ABSTRACT: Expert practical knowledge emerges through sustained participation in some community of practice. However, participation alone is not the sole factor that contributes to high levels of expertise in the workplace. Our multi-year ethnographic study of one fish hatchery and associated activity systems shows that deeper experiential (practical) and conceptual (scientific) knowledge emerged when fish culturists initiated and designed scientific experiments to improve hatchery practice. However, experimentation entered contradictions into the hatchery system. On the one hand, there was the fish culturists’ embodied, practical knowledge built up over many years of experience and, on the other hand, experimentation demanded from them an abstract, formal, de-contextualized scientific knowledge. These two forms of knowing, which constitute the dialectic of practical understanding and explaining, contributed toward the fish culturists’ development as experts. Through participation and reflection, the fish culturists assumed and enacted their evolving identities as fish culturists among other hatchery colleagues and the support biologists who provide science-based advice to the hatchery. When aspects of mediation by other members of community were absent, contradictions arose within the activity system that in some situations led to breakdowns. These mediated relationships of individuals and communities that unfold over historic time are fruitfully modeled by activity theory. Our research thereby contributes to understanding the development of expertise and identity in the workplace, the role of practical understanding and interpretation, and the role of mediation by other community members in development and identity.

KEYWORDS: Workplace, expert knowledge, identity, reflective practice, mediation
Introduction

In everyday activity, the work involved in getting the job done is rendered invisible, requiring special efforts to bring it to the surface (Suchman, 1995). This invisibility has led many researchers in the past to downgrade everyday action to routine, evacuating from theory the very (ethno-) methods that allow us to enact the practices that distinguish humans from other beings. By evacuating from theory this work that makes practical competence, researchers also lose any hope of understanding the identity of the human agents, who produce and reproduce their identity at every moment of practical activity (Roth et al., in press). In this article, we theorize and exemplify high levels of practical competence and the evolution of practitioners’ identities, which are mediated by the cultural-historical processes in the activity system. To articulate the salient issues, we provide the following example from an ongoing, multi-year ethnographic study of salmon hatching. The episode begins at the moment when we arrived one morning at our main study site, a hatchery producing several species of salmon and steelhead trout for the purpose of guaranteeing their survival in the local river system and of providing opportunities for small indigenous and sports fishery.

Jack and Pete (pseudonyms are used throughout) had already donned their drysuits, thick gloves and felt boots that are the standard gear of fish culturists spending long hours in cold water. These hatchery workers nimbly jumped into the 12-foot plastic tubs containing about 20 steelhead trout and began moving around its perimeter to herd the fish into their dip nets. The steelhead trout were immediately transferred to another smaller tank that had previously been saturated with carbon dioxide from a small pump. Due to the lack of oxygen, the thrashing fish soon calmed down over a period of ten minutes. Jack now began to look for female does; he lifted each doe by the tail with his left hand and massaged the belly with his free hand. After examining them this way, he threw a couple of fish in quick succession into another tub filled with fresh water for those fish were the ‘rejects’. They were the ‘unripe’ ones that lacked the precious eggs—the raison d’être of this egg take. All of a sudden and without saying a word, Jack maneuvered the head of one doe he was checking towards Pete who then hit it hard with a child’s baseball bat, killing it instantly. Pete then severed an artery in its gill region and the carcass was placed head downwards in a sloping tube to drain its blood away. Over the next 20 minutes about six such ‘ripe’ does (with bellies feeling like ‘Jell-O’ according to Jack) were similarly dispatched for they would be mothers of the new generation of steelheads this year. Male fish were later harvested for their milt; Jack bent the fish into an arc,
bellies on the outside, and squeezed the bellies from the middle region to tail. The milt squirted in a thin, long and high arc toward Pete, who caught the white fluid in small, sterile plastic containers.

