available and analyzed across chapters 2, 3, and 4, this is precisely what we describe; in those chapters we theorize the relationship between activity, learning, consciousness, and emotion.

Contradictions

> In the same way as concepts, our sensual generalized images contain move-
> ment and therefore contradictions; they reflect the object in its manifold rela-
> tions and mediations. (Leontjew 1982: 73)

The Vygotsky-Leont'ev-Holzkamp lineage of cultural-historical activity theory has
been created to capture the different moments of human life in terms of dynamic,
living processes. This is apparent in the opening quote to this section, in which
movement is attributed to (ideal) concepts and to the sensual generalized images
that accompany concrete, material, and external activity. Consciousness, which
constitutes an affective reflection of inherently dynamic activity, therefore has (to
have) the same flow-like qualities – or it *could not be* a reflection. Static concepts
cannot reflect a dynamic phenomenon. Flow and movement, therefore, if they are
denoted, inherently require internally contradictory concepts. This is so because
they need to capture the 'between-ness' of movement. Thus, to describe the his-
torical changes in the market system, which 'fuels' its own changes, Marx/Engels
required a concept that captured the movement of commodities. The concept that
fulfills these demands is *value* (Marx/Engels 1962). It expresses itself in the use-
value and exchange-value of a commodity. Thus, when we look at any barter trad-
ing action, a particular commodity (e.g., a piece of cloth) *simultaneously* consti-
tutes use-value and exchange-value. The cloth is of exchange-value to the weaver,
but of use-value to the tailor. It expresses itself as such not because seller (weaver)
and buyer (tailor) have different perspectives on this commodity but rather because
value itself has to be thought of as an internally contradictory category that can
express itself one-sidedly in two different ways (Il'enkov 1982). To understand
inner contradictions and the movement with which they are associated, we must
not think of the commodity (object) *abstractly*, that is, independent of concrete
activity. If we did that then we would not be able to understand movement, for why
would a piece of gold make anything move?[17] To understand, we need to think that
there is a natural phenomenon of movement and to reflect this movement, we need
a concept that itself contains movement, that is, a concept that is not identical with
itself.

We introduce inner contradictions here, because without them we cannot think
activity in movement, movement in activity. But when we look at any mathematic
lesson, we note that life does not stand still. Even if the teacher were to say 'stop
everything now' and all students freeze, life would still not stand still. This stand-
ing still would be part of and therefore concretely realize the mathematics lesson as

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[17] Michael Hoffmann, a philosopher with special expertise in Plato and Kant, asked the question in this
way and thereby alerted us to the problematic way of understanding dialectical materialism. Inner con-
tradictions, as idealizations, do not move anything. Concepts that are to represent movement rather than
stasis, however, must contain this movement itself; that is, they must have to contain at a minimum two
states at once *and* the transition between the two. That is, they must, in short, be non-self-identical.

an unfolding process.[18] To understand this movement, we require categories that reflect it. For activity theorists, *activity* is this category. But any human activity that we may observe – farmers producing grain, bakers producing bread, fish hatcheries producing fish, or schools reproducing and transforming cultural knowledge – is in movement, is life and therefore movement itself. The category of activity, to reflect this movement, has to be an internally contradictory one. Contradictions and self-movement are two integral and mutually constitutive moments of thinking activity specifically and human life more generally.

Inner contradictions are the most central but also most misunderstood category of cultural-historical activity theory. In Western scholarship, the category often is reduced to a logical contradiction between two terms or to a breakdown of some instrument or tool as part of the activity. But this is not what Marx/Engels and following them Vygotsky, Leont'ev, Bakhtin, or Evald Il'enkov have in mind. Logical contradictions can be removed; if something is broken, it can be fixed. An inner contradiction of the kind that is central to the category of activity, however, is *endemic* and *cannot* be removed. It is, as Marx/Engels suggest, tied to the evolution of the division of labor and everything else it has entailed – language, culture, consciousness, and so on.

> It is completely irrelevant what consciousness does on its own, what we get from all this garbage is one result: these three moments, productive power, societal condition, and consciousness can and do come into a contradictory relation, because with the *division of labor* comes the possibility, indeed the reality, that the ideal and material activity – that pleasure and labor, production and consumption, fall to different individuals. (Marx/Engels 1958: 32)

Through division of labor, contradiction is also tied to the relation between the universal and particular, for example, the general interests of society and the particular interests of the individuals.

> The problem of the relation of the universal to the individual arises . . . not only and not so much as the problem of the relation of mental abstraction to the sensually given objective reality but as the problem of the relation of sensually given facts to other sensually given facts, as *the object's internal relation to the object itself*, the relation of its different aspects to one another, as the problem of internal differentiation of objective concreteness within itself. On this basis and as a consequence of it, it arises as the problem of the relation between the concepts expressing in this connection the objective articulated concreteness. (Il'enkov 1982: 75–76)

This is a very dense paragraph that requires us to unpack it for its theoretical and practical relevance to be seen in its entirety. The relation between the universal and the individual (particular) is an important aspect of thinking inner contradic-

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[18] Physically and physiologically, all human bodies assembled in a classroom burn energy and thereby change. Even if they remain quiet, particular individuals continue to think, and, because of the brain activity, continue to change.

tions. Thus, to draw on the example Marx/Engels often use, if we think of any individual person, we are confronted with the fact that s/he is both (a) a concrete realization of the human species, that is, the general in its concreteness, and (b) a particular human being. The same inner contradiction exists if we were to denote an object CIRCLE by pointing to it while producing the sound /'sɜːk(ə)l/ ('circle').[19] Here, the category name, denoting the general, is applied to denote a particular. Now Il'enkov suggests in his quotation that this pointing to something else is possible only because of '*the object's internal relation to the object itself*'. Any individual person is both a particular and a (concretization of the) general; any CIRCLE and /'sɜːk(ə)l/ ('circle') is both a particular and a (concretization of the) general. It is only because of the internal relation to itself that one object *also* may denote another, such as when a sound /'sɜːk(ə)l/ or ink trace ('circle') comes to denote an object CIRCLE. To be able to refer to something else, any signifier has to be able to signify itself. As a result, '"the signifier of the signifier' is the movement of language itself' (Derrida 1967: 16). In any actual situation that we may analyze, a signifier (e.g., a word, a gesture, an intonation) points to itself at the same time as it points to something different. This double relation is enabled by the self-relation of the signifier in the same way that *value* stands for movement only when it is related to itself such as it incorporates an inner contradiction (Roth 2011).

