Emotion at Work: A Contribution to Third-Generation Cultural-Historical Activity Theory

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Second-generation cultural-historical activity theory, which drew its inspiration from Leont'ev's work, constituted an advance over Vygotsky's first-generation theory by explicitly articulating the dialectical relation between individual and collective. As part of an effort to develop third-generation-historical activity theory, I propose in this article a way in which emotion, motivation, and identity can be incorporated into the theory. I provide case materials from a 5-year ethnographic research project in a salmon hatchery that underscores the important role emotion and the derivative phenomena of motivation and identity play in the workplace generally, and in mathematical knowledgeability particularly.

Their [intellect and affect] separation 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 themselves," segregated from the fullness of life, from the personal needs and interests, the inclinations and impulses, of the thinker. (Vygotsky, 1986, p. 10)

Without doubt, motive, emotion, and identity are important aspects of our being in the world, and mediate what we know and how we know it. Yet most cognition research still does not include affect, opening it up as a target for the same charges that Lev S. Vygotsky had launched against "traditional psychology." Even research conducted within the framework of cultural-historical activity theory generally does not consider affect, though it plays an integral role in *Activity, Consciousness, and Personality* (Leont'ev, 1978), particularly because of the dialectical role motives and emotions play in activity. However, there now appears to be an emerging sense in the research community that emotion, and the derivative concepts of motivation and identity, ought to be included in the integral analysis of human activities generally, and to mathematical and scientific knowing and learning specifically. Thus, three leading researchers from different disciplines have recently highlighted to me the importance of these dimensions: Yrjö Engeström encouraged me to work on integrating emotions and motivation into activity theory; Jim Kaput suggested that identity would be the major research and development issue in mathematics education; and in science education, Ken Tobin suggested pursuing educational research from the perspective of sociology of emotion. Yet in much of the scholarly literature, emotion and motivation are treated as variables external to but (usually negatively) affecting cognition, and the potential connections between

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cognition and identity are hardly ever explored.[1] Cultural-historical activity theory (Engeström, 1987; Leont'ev, 1978), a widely used framework for studying knowing and learning in the workplace, currently does not have a place for the consideration of emotion and motivation and the relation of these dimensions to identity. The purpose of this article is (a) to provide evidence from a 5-year ethnographic study of a fish hatchery that shows how emotions are integral to what people do and know in the workplace in general, and in workplace mathematics in particular; and (b) to propose a way in which emotions and the associated dimensions of motivation and identity can be incorporated into cultural-historical activity theory as part of its third-generation expansion and development.

GOOD, BAD, AND UNREMARKABLE DAYS

Our performances at work are mediated by how we feel—we all know that good days and bad days influence our working lives, whether we are conscious of it and can articulate it or not. What we do, how we do it, and how much we want to do it, are all part of how well we perform the tasks that we face, and therefore the knowledge that we exhibit and thereby make available to others. This relationship is not unidirectional: Our assessments of our performances also mediate how we feel. Yet current cognitive theories hardly address these aspects at all, which has led to the expression *cold cognition* (e.g., Wyatt et al., 1993). Our preferences, mediated by how we feel and our emotional state, mediate our daily decision-making, both in general terms and in respect to the mathematical representations we find in our workplaces. Take the excerpt from an ethnographic study of a fish hatchery, where Erin, one of the fish culturists, is in the process of telling me (M) about how she uses graphs of targeted and actual average fish weight to make decisions about how often and how much to feed over the course of a year (Figure 1a).

Erin talks about the uppermost graph displayed on the computer monitor in front of us (Figure 1a, left), which had been constructed by a research scientist to guide feeding practices in the hatchery. She describes it as being much higher than her actual graphs and says that she does not like the flat part. The pitch of her voice as she articulates "don't like" almost doubles her normal value, and the speech intensity is four times (6 dB) higher than the normal ($\sim$78 dB), for example, in "the long flat" (Figure 1b)—both expressions of negative emotional valence (affective stance) with respect to the content of talk (cf. Goodwin, Goodwin, & Yaeger-Dror, 2002).[2] She later explains that the flat part, which in another graph provided by a scientist even decreases, means that the fish are starving and losing weight. Erin absolutely wants to avoid this situation. She explains that she does not want the fish to be stressed because of lack of food: "I don't feel as comfortable cutting it that close to the line where I have that long plateau where I have a minimal amount of growth where I'll–I'm just keeping 'em ever so slightly growing." Not only in this situation, but also throughout the many conversations we had in

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[1] There are studies from a sociocultural perspective on identity (Gee, 2001; Holland, Lachicotte, Skinner, & Cain, 1998), but here I contribute to theorizing identity within a radically dialectical and material cultural-historical activity theory framework consistent with current philosophical work on the topic.

[2] Intensity is measured on a logarithmic scale so that each 3 decibels (dB) in intensity corresponds to a doubling of speech intensity. Figure 1b shows much more than can be explicated here in any detail, including the pitch continuations in speaker–speaker transitions, which is an indication of solidarity and (unconscious) efforts to make the face-to-face meeting work (cf. Roth, Tobin, Carambo, & Dalland, 2005).
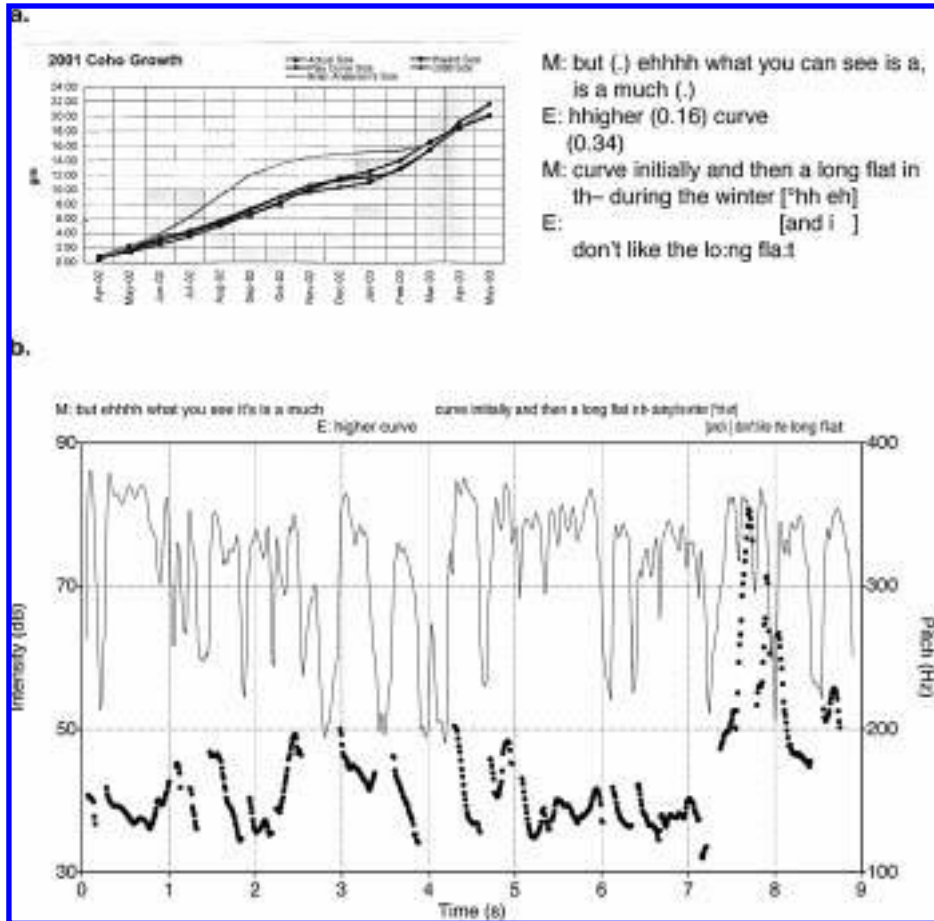
FIGURE 1 (a)Erin talks about why she does not follow the feeding practices that would lead to the (top) weight curve, which a scientist had recommended. (b)When Erin expresses dislike ("don't," "like"), the high pitch (●) of her voice expresses negative emotive value related to the topic of talk; speech intensity (—) is four times higher (i.e., 6 dB) than normal (~78 dB).

the course of this study, Erin articulates different aspects of affect that mediate what she does at work and how she does it. Furthermore, using the computer and a variety of mathematical representations allows her to understand better what and how the fish in her care are doing. Using these computer-based representations increases her room to maneuver with respect to the actions she plans for maximizing the benefits to her fish. The increased room to maneuver constitutes the payoff for the investment she makes, itself permeated by a positive emotional valence.