The two men now cleaned their hands and prepared their equipment for the next step in the egg take. A large aluminum bowl and a small hooked knife were placed in front of them. Pete then held the first ripe doe over the bowl while Jack quickly inspected the fish, for disease as he said, and cleaned off the external slime and blood with tissue paper. Pete now turned the fish upright for Jack to insert the hooked knife into the anus of the fish. The incision was quick and unwavering, resulting in the fish being slit upwards all the way to the gills. Voluminous amounts of large red eggs fell straight down into the bowl. Jack used his hands to scoop out whatever eggs remained attached to the body wall, taking care not to contaminate them with surrounding slime, coagulated blood, or fish tissue. As he explained later, these are ideal substrates for fungal infections and thus have to be carefully avoided, which also explains why the carcass of the doe has to be drained of blood prior to egg removal. The emptied carcass was then placed back into the tube and the process repeated for the remaining ripe does.

Throughout this activity there was hardly any word exchanged between the two fish culturists who seemed to understand each other’s next move with ease. This was a rapid and seemingly choreographed interaction of the type that we have seen played many times in the hatchery. When asked about the rapidity, the sureness and accuracy of every action, Jack responded, ‘Well you asked me we seemed to be fast. I don’t even think about it as being fast, it’s just normal… Yeah, we know, we don’t ask. We just do it boom, boom, boom!’ This response hides more than it reveals. Having participated in egg takes and fertilization tasks, we know that the work is complex and requires a lot of skill; the same work had taken us twice or three times as long, and at the elbows of experienced fish culturists. These differences show that there is work involved, work that became only apparent in our own awkward attempts at participating. How did Jack and Pete coordinate their work so smoothly and efficiently? How did knowledge of complex operations such as the egg take described above become embodied in these fish culturists?

The origins and development of expert knowledge have long intrigued researchers of the workplace. These are not trivial concerns for possession of such knowledge has been perceived as the key to increased productivity and value creation in organizations by knowledge management consultants. However, these forms of knowledge are embedded in collective work practices and are said to be difficult to be described, changed, or be transferred to other situations
(Brown & Duguid, 1998). From detailed ethnographic studies of work, some seemingly routine and mundane occupations such as assembly-line workers, waitresses, longshoremen, and phone operators have revealed that they require a surprisingly high level of experiential knowledge (Smith, 2001). In our three years of field research in the salmon hatchery, we have found that there are similar demands in expertise that fish culturists are required to perform on a daily basis in their workplace. Fish culturists do not ‘just’ feed fish; a newcomer in fact would face difficulties in carrying out competently many of the daily hatchery activities that old-timers take for granted. Examples of such ‘gut’ understandings include knowing when the fish are satiated by observing their behavior, monitoring water flow and temperature without the use of instruments, assessing how ‘fat’ fish are without resorting to a mathematical formula, and knowing when fish are ready to be released to the ocean by scrutinizing their behavior and physiology. Though hatcheries are unique working environments, our study reveals patterns that are of interest to researchers wanting to trace the trajectory of expertise and identity in the workplace. We examine the essential contribution of reflexive elaboration of practical understanding and of mediation by other members in the organization to those trajectories.

Learning as a Social Process

A cultural historical perspective of knowing and learning as socially mediated changing participation in practice offers insights into high-level practical expertise, here exemplified by the actions of the fish culturists Jack and Pete. Various theoretical disciplines such as ethnomethodology, symbolic interactionism, ‘workplace studies’ of the Chicago school, and critical ethnographies of work (Gherardi, 2001) have converged on the same view that learning and knowing cannot be found by looking into people minds. Rather, knowing and learning are instead coextensive with changing participation in continuously changing social relations that make mundane, everyday living. Mastery and skills are viewed in terms of degrees of being an insider, of the continued production and reproduction of oneself as a member of particular community, and of reproducing the relevant practices that are valued there (Gherardi & Nicolini, 2000; Lave & Wenger, 1991). Learning becomes a process of engaging with others (the process of mediation) in practical activity that simultaneously contributes to reify community practices and provides room for innovation and change (Sewell, 1992). Because expertise develops with long-term participation in practical activity, always mediated by social and material relations that make the relevant world, knowing and learning always exceed the individual. Furthermore, this
knowing is always both individual and collective. Any possibility that exists and develops for an individual is a concrete realization of a possibility existing in a generalized way at the collective level. Possibilities for action always exist in a dialectical form: concretely existing to the practitioner who realizes them in his practical actions and understanding and generally existing at the level of the organization, which makes them possible and therefore available in a general sense (Roth, 2002).