Analysis of Activity

In this book, we take a theoretical perspective that is concerned with consciousness and the cognitive and emotional awareness social actors make available to each other. Our analysis is intended to provide an *ethnographically adequate account* of the perspective on activity from the viewpoint of the actors as these make it available to one another (McDermott et al. 1978). We do so because the *internal dynamic* that drives the observed situation is not explained by drawing on hidden parameters. Quite the contrary is the case. Social actors, the subjects of activity, have grounds (reasons) for acting in the way they do, and they exhibit to each other whatever is required to pull off an event as that which it is. When required, they make available reasons for their actions even thought these might not have been in their conscious awareness. Thus, we do not *interpret* individual utterances as having this or that sense. Rather, we understand ourselves to be social actors who overhear the conversation of our research participants (Garfinkel and Sacks 1986). None of the participants in mathematical activity can see any hidden contents of the minds of others. What they act upon and react to is what the respective other makes available to them (Livingston 1986).

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[19] The notation for the sound is from the International Phonetics Alphabet. This alphabet therefore produces a guide for pronunciation independent of any language. It is used in most dictionaries around the world.

In the same way as speech act theory and conversation analysis, dialectical materialist (Marxist) approaches orient us to social interaction as the site of interest for understanding psychology. Thus, 'social psychology first is the ambient milieu of *speech acts* of all kinds, and it is in this milieu that all forms and aspects of the uninterrupted ideological creation is bathed: the conversation of the hallways, the exchanges of opinion in the theater or concert, in the different social meetings . . . the inner dialogue, and self consciousness' (Bakhtine [Volochinov] 1977: 38–39).

Concretely, we do not treat an utterance as a question unless there is evidence that another actor in the setting is treating it as such. This is why the punctuation in our transcripts do not mark grammar but aspects of prosody, which are interactional resources available to the participants. Thus, it may well be that a statement that has the grammatical structure of a statement nevertheless is treated as a question – likely based on the prosodic cues. Thus, in the following excerpt, we observe a sequence typical for a question–response pair *even though* Jeanne's utterance 'How much ought there be already' (turn 158) drops as in a constative rather than as in a question. (The translations of the two transcripts that follow can be found in the appendix and in chapter 3 and 4, respectively.)

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158  J:  =combIEN devraitIL déjà y avoir.
159  T:  u:h:
160  M:  douze
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In turn 160, Mario 'responds', providing a number that is consistent with the number of chips in one of the goblets. On the other hand, in the following sequence, a first turn is both grammatically and intonationally shaped as a question, but it is followed by another turn with rising intonation. A long pause in the verbal 'channel' develops, while the teacher Jeanne moves her fingers to another point in Mario's worksheet. He then produces two more rising speech segments, 'plus three? plus three?' In her turn at talk, Jeanne produces a drawn out 'yes'.