In describing the activities she enjoys, including the use of a computerized database she created, Erin also makes statements about who she is in relation to her work (place and people)

in general and the mathematical representations and computers in particular: She likes her work and she likes working with mathematical representations and computers. A little in jest, tongue in cheek and with a smile, she frequently announces, "I am a bit of a geek [nerd]": She likes both computers and statistics much more than any of her coworkers do. In this, Erin articulates aspects of her identity: She enjoys working with computers and mathematics, and exhibits this liking every time she uses them as tools for thinking about and improving her fish culture practice. Erin is recognized beyond this hatchery to be not only a good fish culturist but also good at computers and mathematics. Being good at something feeds back, makes it interesting and enjoyable to engage in, thereby producing and reproducing emotion, enjoyment, and motivation. Throughout the 5 years that I conducted my ethnographic research in the hatchery, I could observe the centrality of emotions, motivations, and identity issues not only to Erin's but also her fellow workers' work.

EMOTION AND COGNITION

Recent research in the neurosciences provides evidence that emotion (and with it, motivation and identity) is integral to action, even when we have neither good nor bad days, but just normal, ordinary, and unremarkable days (Damasio, 1994/2000). Yet important collections of studies concerning everyday cognition and practical intelligence in adult life (e.g., Poon, Rubin, & Wilson, 1989; Sternberg & Wagner, 1986) contain neither chapters nor index entries pertaining to emotion, motivation, and identity. Similarly, in much of the literature on learning, emotion and motivation are treated (if at all) as part of a system *external* to but affecting cognition (e.g., Hartman & Sternberg, 1993). The same observations are true for mathematical cognition: Emotion, motivation, and identity are absent from models proposed by leading researchers in the field (e.g., Greeno, 1989; Pinker, 1990; Tabachneck-Schijf, Leonardo, & Simon, 1997) or policy statements (National Council of Teachers of Mathematics, 1989). Emotion and motivation are also absent from third-generation cultural-historical activity theory, a useful framework for describing and explaining knowing and learning in the workplace (e.g., Engeström, Miettinen, & Punamäki, 1999; Nardi, 1996). Though widely different, all of these approaches to knowing and learning treat emotion, motivation, and identity as something external to models of cognition, which therefore is denoted as *cold cognition*. In this approach, not only is (mathematical, scientific, work-related) cognition treated independently of emotion, motivation, and identity, but also judgments and knowledge about emotion are treated independently of emotional states and experiences (Damasio, 1999).

Recent reviews of the literature show that there is a renewed interest in the interplay of feeling and thinking in social judgment and in the role of nonconscious processes in reasoning and behavior (Pintrich, Marx, & Boyle, 1993; Schwarz, 1998).[3] Much of our recent understanding of hot cognition derives from neuroscientific studies of patients with frontal lobe damage (Damasio, 1999). These patients usually have unimpaired intelligence, as determined by IQ tests, and frequently respond appropriately to verbal tests of ethico-moral reasoning, but are reduced in their ability to take appropriate actions. As a result, they often (physically, emotionally)

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[3]I distinguish nonconscious and unconscious. Nonconscious aspects of life, such as operations that constitute an action, can be made conscious. Unconscious aspects, however, such as the current level of hormones that constitutes part of the conditions that bring about particular operations, cannot become available to a knowing consciousness.

harm themselves or others. The one feature exhibited by these patients is an emotional flatness, a reduced capacity for feeling emotion. This is now considered to be the likely cause of the patients' problems in taking appropriate practical action. Emotion therefore is shown to be integral to practical action in at least two ways. First, the general emotional state of a person shapes practical reasoning and practical actions. Second, practical action is generally directed toward positive emotional valence—we act so that we are better off in the long run, even if it means that we have to incur costs in the form of emotional hardship in the short term (Turner, 2002). The role of emotional valence can be traced to single-cellular organisms. When it correlated motility with sensibility, the organism was able to fulfill dietary needs—and thereby achieve a state of higher valence—by intentionally orienting in and with respect to the environment (Holzkamp, 1983). Emotional valence hereby is the (inner) reflection of the current state of organism–environment relation in a double sense: (a) It reflects the currently salient (meaningful) aspect of the relation and (b) the degree of control the organism has over this relation insofar as it is individually relevant (Holzkamp-Osterkamp, 1977). Intentionally orienting and thereby achieving positive emotional valence therefore precedes any human consciousness and all the categories that accompany and derive from it.

Consciousness, motivation, and identity are subordinated to orientation and emotional readiness because, from evolutionary and cultural-historical perspectives, the latter predate the former (Damasio, 1999). The integration of emotional states has a dual functional relation: (a) It activates the organism to search for whatever is relevant to its current needs and (b) it is the basis for the identification, differentiation, and use of the thus-found meaning unit (Holzkamp, 1983). Identity and motivation are *effects* of the psychic life of human beings, which require consciousness and collectively organized activity and became possible at the dawn of anthropogenesis, when human subjects found themselves as subjects, separate from other material things and fellow human beings (Ricœur, 1990; Roth, 2006b). Thus, as dialectical phenomenological philosophers point out, any explication of human consciousness that posits the subject to understand consciousness and knowledgeability—as philosophers (Kant, Hegel, Husserl, Heidegger, etc.) and psychologists (all but critical psychologists) have done—inherently is flawed because it does not take account of history, that is, the emergence of the human psyche during anthropogenesis (Derrida, 2005; Franck, 2001; Levinas, 1998). This recent work shows how intersubjectivity and subjectivity are the *results* of collective life and having a material body, which allows the dawning subject, mediated by its embodied and bodily nature, to be conscious of itself as but one among a plurality of subjects (Nancy, 2000). Consistent with materialist dialectics, I suppose that any theory of human activity and cognition that does not take into account its own phylogenetic and cultural-historical origins is inherently nonviable (Roth, 2003).

Received psychological notions of emotion and emotionality are inappropriate for a general cultural-historical theory of activity, consciousness, and identity because they result from a detachment of emotion from action, which leads to an impoverished concept linked to submissive behavior and resignation (Holzkamp, 1991). My proposal for a way of incorporating emotion into cultural-historical activity theory is based on this integral relation between actions and emotions. I follow Vygotsky (1989) in understanding that emotions, practical actions, and reasoning are integral to the unit (of activity) and therefore are dialectically related: They presuppose and influence one another. Emotion and practical activity are not externally related,

in the cause-and-effect form that correlational studies suggest. Rather, there are inner relations between emotion and practical activity that make the former a constitutive element of the latter.