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200  J:  questce que tu vas écrire ici?
201  M:  trois?
202      (2.59) ((Jeanne moves finger to the cell on his left))
203  M:  <<p>plus trois? plus trois?>
204  J:  oUI:: ((he writes))
```

We can gloss this as Jeanne asking a question 'What are you going to write here' (turn 200) and Mario producing a tentative response, 'Three?' (turn 201) 'plus three?' (turn 203), which Jeanne confirms as correct, 'Yes' (turn 204). In Jeanne's finger movements, Mario can recognize the response delivered so far as not yet sufficient, and as soon as he produces two more additions, the evaluation is made known. Readers familiar with this form of analysis recognize what is known by linguists as triadic or IRE sequence, short for teacher *i*nitiation, student *re*sponse, and teacher *e*valuation.

Following the same logic, we do not identify 'episodes' unless particular segments of activity come to stand out because they are marked as such by one of the participants in the setting. Thus, for example, a significant stretch of the activity may be started off by a student, who notes that he understands what they have to

do, and may be ended by the same student who, after engaging in his activity, states that he does not understand and seeks the teacher's help. Or a segment is defined by the instance a teacher comes to help a student until the moment when she states that the student understands and leaves him to continue on his own. Here, it is the teacher who starts off and closes the lesson segment.

Throughout these chapters, we present the translations of the original transcription. This presents particular challenges, as the prosodic cues are somewhat deceiving given that French words, even if they look the same, tend to be pronounced differently and with different stresses. For example, the term dollar, which is part of the mathematical task that the children solve, would be pronounced in English as /ˈdɒlə(r)/, stress on the first syllable, whereas its French pronunciation is /dɔˈlaʁ/ with the stress on the second part of the word. In addition, whereas the English stresses the first syllable (see stress sign), in French, which is a prosodic language, the last syllable is emphasized. Thus, if in her presentation of how to calculate something, the teacher stresses the second part of the word 'dollar', a possible English equivalent would be to stress the first part. This is important because the rhythmical and prosodic aspects are important interactional resources and may have important functions in bringing about desired responses. In our translation of the transcription, we have made every effort to provide the best English equivalent. Our reading of the transcript is based on the French version, which, in addition to the full English transcription, has been provided in the appendix.

2

Reproduction and Transformation of Affect in Activity

In the preceding chapter we suggest that in the Vygotsky-Leont'ev-Holzkamp version of cultural-historical activity theory articulated here, cognition cannot be understood independently of emotion. This is so because the latter constitutes an holistic expression of the subject's current state with respect to the object/motive and the subject's sense of the likelihood of success in realizing the object/motives it has subscribed to. That is, the activity, stimulated by the object/motive, continually transforms the situation at hand, including, as we show here, the emotion expressed and thereby made available to others. Affect is not a static, trait-like characteristic of the subject. Rather, emotion, the sensual valuational reflection of activity in the acting subject, is continuously reproduced and transformed together with the cognitive and material results that emerge from the hands and minds of the subjects. Affect is in movement together with the activity as a whole, of which it is one of the manifestations. That is, in this chapter, then, we show that affect is an irreducible moment of activity, which, like the activity itself, is in and brings about the (self-) movement. The category of activity was created precisely to capture movement; the analysis focuses on inherent change (becoming) rather than on how things are in and for themselves.

In the following sample episode featuring Aurélie, Mario, and Thérèse, we exhibit and theorize this continual production of cognition and emotion, both of which are thought to be reflections/refractions of the living activity. In the process, the subjects make thematic and available to each other and to themselves expressions of the emotional and cognitive reflection of activity. These expressions are resources that are employed in and therefore mediate the movement of the activity itself.

Since the beginning of the study in September 2007, regular meetings have been held involving the teacher, the researchers, and the research assistants at one school in Ontario, Canada. The meetings have taken place either at the school or at the university to discuss the mathematical content of the tasks, the design of the

Problème 4 :

Pour son anniversaire, Marianne reçoit une tirelire contenant 6$.
Elle décide d'épargner 3 $ par semaine. À la fin de la première
semaine elle se dit : « J'ai 9 $! ».
Questions :
a) Modélise le problème à l'aide des boîtes et des jetons jusqu'à la
6ᵉ semaine
b) Remplis la table de valeurs suivante :

Numéro de la semaine	1	2	3	4	5	6
Montant épargé ($)	3 +6	3 +3 +6	3 +3 +6	3+3 +3 +6	3+3 +3+3+0	3+3+3+3+3+0
Ou	3 +6	2x3 +6	3x3 +6	4x3 + 6	5x3 +6	6 x3 + 33

Fig. 2.1. Problem 4 was to be solved by the fourth-grade students. Presented is the copy of
Mario's worksheet at the end of the lesson.

tasks and forms of interaction to be promoted in the classroom. Though experimen-
tal, the tasks were designed to meet the requirements of the provincial curriculum.[1]
Among the curricular topics, one that has gained prominence is modeling. In the
following, we focus on one of the lessons in a fourth-grade class (9–10 years) re-
volving around the topic of modeling situations by means of algebraic concepts.
More specifically, at the heart of the present and subsequent chapters is Problem 4
(Fig. 2.1)[2], from which the fragments that we present below are drawn. Problem 4
includes two main tasks about the modeling of a saving process. The students have
been provided with clear plastic goblets and chips to accomplish the first of the
two tasks.

This first fragment – constituting the first 21 lines of the raw transcript, 46 turns
in augmented transcript presented here – may be glossed in a summarizing way by
saying that Mario moves from having an idea about what they have to do, through
its articulation, to the eventual halt in the activity and the statement that he does
not understand. In the course of this fragment, he moves from expressing confi-
dence to frustration. Aurélie tells her peers that she does not understand, and, even
though her worksheet comes to be filled, expresses frustration. Thérèse both com-
pletes the task and exhibits confidence throughout. How can we understand this
changeover, which itself is the result of the students' activity? We suggest that the
engagement in the activity produces a negative emotional response and a recogni-
tion that they do not understand so that an initially available positive emotional

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[1] The provincial curriculum can be downloaded from the website of the Ontario Ministry of Education
(2005): http://www.edu.gov.on.ca/eng/curriculum/elementary/math18curr.pdf.
[2] The task translates as:
Problem 4:
For her birthday, Marianne receives a piggybank containing $6. She decides to save $3 each week. At
the end of the first week she says to herself, 'I have $9!'
Questions:
a. Model the problem until the sixth week using goblets and chips
b. Fill the following table of values

stance turns into a negative one. Affect here is a reflection, from the perspective of the subject of activity, of the distance between the current state and the anticipated – even if not articulated – object/motive of the activity.

The intent of the task is for students to begin by placing the number of chips into their goblets that correspond to the amount of money Marianne has in her piggybank at the end of each week. But rather than transferring the total number of chips in each goblet to the table of values, students are to note the repeated additions of $3 to the piggybank (see table in Fig. 2.1). To achieve this, the table of value specifies for the first cell +6, inviting the students to add a 3 to achieve the representation 3 + 6 corresponding to the $9 in goblet #1. Similarly, the +6 in the second cell is intended to encourage students to represent the repeated addition 3 + 3 + 6 rather than note the '12' corresponding to the 12 chips in goblet #2. The intent of the third row in the table is to have students write a shorthand representation for the contents of the cell above, which means that they might move from the repeated addition 3 + 3 + 6 to the more efficient multiplicative/additive structure 2 x 3 + 6. By filling the table, fewer terms are embedded in each cell, which embodies the curricular intent to allow the emergence of the pattern (# of weeks) x 3 + 6. To provoke this emergence, the worksheet shades the number of weeks in yellow in the entire first row and for weeks 2 to 5 in row 3. Subsequent tasks on the same worksheet are designed to lead the students to the generalization as they go from calculating the amount of money in the piggybank for weeks 10, 15, 25, and finally, an arbitrary number of weeks above 100. The table therefore constitutes an artifact that embeds a cultural-historical form of thinking about the saving process (Radford 2000). It highlights the theoretical content of the algebraic generalization, where repeated additions are conceptualized as a multiplication – a crucial step towards the *conscious awareness* of the algebraic structure of the sought-after model.

In the terminology of activity theory, the *object* of the classroom activity is learning to reflect algebraically about patterns. In the course of the activity, the object appears in its ideal (abstract) and material (concrete) form. In the material or concrete plane, its ideality is exhibited through particular instances. Yet, the particular instances do not exhaust the object to which they refer. This is why the object of the activity cannot be the production of the algebraic expression 6 + 3n or any other linear expression, like 1 + 2n, etc. In turn, the particular instances appear under the form of a *goal* to be reached – the production of a model featuring an algebraic structure of the saving process. Objectifications, that is to say, the collective processes through which individuals seek to attain the goal and the object of activity are entailed by cognitive and emotional transformations that arise as efforts to deal with the inherent contradictions of activity. These transformations are marked by the *motive* of the activity that is materialized in the form of affective orientation of the individuals as they produce understandings and non-understandings with clear emotional valences. In the next section we explore the question of emotional valences in light of the production of non-understandings.

How Activity Produces Negative Emotional Valence and Expressions of Not Understanding

For cultural-historical activity theorists, activity, rather than the individual subject, constitutes the smallest useful unit of analysis: Without other manifestations such as tools, division of labor, rules, and community, we cannot understand and theorize the events that we see on the videotapes. Emotions, therefore, need to be analyzed at the level of activity rather than at the level of the individual. Emotion, like consciousness, is an inner reflection of the material activity as a whole rather than a mere biological and physiological state of the human subjects involved. It is therefore as part of the unfolding activity that emotions are both reproduced and transformed. Over the course of the following three sub-sections, we exhibit the events in the course of which the nature of the emotions expressed changes from positive to negative, and from negative, to positive. Emotions are an assessment of the current state of the activity in respect to the outcome to be achieved.

'Now I Understand. You got it Wrong'

The three students begin by counting out the number of chips that they place into each of the five goblets. They count out 6 blue and 18 red chips for a pile that ends up next to the fifth goblet and corresponds to the final cell in their table of values (Week 6). At this point, Mario asks, 'What now?' Thérèse points to the table of values on Aurélie's work sheet and they begin the task to fill it. But there is a debate, because the latter points out that they do not have the same as he does. Aurélie and Mario repeatedly ask Thérèse what she is doing. Aurélie has already repeatedly expressed frustration and has rebuffed a student from another table who wanted to help: 'But we don't have the same thing that you have'. She continues, 'but look', we already have done this', while pointing at the table of values on her sheet. Mario tells her, 'Ali, just add on the side'. She asks Thérèse about the numbers highlighted in yellow on the worksheet and then announces all they had to do was 'add three and three'.

Fragment 2.1 takes up the last of these questions that Mario directs to Thérèse (turn 001). There is a long 15.11-second pause that follows during which Mario gets back to his sheet. We can see Mario moving his fingers up and down between two consecutive rows of the table of values. Aurélie pounds the desk with her fist, then throws herself backward against the backrest (Fig. 2.2), throws her hands up in the air, and then lets them drop into her lap (turn 002). Thérèse, who has been filling her table of values leans back and breaks the silence, utters a very long, drawn-out 'okay' (turn 003) continuing to gaze at her worksheet (turn 003). There is a pause, and then Mario produces an interjection of surprise, 'Oh, oo' and then says, 'Now I understand' (turn 005).

Fig. 2.2. Aurélie (left) has disengaged after pounding on the table (turn 001).

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Fragment 2.1
001 M:  <<all>resa> what are you DOing? ((Aurélie leans
        backward, Fig. 2.2, Thérèse writes on the oriented
        toward her; English in the original))
002     (15.11) ((Mario orients to his sheet, Finger moves up
        and down between rows, pounds on table, throws herself
        back))
003 T:  okay::::::
004     (1.40)
005 M:  <<f>oh oo> now i understand. you did it wrong! (1.49)
        .hh the first wEEK (0.78) she has how much; (0.21)
        ((He points to the goblet of Week 1)) n:IN:E. (0.89)
        we write n:IN:E (1.19) the second week (0.43) she has
        how much? we write it (0.24)
                    th[ird (0.35) how much            ] ((A
        still leans back))
006 A:  <<plaintive> [we havent even finished the fir]st
007 T:  no no no ((She laughs))
008     (0.74)
009 A:  <<plaintive> [we havent even finished] the first
        [And like it doesnt make sense]>
010 M   [look tresa, (0.58) look the  ] first s: (0.44) the
        first week, (.) she has nine. ((points to Week 1, Fig.
        2.3)) (1.10) second wEEK, she has:: (2.00) elEVen
        (0.63) wait no. (1.09) ((he points towards week 2))
        twELve. (0.74) third wEEK, she has (2.18) FIFteen
        (0.75) ((physically establishes relation between
        goblets and cell in table of values [Fig. 2.3]))
        (.)                   [we write (0.32) that.  ]
011 A:  <<plaintive> what [are you doing thérèse .] ((hits
        table, rests head on table, Fig. 2.4)) ((3:01))
```