TOWARD A MORE INCLUSIVE THIRD-GENERATION CULTURAL-HISTORICAL ACTIVITY THEORY

Conscious, goal-directed actions take a central place in cultural-historical activity theory, where they mediate between activities directed toward societal motives, and nonconscious operations conditioned by the context (Leont'ev, 1978).[4] Actions are therefore both conscious cultural-historical and nonconscious, materially embodied features of human cognition. On the one hand, activities and actions mutually presuppose each other. Activities such as "fish hatching" are realized through concrete, goal-directed practical actions such as "fish feeding," "ordering feed," or "cleaning a fishpond." But actions are only accomplished *because* they realize a specific activity. The sense attributed to a particular action arises from its relationship with the activity such that the same action has a different sense when produced in a different activity system. The actions of fish feeding or cleaning a fishpond look very different, and are related to a different sense, in the context of a backyard pond. This results in the societal dimension of a (material, discursive) action. On the other hand, actions and operations also presuppose each other, as a particular practical action is concretely realized by operations that are executed only to bring about the intended action. Thus, the action of feeding fish involves many operations of which the fish culturist is not consciously aware, such as flicking the wrist to achieve a fanlike spreading of food particles and perceiving whether fish snap for food. The same flicking of the wrist, or the same type of gaze, accomplishes very different actions in other contexts. Among the conditions shaping an operation are the current state of the action and the neurological, biochemical, neuromuscular, and emotional states of the body (Damasio, 1994/2000).

There are three aspects to emotion relevant to this study, which I understand as standing in dialectical relations to one another.[5] First, individuals act such that there are some payoffs on a short- or long-term basis (Turner, 2002); emotions "reflect relationships between motives (needs) and success, or the possibility of success, of realizing the action of the subject that responds to these motives" (Leont'ev, 1978, p. 120). Learning that occurs in the process is expansive, for it leads to the increase of a person's room to maneuver and increased likelihood of success (Holzkamp, 1993). It is not pleasure that is maximized but emotional valence. Losses have a negative valence and generally are avoided—at least on a long-term basis; learning to avoid losses and penalization is defensive learning. People consciously participate in certain activity systems over others and frame goals that have a higher probability of success, and therefore a higher emotional valence. However, simply talking about a practice does not give

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[4]In English, activity in the sense of cultural-historical activity theory, and activity in the sense of doing things, are not distinguished, leading to considerable confusion in the research community because theoretically important distinctions are not made. Other languages, such as German, do make the distinction—Tätigkeit and Aktivität, respectively—and thereby avoid the theoretical confusion observable in the Anglo-Saxon literature.

[5]Only in a dialectical perspective, where emotions are both produced and reproduced in concrete practical activity, can scholars overcome "openly hedonistic conceptions, the essence of which is that all activity of man is in some way subordinated to the principle of maximizing positive and minimizing negative emotions" and the associated "hedonistic conceptions of motivation" (Leont'ev, 1978, p. 120).

"access to ideas, methods of reasoning, 'skills,' and emotions from that practice" (Evans, 2000, p. 151); there is ample evidence from research on teaching and other practices that talk *about* practice yields substantially different forms of knowledge than *enacting* practice (Bourdieu, 1990), including the attendant emotional aspects (Roth & Middleton, 2006). In fact, the aforementioned research on persons with frontal lobe damage showed that they did quite well on word problems requiring talk about ethical aspects of acting; but these people did not do well when participating in praxis and practical reasoning (Damasio, 1999).

It is the second, tacit aspect of emotions that is of relevance to the nature of actions in practical activity. Here, unconscious aspects of emotions—the emotional states of the living body—condition operations and therefore the concrete ways actions take shape. These emotional states are the result of various bodily systems—including neuromuscular, biochemical, and neurological (internal) environments—that constitute the conditions for the operations which, properly seriated, produce an action. These emotional states themselves are the outcome of practical action, so that we have to understand them as continuously produced and reproduced in practical activity.

The third aspect concerns its collective aspects. Emotions are not only individual but also collective. Through social mediation, individuals come to know about emotion (Collins, 2004), but we also shape and are shaped by the collective emotional state of the moment, often denoted by the term *mood*. Being at the workplace, attending a sports event, or having a drink with friends mediates how people feel: We fear the boss, go crazy over our favorite who is winning the game, or enjoy the company of others, but we know these emotions only because we have learned about them in interactions with other members of the culture. Within activity theory, the key entry point to understanding lies, again, in practical action, by means of which persons nonconsciously make emotions and emotional states available to others. These others may, in their own actions, produce and reproduce the same or similar emotions, leading—through the process of entrainment—to the production of a collective emotion. Collective emotion expresses itself, for example, as widespread job dissatisfaction, discontent with management, or disidentification with the workplace (Roth, Hwang, Lee, & Goulart, 2005).

ETHNOGRAPHY OF A SALMON HATCHERY

In this article, I draw on an ethnographic study of the Canadian *Salmon Enhancement Program* in general, and one of its hatcheries in particular. The main purpose of a hatchery is to take eggs and milt from salmon after they return from their ocean journey and before they die. The eggs are fertilized with the milt and then raised in spawning channels or incubation batteries until young salmon hatch. These salmon are then raised to a size ready for their release, the optimal release size and date being determined by past experience and some scientific experimentation. The work in the hatchery involves an important part of the lifecycle of the fish, beginning with an "egg take" and fertilization (Figure 2a), raising the eggs in basins stacked in the brood hall until the fish hatch and turn into alevins, and then fry (Figure 2b), transferring fry to an outside pond (Figure 2c), and feeding the young fish until they smolt, at which time they are released into the neighboring river (Figure 2d). After spending between 2 and 5 years in the ocean, the surviving adults generally return to the same hatchery, where they die or are killed for the eggs and milt to be taken.

FIGURE 2 The societal motive driving salmon hatcheries is the production of juvenile fish for the purpose of increasing the number of adults returning from their several-year sojourn at sea. The work includes (a) taking, fertilizing, and processing eggs; (b) raising the eggs to the alevin and fry stage; (c) transporting the fry the outdoor ponds; and (d) feeding the fry until they smolt, at which time they are released. Tools, instruments, and technology heavily mediate the activity system as a whole and many individual actions.

The hatchery under study consists of two managers, five fish culturists, a maintenance supervisor, and an administrative assistant. Depending on seasonal demands, up to 30 temporary workers assist in the operation (e.g., feeding) and maintenance of the place. Much of the work takes place outside the offices, though each fish culturist has an office where records are kept, books and other work-related resources are stored, a computer with Internet connection is available, and so on.
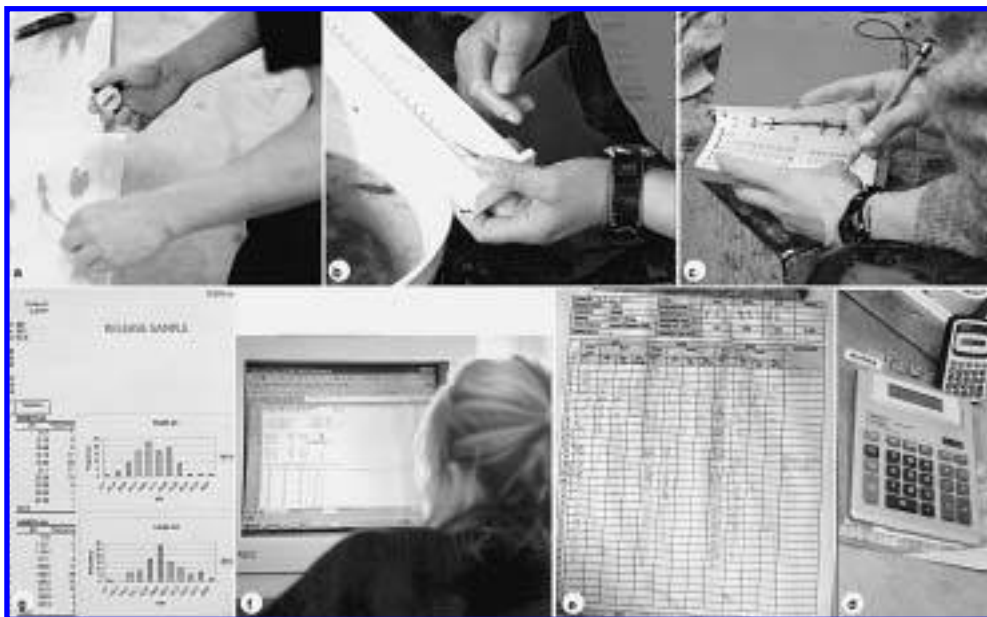
FIGURE 3 Mathematical behavior is observable throughout the activity
system and usually is mediated by some tool. This behavior includes (a)
counting, (b) measuring, (c) note taking, (d) calculating, (e) recording,
(f) processing and transforming data, and (g) producing reports including
a variety of mathematical representations.

Mathematical behavior is pervasive in this workplace. It includes counting (e.g., of eggs
during the egg take [Figure 3a]), measuring of fish length (Figure 3b) and weight, producing
and recording many different kinds of data (Figure 3c), calculating various mathematical indices
(Figure 3d), recording the amount of feed used and mortalities on a daily basis (Figure 3e),
entering data into computer databases, transforming data into mathematical representations
(Figure 3f), and producing reports that include tables, graphs, histograms, and many other
calculated variables that are important to the management of a fish population (Figure 3g).

As part of this study, I collected data both (a) as a contributing participant in the major daily
and seasonal tasks at the site and (b) as a mere observer of events. As part of my research
agreement with the hatchery, I contributed as a helper in the various tasks that had to be done
on a daily, weekly, monthly, and even yearly basis. By working as an apprentice in the hatchery
and thereby contributing to the realization of its object/motive, I learned the different tasks
and got to know the hatchery activity system from the inside.[6] As a helper, my goals were
therefore those defined by the task and motive of activity; in this case, reflection on the day's
work constituted the means of collecting informational sources. At other moments, I engaged
in observation and recording. In this mode, the data sources included observational field notes,
videotapes of everyday activities, recorded and transcribed formal interviews, photographs,

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[6]For information on apprenticeship as ethnographic method see Coy (1989).

documents, scientific and mathematical representations, and various other notes and reports created and used as part of the everyday work in the study site. The two forms of ethnographic work—participant observer and observing participant—provided different perspectives on, and constitute complementary ways of experiencing, the productive work in the study site (Roth, 2005c).

The central dimension studied here is emotion related to mathematical activities in the physical plant and in the offices of the hatchery. Two aspects of emotion are articulated in different ways during the analysis. On the one hand, the hatchery workers articulated, during interviews, goals and purposes, levels of job satisfaction, (dis-)identification with the organization, and other comments pertaining to emotionality made during the work itself. This aspect of emotion is therefore available through analysis of interview and (recorded) observations (Roth, 2006a, 2006c). On the other hand, momentary and long-term emotional states are, in part, expressed by means of prosody (Goodwin & Goodwin, 2000; Johnstone & Scherer, 2000); these aspects therefore can be revealed through the analysis of voice parameters such as pitch, pitch contour, speech intensity, and speech rate. The method has been shown to be reliable in a number of different ethnographic research settings, including the analysis of seventh-grade students learning physics through artifact design (Roth, 2005b), studies of mathematical cognition (Hoffmann & Roth, 2005; Roth & Middleton, 2006), and student–teacher and teacher–teacher interactions in multicultural inner-city classrooms (Roth, 2005a). In this study, I used PRAAT, a computer software package for voice analysis.[7]

EMOTIONS AT WORK

Emotion, motivation, and identity are pervasive dimensions of everyday work that, though sometimes hidden from first sight, become apparent during extended participation in everyday, routine, and not-so-routine, work. Here, I articulate some of the ways in which observed emotions mediate engagement in the hatchery workplace.

Emotions and Understanding Work

Studies of cognition generally deal with information available to workers and what they do with it, including—depending on the theoretical framework used—processing, interpreting, or making sense of it. Researchers thereby neglect the fact that human beings are involved in activities with motives realized by concrete, goal-directed actions. Workers have a practical understanding of the progress toward reaching the intended goals and motives; they exhibit this understanding to others as the activity unfolds. The understanding may express itself prior to any reflection, which may subsequently come to be articulated as well. The tapes recorded in the hatchery exhibit many instances of both types of expression, as exemplified in the following episodes recorded while Erin—a fish culturist with over 13 years of experience—was doing one of her monthly samplings which includes measuring the length and weight of 100 randomly drawn fish from each of three ponds.

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[7]This software can be found at www.praat.org and is available for all major operating systems.

The first two episodes exemplifying emotion at work were recorded while Erin was measuring coho salmon lengths (Figure 4, top), assisted by a helper who (a) measured fish weight and (b) entered lengths and weights into a computer database. In the first episode, Erin uttered "O::ü:: (0.61) ah:: one thi:rtee:::n (0.95) wicked" (Figure 4, center). The interjection occurred in a pitch range more than twice the normal level for Erin; even in the subsequent verbal articulation of fish size and the subsequent commentary, the pitch was considerably above Erin's normal range of 160 to 190 Hertz. Furthermore, the sounds and words in the initial part involved speech intensities between four and eight times higher than the surrounding talk (Figure 4, center). Contentment and happiness are indeed correlated with increases in pitch, pitch range, and speech intensity (Pittam & Scherer, 1993). Here, the initial outpour was drawn out, expressing a positive emotion over the fish size available to Erin, which turned out to be 113 millimeters; the production of the vowels in "thi:rtee::n" was drawn out, therefore producing audible emphasis of the number. The initial emotional expression was then articulated verbally by means of a term normally used (in slang) to express or denote states of affair judged to be excellent, splendid, or remarkable ("wicked"). Here, therefore, the positive emotional state over the measurement in particular, and its contribution to the representation of overall fish health in general, was made available to others present in the wet laboratory by prosodic and verbal means.

Similarly, Erin expressed disappointment when she selected a coho salmon from the basin that was particularly small (Figure 4, bottom). Thus, in one instance, Erin commented, while picking up a fish, "way low," which she followed up with a strong expression of dislike ("darned"). Here, the expression involved a much lower than normal pitch and pitch range, and the speech intensity also was much lower than normal. All three are expressions (correlates) of resignation (Pittam & Scherer, 1993).

Erin's emotions were also available in her actions while she was working with mathematical representations. Immediately after completing the sample, Erin decided to take a look at mean fish weight and size, and at the distributions (Figure 5, top). When distributions became available on the computer monitor, she moved the cursor to the upper end of the histogram of weights and directed my attention with an outburst, "Oh my god, look at them up there, ohoh." She then uttered, "I am there, I am so there," by means of which she indicated to be on target (or better) with respect to the ideal fish size at release. She finally made a reflexive comment, "I'm not even concerned," which connoted the fact that the 18-month effort of raising this brood would be successful. The voice analysis provides evidence of the high level of emotional energy expressed: There was an increasing average pitch level during the outburst, accompanied by high peaks of speech intensity. Even during the subsequent speech productions, the average pitch level was considerably above normal pitch, and the range between the peaks and valleys was very large (i.e., about 200 Hz for "I am there" [Figure 5, bottom] compared to the 35 Hz in the expression of disappointment [Figure 4, bottom]).