Mario further suggests to Thérèse that she has done something wrong and then articulates what needs to be done all the while doing it (turn 005). Placing his left arm and hand such that his index finger comes close to the goblet marked '1', he says, 'the first week . . . she has how much?' He continues, 'Nine'. He orients to

Fig. 2.3. Aurélie continues to be disengaged, Thérèse (center) writes, and Mario explains to her his understanding of the task (turn 010).

his worksheet, points to the first cell with the index finger of the left hand and then writes (right hand) while saying, 'we write nine'. There is a pause, during which he orients to the second cell in the table, and says, 'the second week he has how many, and you write it'. He continues, 'the third week, how many' and then moves his hand pointing to two more cells in the table exhibiting its sequential nature from left to right. In a plaintive intonation (high, strongly falling to the end), Aurélie suggests in a plaintive voice, 'We haven't finished the first, and further, that doesn't make sense' (turn 006).

Thérèse, who up to this point has apparently been listening but stared into the air, turns to Mario who rises from his worksheet to turn and gaze at her, when she says 'no' three times (turn 07). In a plaintive voice, Aurélie repeats what she has said before, 'We haven't even finished the first' and then continues, 'then, like this doesn't make sense' (turn 009). Neither Mario nor Thérèse appear to react to what Aurélie has said or how she has said it. Instead, simultaneous with the second part of Aurélie's utterance, Mario begins his explanation again. 'Look Thérèse, look, the first week, she has of it nine. Second week, she has . . . eleven . . . wait no . . . twelve. . .' (Fig. 2.3). He moves his sheet onto Thérèse's table, close to her. He continues, 'Third week she has of it . . . fifteen . . . and we write that' (turn 010). Aurélie rises from her lounging position, pounds the desk, then asks, 'What are you doing Thérèse?' (turn 011) with apparent frustration in her voice, then places her head on the folded arms on her desk (Fig. 2.4). At this point, Thérèse has completed four cells of the first row of the table of values and the entire second row (see statement of Problem 4). Mario, although he has verbally articulated how to fill the cells of the second table row, has not yet begun filling it in. Aurélie has just begun with the first cell.

Fig. 2.4. Aurélie, head on table, has disengaged from seeking a solution to the problem (turn 011).