In addition to the expressions of current emotional states, my data exhibit changes in basic emotional toning over longer periods of time. Toward the end of my research project, Erin, who filled in for another fish culturist, was laid off. At the same time, her coworkers suggested that she often "wasn't her old self." She became "higher keyed" and frequently was "on the edge." Interestingly, the analyses of pitch levels prior to, and after, the layoff notice show an increase of mean pitch level and a widening of range, from 200 to 240 Hertz. Such a higher pitch level is equivalent to the verbal expression of "higher key." There were also many more
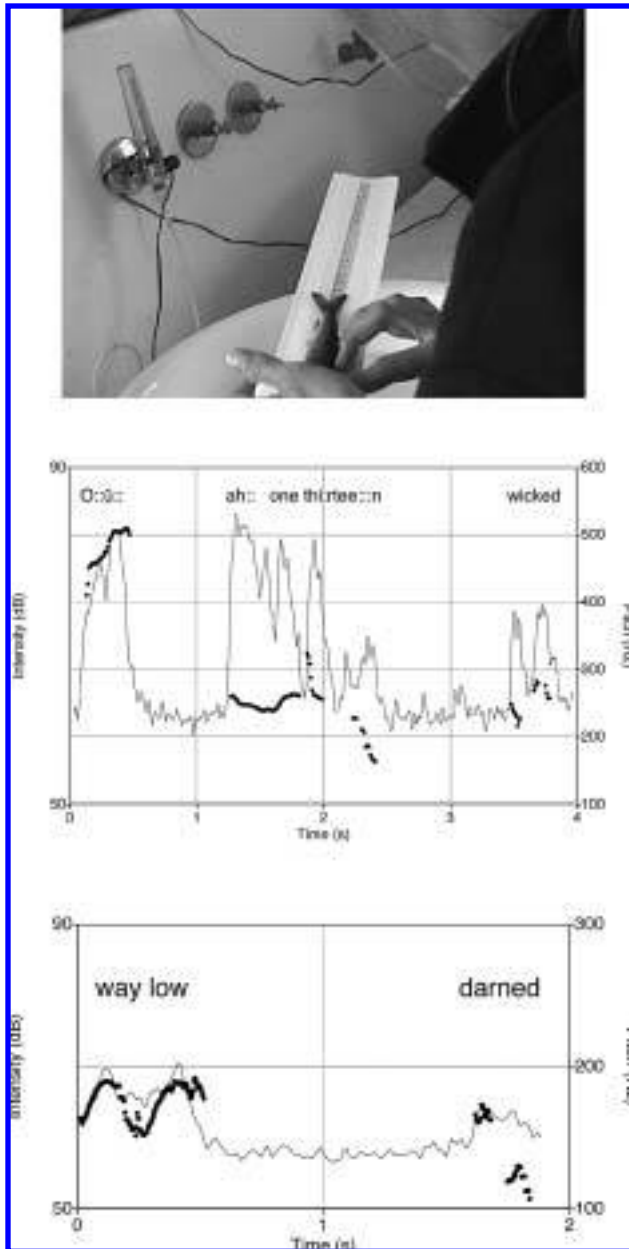
FIGURE 4 Erin is in the process of taking a sample, measuring fish length (top). She expresses elation over the size (length) and therefore health of a specimen while doing her monthly sampling (center). She expresses disappointment when a fish is small (bottom) Erin intuitively knows how this fish will contribute to the subsequently plotted distribution of fish length and weight and this intuitive knowledge is associated with emotional states (elation, disappointment) that are made available in real time through pitch.
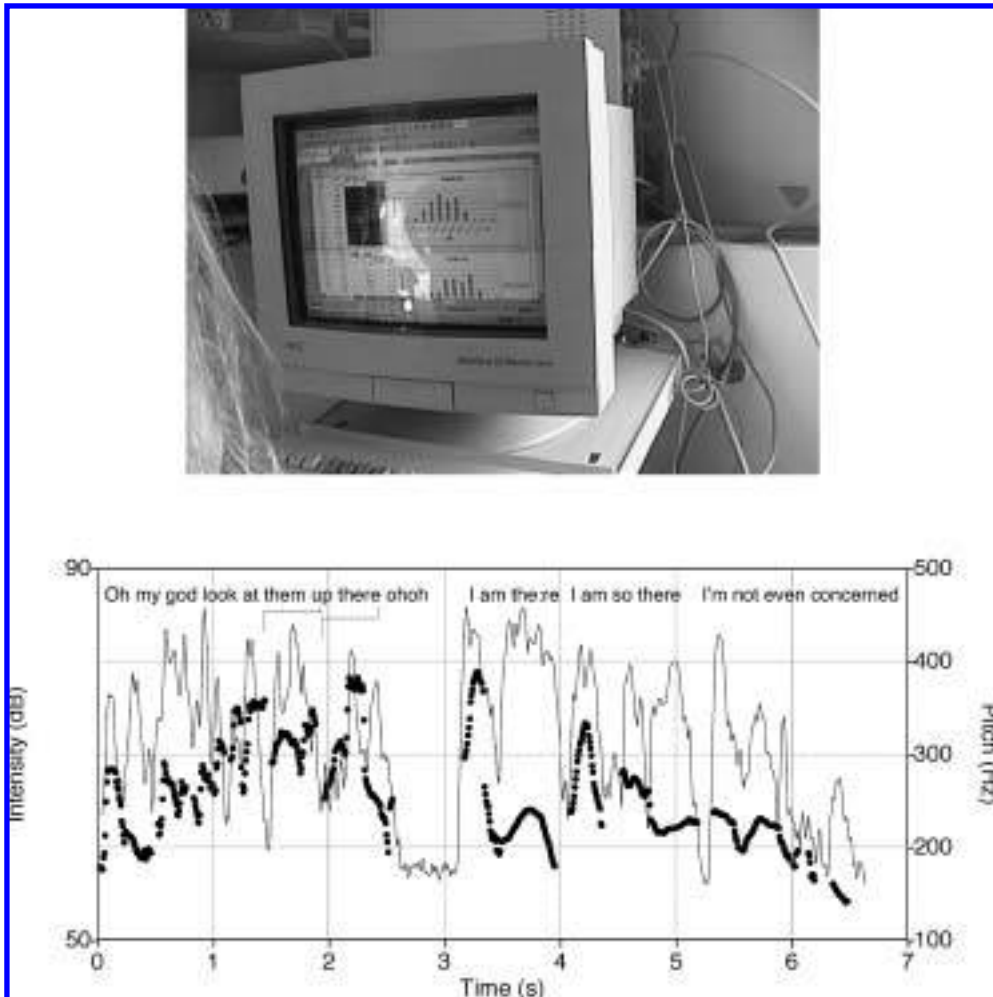
FIGURE 5 As the histograms displaying the length and weight distributions become available on the computer monitor (top), Erin vocally expresses high emotional valence prosodically and then articulates the reasons for the positive emotions in terms of "being there," that is, having distributions that express a nearly ideal state of the salmon population (bottom).

emotional outbursts with large differences (as in Figure 5) after the layoff notice compared to the data from the years prior to it. There was, therefore, an observable correlation between emotions, as expressed unconsciously through prosody, and the changes in work-related material actions.

EMOTIONS AND CHOOSING BETWEEN
DECISION ALTERNATIVES

Emotionality is not only associated with bodily states but also enters practical-reasoning processes where subjects of activity deliberate about short- and long-term outcomes and actions are taken such that in the long run they lead to positive emotional valence. That is, actions and their outcomes mediate short- and long-term emotional states. This aspect of emotionality of work is exemplified in the following examples.