In this first segment from the episode, Mario announces to his peers an insight, declares that Thérèse has done badly, and then explains twice what they have to do. His intonation – based on the correlates between prosody and emotion identified in psychological research (Scherer 1989) – expresses firmness and confidence. During his explanation, his gestures make an embodied link between the goblet-chip model (left hand index finger) and the worksheet in front of him (right hand pencil). While he explains, Aurélie repeatedly makes statements about the status of their work, her intonation expressing complaints, and says that this does not make sense. She pounds the table repeatedly, and throws herself back against the backrest, slouching for a while in disengagement.

As their sympractical activity unfolds, Mario exhibits confidence, and when Thérèse responds negatively to his first explanation, Mario does it over again, this time providing the actual number of chips for goblets 1, 2, and 3. She has finished her table of values and, following Mario's first explication, confidently says 'no' repeatedly, shaking her head sideways in apparent disagreement. Aurélie, on the other hand, increasingly exhibits frustration and disengagement from the activity. In the turn before the present fragment, she has already indicated that she will go on to the next because, and she continues in English, 'I have no clue what she is doing'. Thérèse appears confident. At the end of the fragment, Aurélie asks Thérèse again what she is doing.

There are three aspects to Aurélie's expressions. She makes statements about the status of the task and describes the situation as not making sense. These are cognitive expressions, ways of articulating forms of experience to others using words. They pertain to what she knows (does not know) the task to be, what to do next, and statements about understanding. Second, her intonation and other voice parameters – which tend to be produced unconsciously – express emotional valuations, here, of the negative type. Third, she makes two types of bodily expressions that can be seen and heard as expressions of emotion: she pounds on the table and she throws her body backward against the backrest. In fact, she is not simply producing these expressions sequentially, but the plaintive voice, expression of emo-

tion, simultaneously articulates speech sounds that encode cognitive statements. In this situation, the difference between emotion and cognition is undecidable. The same vocal material expresses both emotion and cognition: it has conscious and non-conscious aspects simultaneously.

Aurélie as a whole becomes an expression of the sensuous-valuational and volitional character of activity. She wants to engage in the task, complete and understand it, but at the same time, the sensuous-valuational aspects are expression of the distance between where she is and where she has to get. Wanting to understand and complete the task and the prospects of getting there are co-expressed reflections of the current state of the activity as Aurélie concretizes it in and with her actions.

'What are You Doing. . . I Don't Understand. And I Will Never Understand'

Following Aurélie's question to Thérèse of what she is doing, there is a pause, then an interjection (turn 013). Mario asks Thérèse what she is doing, and the latter suggests following another interjection, 'just copy me' (turn 015). Overlapping her, Mario indicates the intention to speak, but then stops, as Aurélie, in a plaintive intonation, suggest, 'We have no clue what you are doing, so' (turn 017), but Thérèse produces another series of repetition of interjections (turn 019). There is a pause, during which Thérèse turns her worksheet so that Aurélie can read it, and then she produces another interjection (turn 019). Aurélie has placed her head on her folded arms on the table (Fig. 2.4). As the camera zooms in, Thérèse addresses Aurélie by name, as if calling her and inviting her to participate, and then tells Aurélie that the camera is 'watching' her (turn 023). That is, Thérèse makes apparent to any bystander (including the analyst) that she is aware of Aurélie's disengagement and that this fact can be seen on camera.[3]

Thérèse then begins to fill in the first figures into Aurélie's worksheet and, after a 6.45-second pause, Mario in turn suggests to Thérèse that she, now filling out Aurélie's sheet, is on camera, to which Thérèse responds in a low voice and in a slow and deliberate manner that she knows and that she does not write anything (turn 027). During the pause that follows, Mario turns, leans far back, and looks around the classroom. He raises his hand (Fig. 2.5). His whole body is, following Merleau-Ponty (1945), an expression; teachers understand such expressions as those of students seeking help. There is another pause before Aurélie suggests that she does not understand and that she will never understand (turn 029). Mario has returned his gaze to his worksheet still holding up his right hand, but elbow on his

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[3] It is evident in situations like this that the participants themselves make available to each other what they are conscious of and what they attend to. The researcher does not have to attempt to get into the head of the participants, who make available anything and everything required to each other for mutual and *participative understanding* of the situation.

Fig. 2.5. Mario raises his hand, turns toward the classroom; the teacher will eventually come and thereby acknowledges the gesture as a call that he has a question (turn 028).

desk. In this second part of the fragment, we observe further expressions that are simultaneously emotional and cognitive reflections of the activity from the perspective of the acting subjects. Aurélie's intonations are plaintive and lamenting while she repeatedly addresses Thérèse, complaining that she does not know what she does.

```
Fragment 2.2
011 A:  <<plaintive> what [are you doing tresa.  ] ((hits
        table)) ((3:01))
012     (2.69)
013  A: um chums.
014  M: <<p>what are you> DOing.
015  T: <<p>aw chuggy just [copy me. >   ] ((English in
        original))
016  M:                 <<p>[okAY so first] [of all. > ]
        ((turns to Thérèse; English in original))
017  A:                          <<lamenting> [we have no] idea
        what youre dOIng sO> ((very high pitch, 570 Hz max,
        3:09, both A & M oriented toward T))
018     (1.33)
019  T: dan dan dan dan ((she moves the chips away from her
        page and toward))
020     (4.14)
021  T: <<confident>(qwi::::?) (gret?)>
022     (1.73)
023  T: <<f>aLI::;> cameras wATching you. ((3:21, Thérèse
        fills up the table for Aurélie))
024     (6.45)
025  M  <<p>tresa, youre on camera; >
026     (1.19)
027  T  <<len>i=know, i=m not writing anything. >
```

Fig. 2.6. Aurélie stares at her hands placed on the worksheet, while explaining in a plaintive voice that she does not understand and that she will never understand (turn 029).

```
028       (3.41) ((Mario raises his hand, turns around))
029  A:   <<plaintive>i dont understAND; and I will nEVer
          understand.> ((Stares at her hands placed on the
          worksheet, Fig. 2.6)) (3:38)
030       (0.84)
```

Aurélie has placed her head on her hands on the table, while Thérèse, confident throughout this part of the segment, fills out Aurélie's table of values. That is, Thérèse exhibits a recognizable act of helping. In her actions, she exhibits for Aurélie and for the analysts her helping stance. Her actions realize a request for (provision of) help interactional pair. The 'request for help' is articulated in multiple ways. In other words, these emotional expressions in the intonation and the inactivity (frustration?) are produced simultaneously with the cognitive content about the state of their tasks (not knowing what Thérèse does), about not understanding, and, very importantly, about never being able to understand. Emotion therefore constitutes an index of the possibility Aurélie anticipates to have about obtaining control over the activity and achieving a successful outcome: realizing the object/motive. When there is a high to perfect likelihood that success will not be attainable, then the emotional valuation will be negative and there is less likely for it to pursue the activity. There is no reason to do so, for the prospect is that the activity will not lead to an expansion of control and room to maneuver.

Mario has begun to look around, as if searching for the teacher. He has raised his hand, but, after some time without response to the raised hand, returns his gaze to the worksheet. These may be seen as the first signs of uncertainty. Whether his action interactionally is realized as a request – by providing the requested help as a response – remains to be seen. Given our cultural experience with children in schools, we may anticipate particular responses to be exhibited if the request for help remains unanswered.

'This is Dumb. I Don't Understand'

The third part of this instant of classroom life begins with Thérèse's instructions to Aurélie to do 'three plus six' and, mixing the two languages, 'to write whatever' (turn 031). Thérèse then turns around and begins to talk to the group behind at the next table. Nobody speaks during an extended period of time (49.52 seconds). During this period, Aurélie and Mario are writing, where Aurélie every now and then takes a look at Thérèse's worksheet (where she might be copying). Mario intently gazes at his worksheet, finger on table of values, moving up and down between the rows. He turns toward Thérèse, then turns about and gazes toward the other parts of the classroom. Near the end of the pause in speaking turns, Mario again raises his hand, continuing to look around. Thérèse breaks the silence saying 'Oh my god' and then, after another pause, turns back to the table and leans toward Aurélie. The latter pounds her fist onto the desktop (in apparent frustration), to which Thérèse responds by saying, 'We are all mixed up' (turn 038). Aurélie overlaps her, repeating in apparent frustration (intonation drops from much higher than normal pitch to very low toward the end) what she has said before, 'I don't understand' while pointing to her sheet (turn 039). Following a 2.46-second pause, Thérèse produces another confidently expressed interjection. A further long speaking pause unfolds. During this pause, Mario drops his hand (turn 042). During the same speaking pause, Aurélie pounds the desk again, throws herself against the backrest (turn 042). Mario gazes back at his sheet while Thérèse is writing something. Mario repeatedly shakes his head (sideways) in ways that we can observe in situations where the needs of someone (standing in line) are not addressed, which culturally competent people tend to understand as expressions of frustration. Thérèse continues to write, Aurélie places her feet on the bookshelf of her desk, and Mario raises his head again, looking around the classroom.

```
Fragment 2.3
031  T:  here (0.30) you have to do (1.41) three plus six
         (0.60) yup. (1.79) <<len, p>y=write whatever>
         ((Thérèse turns around and speaks to members of Group
         4 about other things))
032      (1.29)
033  A:  yeAH?
034      (49.52) ((Ali writes, Mario raises hand and Thérèse
         talks about something else))
035  T:  ah my god.
036      (8.70)
037  A:  ((pounds on the table))
038  T:  <<p>kay we are all mi[::xed up>            ]
039  A:                       [i dont understand] ((points to
         her page, Fig. 2.7a))
040      (2.46)
041  T:  <<confidently>uh hu:::; uh huh. >
042      (25.56) ((M drops his hand)) ((Ali pounds table again,
         throws herself back against back of seat)) ((4:57,
         Mario gets back to the task, A leans back, Fig. 2.7b))
043  J:  <<f>yes.> (0.52) whAT is the ques[tion.]
```
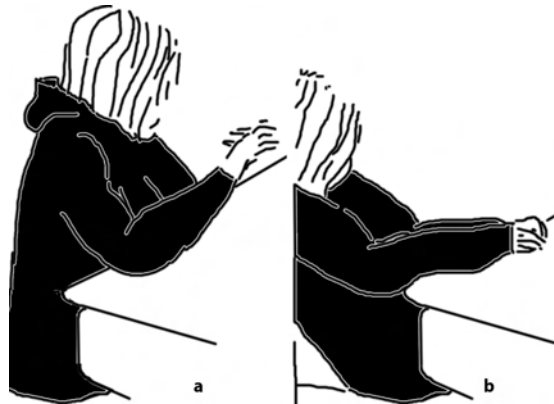
Fig. 2.7. a. Aurélie throws up her hands as she reiterates saying that she does not understand (turn 039). **b.** She throws her body backwards, visibly disengages with the task (turn

```
044  M:                                      [its  ] ^this :::
          (0.38) <f>um[::>] ((hands move downward, restrains not
          to pound on table, gazes at sheet, Fig. 2.8))
045  T:          [aur]élie sit properly (55:00)
046  M:  look this is (.) dUMb, <<p>i dont understAND. >
          ((487>217Hz))
```

Mario turns back to his worksheet noting something, then turns both hands upside, moves lips as if saying 'quoi' (what?) (just before turn 043). He looks up, and just at that moment, we can see the teacher Jeanne approach stating, 'Yes . . . what is the question?' (turn 043). With this, Jeanne exhibits a response to Mario's request for help, or rather, in approaching the table and asking 'what is the question', she formulates for us her understanding of the nature of Mario's preceding actions to be a question. 'It's this', Mario responds, and then produces an interjection. The palms of his hands open toward the ceiling, his arms move up and down as though he is containing himself with a lot of effort (Fig. 2.8). The intonation falls from high (480 Hz) rapidly to a much lower pitch value (300 Hz). The mean pitch is 396 Hz, up from 280 Hz, F1 mean is up from normal 500 Hz to 787 Hz.[4] All of these are consistent with the research that shows correlations of these parameter changes with despair/disgust and irritation (Scherer 1989). Jeanne then addresses the way in which Aurélie is sitting and articulates it as an improper way of sitting during this task: 'Aurélie, sit properly' (turn 045). Mario continues with expressions that provide intellectual assessments of the situation: 'look this is dumb, I don't understand' (turn 046).