The amount of feed to be dispensed to the fish is not a purely mathematical problem, to be calculated based on the equation:

$$\text{desired average weight} = \text{present average weight} + \frac{\text{feed [kg] * feed conversion rate}}{\text{number of fish in pond}}$$

The desired increase, implemented by means of actual feeding actions, is itself laden with emotional valence, as my introductory example showed. But there are other decisions that are equally laden with positive or negative emotional valence shared by other members in the hatchery community. For example, changes in the price regime are associated with threats to the budget, and therefore inherently laden with threats to jobs and other aspects of the hatchery operation, and ultimately the survival of the hatchery itself. Even if these attendant considerations did not exist, making a decision to use one product over another is centrally shaped by the coarticulated emotions. Thus, for example, different companies produce feed of different composition, price, consistency, shape, size, structure, and so forth. Going with one company over another is not something that can be done entirely using logical calculus. Choosing one company over another according to any one or more of these factors involves a cost-benefit consideration, which, in practical decision-making (rather than laboratory experiments, e.g., Damasio, 1994/2000), inherently involves uncertainty, risk, commitment, and potential repercussions for the fish, the individual fish culturists, and the hatchery collective.

> There's been about a 20% increase in the price of food–um that was a decision-making factor for me in ordering food to . . . to finish off my coho for this year where I had been feeding Moore-Clark [a feed company] but because of that 20% price increase that they had a little bit earlier than EWOS [another feed company] I went with EWOS. (Erin, personal communication, February 7, 2002)

In this situation, the decision-making did not just account for higher prices. Decision-making inherently was about costs and payoffs. The action of relevance here is making an order, and in placing the order, there is an emotional stake. These emotions are not just individual—somehow the product of hormones and chemistry in Erin's body; they are shared within the hatchery collective, by all other fish culturists and the management. This shared emotional state is produced and reproduced in daily face-to-face meetings; each individual fish culturist contributed to concretely realizing the collective state, but the collective emotional state mediated the individual state. The situation in the hatchery became morose when the operating costs increased, while the funding to the hatchery provided by the federal Department of Fisheries and Oceans decreased and continued to do so during the course of my research. This then led to Erin, among others, losing her job—itself an event that further decreased the collective emotional valence concerning the workplace.

Erin's emotions during this period were ambivalent. On the one hand, she was no longer the same, which her coworkers attributed to the layoff. On the other hand, her emotional valence remained relatively positive. It was apparent in the fact that she continued to do "300 %," (Erin, personal communication, May 24, 2003), and to share continued concerns for the costs incurred to the hatchery throughout its operation. For example, on one occasion, Erin and I had returned from a trip into the estuary, where we had fed and taken measurements on juvenile chinook salmon kept in a floating pen for the last 4 weeks before their release. Erin had the keys to the harbor site, which were needed by another group of employees working with juvenile salmon in the harbor. Concerned with the costs of doing multiple 50-kilometer roundtrips between hatchery and harbor, Erin called the hatchery and, having found out that the other team was on its way, decided that we would wait in the truck to hand over the keys. (It turned out that the two groups missed each other and Erin had to return without having accomplished the passing of keys.)

Here again, Erin's action of waiting in the truck, though she could only guess that the other group would come past our parking spot, centrally involved the concern for cutting costs for the hatchery. Such actions also fed back on her emotional state, making her feel good for having accomplished something. Many other persons in her place might have exhibited the opposite reaction and, indicating that they did not care, returned to the hatchery, thereby necessitating a double trip. Even in this case, an emotional valence would have been a central aspect of the decision—here a negative one. Another fish culturist, Jack, was "fed up with the management" because it had interfered with bringing about experiments that satisfied his learning needs. Jack continuously acted with and reproduced a negative emotional valence, which expressed itself in his discontinued identification with the motives enacted by the hatchery management. Presumably, emotional valence was a central operative factor even if no emotional reaction was apparent, because it provided workers with a sense of who they were at any one moment, and therefore the grounds for taking actions that increased the current emotional valence.

MOTIVATION AND IDENTITY AT WORK

Motivation and identity are not independent constructs but are derivative, an integral aspect of an activity system in general, and emotion—which is centrally involved in the shape of practical actions and practical reasons—in particular. Motivation and identity build on the motive, goals, and associated emotional valences available in practical action and practical reasoning. Brief examples from my fieldwork for each construct are provided.

Motivation

The two latter examples in the previous section not only exemplify the role of emotion but also the nature of motivation as a result of the level of emotional valence to be gained through practical action. Motivation therefore is not an independent aspect of action but is constituted by a (conscious or nonconscious) consideration of the emotional payoffs that result from the

action (Osterkamp, 1990; Turner, 2002).[8] Motives and goals are conscious; associated with motives and goals are intuitive understandings of the levels to which these have been achieved. Individuals choose to participate in activities and, as part of this participation, choose goals that promise some type of payoff—more often than financial, payoff is related to satisfaction, sense of accomplishment, expansion of action possibilities, expansion of control over life conditions—and higher emotional valence.

Erin always felt rewarded when she knew that a task was well done. Her learning was expansive in the sense that she became better at being a fish culturist and gained greater control over the various aspects that produced a healthy fish population at release time. Learning to operate a database and produce mathematical representations increased her practical understanding of pisciculture; reflexively, her increased practical understanding of pisciculture mediated increased control over the mathematical model of the fish population (Roth, 2005d). Erin continued to reap emotional benefits from working, even though her relationship to management deteriorated, given that it had decided to give an equivalent short-time position to another person currently not employed. Whereas she was at variance with management, the negative emotions produced and reproduced individually and collectively in encounters with both managers were not sufficient to decrease the positive emotional valence that she achieved from a job well done. Although Erin knew her job had gone, each action confirmed that she was (for herself and others) not only a competent but also a dedicated fish culturist; from this confirmation arose a positive emotional valence that kept her going "at 300%."

Jack's situation was different. There had been a time when he, too, was "giving 300%." (Jack mentored Erin, in whom he saw another outstanding fish culturist.) In part because he gave so much, Jack learned a lot and became widely known as *the* expert concerning chinook salmon and steelhead trout: The successes of this hatchery were to a large extent Jack's successes. However, he experienced a number of setbacks that changed the situation. One particular instance that repeatedly cropped up during interviews was an experiment that he had designed and conducted; he still proudly showed visitors the internal report he had produced with the help of a support biologist. In his assessment, the study was so well conceived that it deserved publication in a scientific journal, because it would have acknowledged the knowledge-producing aspect of everyday fish-hatching praxis. For another study, he had received a national award. However, neither the support biologist nor the hatchery managers nor research scientists were sufficiently interested in providing the necessary support that the high school graduate Jack would need to produce an article that would stand scientific peer review. Jack began to attribute this and other incongruities to the corporate culture (of the Department of Fisheries and Oceans) in general, and to the then new hatchery management in particular. The attribution was related to a continuous production and reproduction of anger (a negative emotion) toward the institutional system that entailed a lowering of his commitment.

Interestingly, there were some fish culturists who felt a sense of solidarity associated with negative emotional valence toward the management. The sense of solidarity was produced and

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[8]Educators often use motivation to explain why students do not do what the teacher asks them to do. If some task does not lead to a payoff—emotive gains that come with the expansion of action possibilities students obtain by realizing an object/motive—there is no reason for them to engage and therefore they are "unmotivated." This articulation shows the derivative character of the motivation concept. Further, this framing shows the nature of the traditional construct as the internalization of external constraints—"motivated" are those who do on their own what someone else wants them to do (Holzkamp, 1993).

reproduced whenever these workers engaged in face-to-face talk, with workplace problems as conversational topic. There was an apparent dialectic at work. On the one hand, the participants in these encounters—for example, Erin and Jack—accounted for the aspects that negatively mediated their relationship to the workplace. On the other hand, the negative relation was sustained and even further aggravated during such encounters—for example, after Erin received the layoff notice, and again when the managers offered a temporary fish culturist position to a less qualified and less experienced person. The fish culturists not only were subject to the collective mood of the workplace, but each contributed to producing this mood. The participants expressed "disgust" and "disappointment;" both terms denote negative emotional valence with the event. On the other hand, collective emotions only existed through their concrete realization in individually embodied emotions. In his everyday actions and talk about work, Jack expressed negative emotions toward work and these negative emotions were sustained and even augmented in conversations about management with like-minded coworkers. Collectively, there was, then, a sense that things were going from bad to worse.

Identity

In the context of cultural-historical activity theory, identity is a derivative construct in the sense that it presupposes the existence of the subject who, regulated by emotions, engages with an object of motive-directed activity, and who becomes aware of itself as self. Identity presupposes the presence of memory and consciousness (Ricœur, 2004). The construct of identity pertains to who someone is. However, we do not know *who* a person is independent of the actions of that person. Being shown the middle finger by another car driver, we may think, "he *is* a rude person;" overhearing someone using the four-letter f-word incessantly, we may think, "she *is* crude;" and seeing a group of students performing incredible stunts on their skateboards, we may think "they *are* skateboard experts." In all of these examples, attributions about *who* someone *is* are made based on observable behavior (actions). Actions that are already means of expressing emotions and motivations also come to express identities. This was also the case in the fish hatchery, where, as I already noted, Erin's peers found her to exhibit a different self after she received the layoff notice. This different self was in part expressed in different emotional valences. The case of Jack expresses the changing nature of identity in the workplace and how it is related to emotions and emotional payoff.

   Peers and scientists recognize Jack as one of the outstanding fish culturists in the entire salmon enhancement program[9] and in Erin they recognize a legitimate heir to her mentor. That is, in each of their actions, others not only recognized Jack and Erin as doing their jobs, but also witnessed levels of competency that exceeded that of other fish culturists. Although Jack has been a member of the hatchery collective from the start, with its object, means of production, division of labor, and rules, some attribute to him the tremendous successes associated with one specific rearing program. Among his peers, support biologists, scientists, and veterinarians, therefore, Jack is recognized as a knowledgeable expert, someone giving "300 %," and an ideal mentor for fish culturists, their replacements, and temporary workers alike. In former times, Jack felt intrinsically rewarded by his work and, with it, he felt good about himself. He knew

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[9]There currently are 18 federal hatcheries spread over a province 7.3 times the size of England and 1.4 times the size of Texas, the largest U.S. state.

that others appreciated his expertise, and was aware of his ability. In each of his actions, Jack not only recognised who he was with respect to others and himself, but he also produced and reproduced the identity of a competent fish culturist.

After a series of events, however, he became disaffected with the hatchery management, which led to a downturn in the satisfaction he received from his work. When he started working at the hatchery, its manager had, in Jack's words, "gone out of his way" to make available resources that allowed the personnel generally, and Jack in particular, to engage in practices that were linked to learning. Jack designed and conducted experiments, attended workshops and conferences for fish culturists, and contributed to the production of documents (i.e., a primer on fish diseases, and experimental reports) that others could use as resources for changing their own practices. The new managers, however, made it more difficult to propose and conduct experiments, cut the budget for attending conferences, and made any change in current practices (i.e., the status quo) more difficult. Interactions with the new managers were laden with conflict. From the perspective of interaction ritual theory, such conflict-laden interactions draw emotional energy from a person, which is required for the ongoing sense persons have of themselves and for their ongoing self-confirmation (Collins, 2004; Turner, 2002). Because the endless discussions were emotionally draining, Jack began to orient himself toward work as "just another job." He worked to rule, did his 8 hours, and generally selected tasks that allowed him to work on his own and minimize contact with managers. He was no longer interested in learning by conducting experiments or by adopting and becoming knowledgeable about new tools that had become available in the course of his tenure at the hatchery. For example, when he had started, computers did not exist. Now all fish culturists and managers have computers on their desks. However, apart from an occasional e-mail, Jack does not use the computer, the databases, or the mathematical models. He does not use them, although Erin, a self-avowed "computer nerd," offered repeatedly to assist and teach him. He did not have a sense that learning to use computers and mathematics would increase his possibilities as a fish culturist. In his autobiographical narratives, Jack repeatedly produced and reproduced himself as the diametrical opposite to Erin, not interested in mathematics and computers, only being high school educated, and having no ability in those areas. At the same time, becoming more knowledgeable no longer promised a higher emotional valence; that is, he was no longer "motivated" to learn and change his practices. There no longer exists an emotional payoff. Management and outside visitors now may easily conclude that Jack, despite his tremendous knowledge, is an "unmotivated" worker who merely "puts in his time," getting his emotional rewards from activities after work—including growing garlic and other vegetables for sale, or building a new home from scratch. That is, who Jack is with respect to others and himself is integrally tied up with his actions and the emotional valences that they produce and reproduce. As Vygotsky (1986, p. 10) noted, "the influence of thought on affect and volition" as an integral aspect of activity becomes evident only when intellect and affect are theorized and analyzed as complementary expressions of the same unit.

EMOTION, MOTIVATION, AND IDENTITY: A REVISED THIRD-GENERATION CULTURAL-HISTORICAL ACTIVITY THEORY

In the two preceding sections, I provide evidence and examples for the pervasive nature of emotions at work, denoting both (a) how they do work in mediating actions, motivation, and

identity and (b) how persons continuously produce and reproduce them as part of their ongoing engagement in the workplace. Because emotions are an irreducible aspect of activity, they cannot be claimed to be the cause of other aspects of the activity. Thus, positive emotional valences lead Erin to use computers generally, and engage in mathematical modeling specifically, and in this engagement she produces and reproduces actions that lead to the construction of her geekish nature. But because of this geekish nature, she uses computers and mathematics more than any other person in the hatchery. The two aspects mutually presuppose each other, as do any other set of aspects that one might wish to analytically separate out. Erin's intention to learn about the fish in her care is as much a part of the activity system as the technology she uses to plan and act, such that it optimizes fish health and minimizes negative impact (e.g., stresses related to inspection and data collection or lack of food and starvation during winter months). And each time she successfully completes a report about a fish population released, there is positive emotional feedback deriving from a task well done, a sense of competency with fish and technology, and job satisfaction generally.

The evidence shows that there are at least two very different aspects to emotion. There are aspects that are part of the grounds for forming goals and buying into collective motives[10] and therefore practical reasoning, which deliberates intentions, reasons (grounds) for action, and payoffs. For example, Jack knows that discussions with management are emotionally draining, leading him to work to rule and to draw gratification from his after-work activities. These conscious aspects, however, are not the most important ones. There are emotional dimensions that are inaccessible to consciousness yet still mediate practical (situated) action—the financial uncertainty related to her layoff put Erin "on the edge," which was associated with forgetting to do tasks. The examples show that emotions mediate and shape actions and, in turn, actions and outcomes shape emotions and emotional valence.

Emotion, motivation, and identity are three integrally related concepts, the latter two being effects of the former (Turner, 2002). According to categorical reconstructions of human cognition and consciousness (Holzkamp, 1983) and recent neuroscientific research (Damasio, 1994/2000), emotion is an integral aspect of practical action that always involves commitment and responsibility. Brain damage studies show that afflicted persons retain normal levels of intelligence—particularly declarative and procedural knowledge—but when emotion-generating parts of the brain are impaired, practical decision-making is impaired as well. In Figure 6, I present a model that integrates emotions, motivations, and identity into an approach grounded in cultural-historical activity theory in which practical action takes a key role (e.g., as analytic starting point).