---

[4] The pitch, or F0, is the main and lowest contributing frequency of the voice. F1, F2, . . . are the next (higher) contributors to the voice. Psychological and sociological research have shown significant correlations with emotions of the first two frequencies, F0 (pitch) and F1 (e.g., Scherer 1989).

Fig. 2.8. Mario expresses spending energy containing frustration, as if taking something and shaking it between his hands (turn 044).

Signs indicating that Aurélie and Mario do not understand mark this third part of the fragment. Their frustration is 'written all over the situation'. The emotional expressions include the pounding of the desk, leaning backward, looking around the classroom with raised hand, and the shaking of hands while articulating the fact that he is not understanding. The fragment does begin with the marking of an insight and the subsequent articulation of what the task is about. From the perspective of a person 'in the know', he is absolutely correct. Yet Mario apparently seeks the teacher's help substantiated in her addressing him with 'Yes, what is the question?' Jeanne has recognized that Mario has a question, and she articulates this understanding for us. The teacher also lets Aurélie – and everyone overhearing – know that her current way of sitting is not appropriate, and she asks the student to sit in the way one is expected to sit. Mario has filled the first row of his table of values, which is one of the goals communicated on the worksheet, and, despite successfully doing so (as judged from the outside), has become increasingly frustrated. That is, in the unfolding of his activity, as he realized his activity in a concrete way, Mario also changed his emotional tonality from confidence to frustration. As the activity is concretely realized in the material outcomes of Mario's actions, it also produces a negative affect. The coincidence of the affective expressions with the cognitive expressions is observable throughout this fragment. In fact, the difference between the two is undecidable, as they are produced simultaneously, in the case of the verbal productions even in the same medium (sound). One part of the sound material is heard as expression of cognitive content, the other as emotional content.

The instant is an expression of an inner contradiction, the co-presence of the current state and an object/motive that is not yet realized. The contradiction is reflected in consciousness, and expressed in both cognitive and emotional terms. Because cultural-historical activity theory is a dialectical approach, inner contradictions of the activity are understood as drivers of change: they are expressions of

change itself. Thus, contradiction is regarded 'as a necessary form of development of knowledge, as a universal logical form' (Il'enkov 1982: 234). That is, this contradiction is a necessary but, as we see, not sufficient condition for learning to occur.

The Relation of Emotion, Cognition, and Practical Activity

In this lesson fragment involving Mario and his two peers, the object/motive of activity does not and perhaps cannot emerge from their engagement because what they are conscious of (in what they make available for each other) is not that from which the generalization can (more easily) emerge. They count, they are busy with filling the required number of chips into the goblets, and they fill the upper row of the table of values. But this is not the object/motive of the activity. Mario announces his recognition of this fact in the expression 'I don't understand [Je ne comprends pas]'. It is precisely the momentary abandonment and the intonations that allow us to perceive the emotional quality of Mario's and Aurélie's current state, their frustration, their disorientation, and their questions. Each announces his/her assessment of his current cognitive state, 'I don't understand'. There is a gap between what they know and the object/motive of the learning activity, and this gap is so *large* that their current actions do not get them any closer; in fact, they cannot even establish how far away or how close they are to the object/motive. The contradiction that exists here is that Mario has already stated how to fill the table, already is on the way of realizing one of the goals toward the completion of the activity, but his emotional valuation is negative. Also of importance is the fact that Aurélie expresses extreme frustration although in the course of this fragment, her worksheet comes to be filled. That is, completion of the worksheet is not a sufficient criterion for completing the activity. Her frustration is the expression of the emotional valuation of the distance between where she is and the object/motive of the activity; this valuation goes hand in hand with the cognitive assessment: 'I don't understand. I will never understand'. We can appreciate here that the question for Aurélie is not just to get the table filled. She *wants* to understand, and not only to please the teacher.

In cultural-historical activity theory, 'the particularity of emotions is that they reflect the relation between the motives (needs) and the success or the possibility of a successful realization of the corresponding activity of the subject' (Leontjew 1982: 145). That is, 'emotional valences arise from emotional valuations of sensorially or cognitively comprehended object properties with respect to the 'appropriateness' for the reduction of certain negative state value and *change with the changes of the cognition of the corresponding objects*' (Holzkamp-Osterkamp 1976: 49). Emotions are the product and the mechanism of the motion of the activity. In Aurélie's and Mario's instance, we observe their emotive reaction as a result of the fact that despite their efforts, the motive of the activity does not reveal itself. We can also see in Thérèse's expressions of confidence the expressions of positive

valuations, as she has completed the important third row of the table of values with the corresponding values (3 x 1 + 6, 3 x 2 + 6, . . .). As the first part of the episode progresses, this becomes increasingly evident, and initially the girl, then Mario, indicates not to understand ('I will never understand'); both demonstratively stop their engagement. It is only at the very end of the events analyzed here (see next section), the positive valuation occurs as the motive progressively reveals itself, leading to a positively valued emotional state, clearly available to the onlooker in his comportment and the satisfied cognitive assessment of his current state by means of the utterance 'I understand'.

To become a learning *motive*, it is insufficient that the learner be conscious of the difference between his/her current prior knowledge and the learning object. S/he also needs to experience *directly the insufficient and partial nature of his/her current articulation of the learning object*. This experience necessarily introduces an emotional-motivational component: 'The obstructions to the realization of actions implies – as a limitation of control/life quality – a certain emotional sense of insufficiency, "frustration", disquietude, fear, and the likes as undisclosed premises with respect to the grounds and possibilities for overcoming the obstacles to action' (Holzkamp 1993: 214). It is this realization that serves as the emotional valuation at the source of the actions that diminish the gap between the current knowledge and the learning object. And the successful disclosure of the object/motive of the learning activity in its entirety – its objectification – is marked in terms of a positive emotional quality. Thoughts do not think themselves, and they do not *inherently* push themselves to learn and develop (Vygotsky 1986). It is only when there is an inherent emotional quality to knowing and thinking that we can understand why someone *wants* or *should want* to learn. But learning activity is easy to understand if successful disclosure of the initially unknown learning object leads to increases in control and action possibilities, increases that are associated with positive emotional valuations. It is precisely here that emotionality obtains an orientational function in activity with respect to the acquisition of knowledge (Holzkamp-Osterkamp 1978).

Evaluative feedback occurs by means of an emotional tone, which has a complex quality, and 'condenses all particular evaluations automatically into a unitary execution of action, on the basis of which alone goal-directed action is possible' (Holzkamp-Osterkamp 1991: 104). The emotional valuation of the conditions constitutes the first step of cognitive processes, including those that are involved in learning. 'The emotional reaction, generally a more or less diffuse feeling of "ease" or "unease" evoked by the complex situation, serves to inform and correct the conscious goal- or task-oriented exchange with the environment' (ibid.: 105).

Some educators might think that the teacher should have simply given the students the instruction to copy the number of chips into the equivalent table cell and given them the formula that could have led him to fill each of the cells in the third row of their table of values. But this would have been a mechanical acquisition of a lifeless fact that Mario might remember but that he would have less likely been able to use. It is possible, writes Leont'ev, to acquire factual knowledge in mathematics or physics in such a way that it remains dead and unused until life itself

awakens it – if the student does not forget the facts in the meantime. But 'if the subject matter content is not to be acquired in a formal manner, then we must not just "sit through" the lesson during learning, but we have to live it through' (Leontjew 1982: 281). This living through a productive process changes the person, who, in productive activity objectifies himself in the product of his labor and is subjectified as he becomes conscious of the outcomes of production, subjectifies the thing and activity in the form of the inner reflection and object/motive (Marx/Engels 1983). 'The inner (the subject) operates on the outer and thereby changes itself' (Leontjew 1982: 174). The lessons themselves have to become part of the significations for students generally and Mario here particularly. This signification arises from the motive of his activity, which is, as activity among other activities, constitutive of the totality of his life. It is precisely in the real life of the child that motives develop. The purpose of the lesson is not just to fill the worksheet, to get the numbers right in each cell. The purpose is for Mario and his peers to become conscious of the object/motive of their activity, which discloses itself in the course of the activity. It is not just the fact of the entries taking the form $3n + 6$ that matters but the child's consciousness of *his* activity and the role the object takes. Consciousness of his activity is possible only when the child actually brings about the activity, not when he is presented with the fact that the content of the cells take a particular form.

For Leont'ev, the transformation of the materials and means – that is, the text of the task into the goblet-chip model, and the table of values into the $3n + 6$ and into the consciousness of this product as it relates to the activity as a whole – *constitutes* the object/motive. The subject's awareness of how close it is to achieving the motive expresses itself affectively: positive emotive valuation when the object/motive is realized, negative emotive valuation when the object/motive remains out of reach. The thing subsequently produced is $3n + 6$. This is the *goal* of the activity and, at the same time, is only the material side of the double nature of the *object*. The formula $3n + 6$ is a material instance of the ideal object of the activity, which is *thinking algebraically about patterns*. The object only exists in this dual nature, and this would not exist if the teacher had told him that what he had to do was to fill the bottom row of the table according to the formula. This would have allowed Aurélie and Mario to fill the table of values in a routine, mechanical (thoughtless), and alienated manner. But this cognitive motive does not fulfill itself; rather, there has to be some *reason*. This reason is not the Kantian legislative and schematizing reason of human actions. It is rather one of the cultural and historical possible reasons that opens up possibilities for *thinking and feeling* marked by resonance in social forms of knowing. It is a reason out of which a sense of belonging is made apparent to the students. It lies in a positively valued subjective experience of an increase in control over life conditions, and room to maneuver and express oneself in a field of potential actions, agreements and disagreements.

In activity there is a primary sensuousness that contains cognitive and affective moments. As constitutive moments of sensuousness, the two moments cannot be understood independently but they are mutually constitutive and subordinate to the sensuousness, a psychic reflection of material activity. The vocal track, too, is a

means to articulate cognitive content (language) and emotional valence simultaneously. Mario does not just say that he does not understand, but the various prosodic parameters all are consistent with despair/frustration as shown in research on the correlates of affect and prosody (Scherer 1989). Because they are available to others, including the teacher, they also become resources in the interactional setting. These moments are created in sensual practical activity and are a reflection of the material world. Cognition reflects the object-content aspect of the conditions; emotions constitute valuations of the current conditions with reference to the object/motives that the ongoing activity is to achieve. *In* and *as result of* practical activity – which may entirely concern ideal entities – the 'affectogenic character of entities may be changed' (Leontjew 1982: 190). The same entity, in Leont'ev's case, a bear, may be the source of fear, during an unexpected encounter, or joy, in the case of a bear hunters waiting for their game. The emotional tonality of actions reflect the object/motives of activity, even when these are not present in consciousness, so that object/motives are never separate from consciousness, that is to say, from *objectifying* processes.

Emotions are expressed in sound as much as cognitive content is: Both are part of the same expressive material and therefore should not be considered as functioning independently (Merleau-Ponty 1945) but as two moments that each reflect the same situation but only partially and one-sidedly (Leontjew 1982). It is their embodiment and their physical co-presence that allows participants to make and have access to emotional valuations of each other: In this way that they shape the interaction rituals in and through which participants create society at the microscale (Collins 2004). The co-expression of cognition – Mario knows that he does not know – and emotion – Mario, as Aurélie, expresses frustration – is available to others, here Jeanne the teacher, who act upon these expressions. Jeanne and Mario are not mindless machines (computers) passing information (signals) between each other, they are corporeal human beings with emotions that they, too, make available by a variety of means including their body positions, body orientations, gestures, and prosody. Jeanne and Mario jointly orient to and collaborate in the production of sympractical activity, and this joint orientation is constitutive of their *participative (non-indifferent) understanding* (Bakhtin 1993). But theoretical cognition alone cannot explain the events we followed so far. Only activity as a whole gives us an understanding of the actually observed events. Cognitive content, too, may be articulated for others by nonverbal means, such as when a person nods to suggest agreement, and even hand gestures. In fact, hand gestures may articulate both, an affirmation that a response was appropriate (see gesture) even in the absence of words and a particular emotional orientation to the situation. Thus, just before the end of a subsequent fragment, Jeanne will make a two-handed gesture that might be glossed as 'You got it, so what was the problem'. We come to this and similar expressions on the part of the teacher in the following two chapters.