Activity theorists begin their analyses with a consideration of the nature of the activity and then proceed to ask questions such as: "Who is the acting individual or collective subject?"; "What is the object of activity?"; or "Toward which collective entity (community) is the subject oriented?". In this approach, subject and object cannot be understood independently but stand in a dialectical relation (Leont'ev, 1978). Because the relevant object includes the motives, materials, knowledge, and vision of the outcomes, the nature of the object necessarily

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[10]Buying into collective motives should not be seen in negative terms and as part of contextual (societal) determination of individual behaviour. Rather, there is a dialectic at work whereby in buying into, and thereby submitting to, collective motives, individuals open up possibilities for themselves and expand their control over their life conditions, and the room they have to manoeuvre in, in conducting their lives (Holzkamp, 1983).
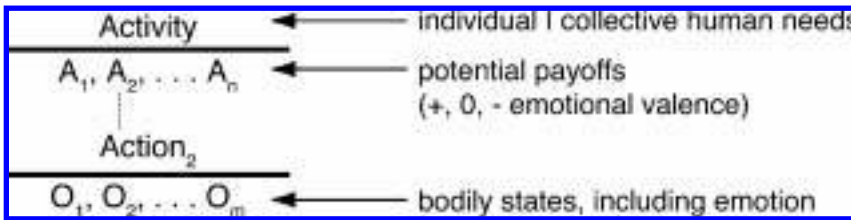
FIGURE 6 In this activity-theoretic model of practical activity, emotions enter at two levels. At a conscious level, goals/actions are chosen when they promise to lead to positive payoffs (in the long run), which are associated with positive emotional valence. Goals/actions with negative payoffs are avoided. Operations in part are unconscious and depend on bodily states generally and emotional states specifically.

presupposes the knowing subject and the nature of the subject necessarily presupposes the object as apparent in perception.

Activities are oriented toward collective motives—for example, hatching salmon to guarantee their survival—which have arisen in the course of cultural-historical development. An activity presupposes the goal-directed actions by means of which it is concretely realized. Action follows upon action, transforming the object of activity, which includes situation, materials at hand, the difference between the current state and conceivable future states, and even the vision of future outcomes (Figure 6). Individual actions presuppose the activity that they are intended to realize in concrete form, concerning both their nature and sequencing. As there are ranges of actions in most situations, the acting subject must select. Even if there is no conscious selection process, acting is normative and always concretely realizes one among many conceivable alternatives. The choices available in, and to, practical reasoning are always oriented toward higher emotional valence.

Studies of individuals with impaired brain functions show that they can generate action possibilities, but do not implement socially acceptable actions (Damasio, 1994/2000). Here, the unconscious aspects of emotion—long-term emotional state and short-term fluctuations—constitute part of the context to which operations are oriented. Emotional states therefore shape the nature of practical action as it unfolds, by contributing to the determination of the next operation (Figure 6, lower half). Similar to the gap between plans and situated action (Suchman, 1987), there is a gap between the consideration of payoffs and the positive emotional valences stemming from them, and the shaping of practical actions by current (fluctuating) emotional states inaccessible to conscious awareness.

Third-generation cultural-historical activity theory constitutes a suitable framework for understanding the phenomenon of collective emotion and its relationship to individual emotion. My examples hint at a dialectical relation linking individual and collective emotion. The tacit aspects of emotion shape actions, which are observed by, and available as resources to, others. These others find themselves in emotional states, and interpret the actions of others in terms of the emotions they express; this interpretation is mediated by the activity system that frames the actions. In their own actions, these others may express the same emotions, which then gives rise to a sense of solidarity, which sustains and fuels individual short- and long-term emotional states.

Motivation arises from the difference between the emotional valence of any present moment and the higher emotional valence at a later moment, to be attained as a consequence of practical action. The workplace-related motivation is high when the subject realizes both individual and collective interests in the same action—for example, when "putting in 300%"—benefits the hatchery as a whole, and produces job satisfaction in the individual. The workplace-related motivation is indifferent or low when there is a gap between individual and collective interests—for example, when a fish culturist "puts in his time" or "works to rule." In the latter situation, work-related action does not (promise to) increase the agent's emotional valence. That is, motivation is an effect of emotion, related to the promise of increases in emotional valence by the completion of one action rather than another.

Identity, too, is an integral part of human activity and an effect of emotion. Who I am with respect to others and myself is fundamentally related to my participation in collective activity and to individual and collective emotional valences arising from (orientations to) face-to-face interaction with others. In each action—feeding fish, keeping records, or creating mathematical representations—fish culturists not only get the day's work done but also provide evidence to others in the hatchery that they are competent fish culturists. That is, in whatever they do, fish culturists recognizably produce and reproduce themselves as constitutive members of their workplace—whether they identify with, or dissociate themselves from, its motives (e.g., when promise of higher emotional valence is nil and therefore motivation is low). That is, every action that concretely realizes pisciculture (i.e., the activity) also leads to the production and reproduction of the identity of the acting individuals.

CODA

Vygotsky (1986) suggested that if emotion were left out in the analysis of actions, "thought must be viewed ... as a meaningless epiphenomenon incapable of changing anything in the life or conduct of a person" (p. 10). In this article, I analyzed the role of emotion and its derivative constructs of motivation and identity, in the workplace generally, and in workplace-related scientific and mathematical practices in one hatchery particularly. I began my hatchery study with a predominant framing of cultural-historical activity theory that articulated knowledge-ability only in terms of scientific and mathematical actions; that is, I had not included emotion, motivation, or identity as components of displayed knowledgeability. In the course of this study, the centrality of emotion emerged, for understanding not only motivation and identity but also for understanding cognition at work. This forced me to work on developing and expanding Engeström's (1987) version of cultural-historical activity theory. Consistent with the dialectical approach, the confrontation of the theory with praxis led to change of the former as part of a process in which theoretical notions become increasingly apt to reflect practical activity in individual and collective consciousness. That is, workplace-related cognition in general, and mathematical cognition in particular, imply emotional as well as "cold" cognitive and mathematical properties of knowledgeably acting subjects. In the course of this study, I developed the firm conviction that Vygotsky was right in saying that thought and emotion presuppose each other and therefore that it makes little sense to attempt to study "cognition in the wild" or "cognition in the workplace" without also investigating how emotions mediate motivation, identity, and mathematical structures.

One year after the end of the 5-year ethnographic effort, and 1 year after originally writing this article, I returned to the hatchery to find changes that now complete this article in truly dialectical fashion. After having been laid off, Erin has had nearly continuous temporary contracts in the hatchery, working on special projects for which Jack had obtained funding. The latter has completely changed his emotional orientation, engaging in his work with the same fervor that characterized his actions 20 years earlier. Erin, too, enacts the special projects with fervor, drawing tremendous emotional payoffs. It turns out that the special projects draw on the technological expertise Erin has with computers, data collection, and producing different mathematical representations. Jack has recognized that these technologies are useful not only for monitoring their special projects but also in constructing reports that provide convincing evidence for the successes (and failures) of the special projects, leading to subsequent proposals and funding for even more projects. It is in their collaborative work that the somewhat different types of expertise truly come to fruition. On the one hand, there is Jack's unmatched embodied experience of fish hatching, which derives from years of handling the fish. On the other hand, there is Erin's technology-mediated understanding *about* certain aspects of fish hatching and the skill in constructing evidence that has greater purchasing power outside the hatchery (e.g., with funding agencies) than Jack's highly contextual expertise. Together, they are now known as a "power team," an expression that recognizes the complementarity of the two forms of expertise that Jack and Erin bring to fish hatching.

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