Identity Emerges from Participation

By engaging in community practices, identity, which is a sense of who one is in relation to others, and self emerges. Researchers like Brown and Duguid (1991) have asserted that ‘workplace learning is best understood, then, in terms of the communities being formed or joined and personal identities being changed’ (p. 48, emphasis ours). This coupling of practice with identity or ‘you are what you do’ (Nardi, 1998, p. 34) in roles as diverse as midwives, naval quartermasters, tailors, recovering alcoholics, or construction workers (Gherardi & Nicolini, 2002) can be appreciated when we consider how the concept of identity was conceptualized within traditional psychology. There, a ‘well’ metaphor is often used—identity is something innate to a person, who needs to expend effort to locate and cultivate it for healthy psychological functioning. In contrast, a sociological perspective positions identity in social processes—the ‘self emerges as a mirror to the social processes in which it participates’ (Côté & Levine, 2002, p. 55). Identity therefore becomes dialectical in that it comes to serve ‘as a pivot between the social and the individual, so that each can be talked about in terms of the other. It avoids a simplistic individual—social dichotomy without doing away with the distinction’ (Wenger, 1998, p. 145). Learning and identity are thus intertwined; one presupposes the other by membership in organizations and communities. In addition, because learning in the hatchery, or in any other contexts from shop floors to boardrooms to classrooms is dynamic and fluid this likewise implies that identity is itself changeable and evolving. In fact, because each action of a human subject on the object of activity is mediated by other entities in the system, the identity of the subject is produced and reproduced in every practical act (Roth et al., in press). Changing identity, as learning, is co-extensive with changing participation in a changing world of practice. Hence, activity theory is an ideal analytic tool for our research on expertise and identity formation in the workplace for it analyzes the dialectical interdependence of individuals in the contexts of communities that change over time.
Activity Theory

Activity theory is a descriptive framework in the social and psychological sciences that links and explains how (groups of) individuals go about their daily projects competently and effortlessly. An active, creative human consciousness is woven into seemingly mundane tasks like schooling, cooking, reading, gardening, or even rearing fish—activity theory aims to describe this consciousness without abstracting it from the details of practical action that give rise to it (Nardi, 1998). Past psychological analysis had privileged either environment or mind in explaining human behavior, dualistically opposing the two, or making one the causal effect of the other.

Cultural-historical psychology recognizes that cognition arises not solely from the environment nor from within the individual, but is instead co-constituted by both the environment and the individual. This position highlights the importance of social and cultural aspects of a person acting in society over one’s genetic heritage or unseen psychological phenomena. Thus, the Soviet psychologist Vygotsky suggested that the origins of higher mental functioning—e.g., learning and memory—can be found in sociocultural factors. Others articulated labor or activity as the essential condition of mankind responsible for human psychological evolution (Leont’ev, 1978; Wertsch, 1981). Labor, according to Marx, is part of our species being that humanity cannot but perform (Marx & Engels, 1846/1970). Through labor, which is always mediated by tools (both material and psychic), consciousness and human society arise. Tool making is integral to and constitutive of the history of human culture; tool use is integral and constitutive to human consciousness. The division of labor mediates tool making and tool use so that ‘action is always social action, even when it is performed individually’ (Gherardi & Nicolini, 2000, p. 331). And as much as people change nature through tool use, the environment changes the tool user, too—mankind is as much a product of circumstance as well as potential change agent of the circumstances.

The Scandinavian school of activity theory has conceptualized the activity system as comprising six elements or nodes: subject, tools, object, rules, community and division of labor (Engeström, 2001). Tools, rules, community and division of labor in this model mediate between human subjects and the objects of their activities. Within individual nodes, the entire activity system or between different systems there are structural tensions that accumulate over time; such tensions, theorized in the term ‘contradictions’, are potential sources of learning and development.
Research Design

This research study was part of a large interdisciplinary project that examined the interactions between traditional, local and scientific knowledge exchanges in coastal communities of Canada.

Site and Participants

Hatcheries are a vital part of the Salmonid Enhancement Program (SEP) first begun in 1977 by the Canadian government, specifically under the Department of Fisheries and Oceans (DFO). The initial aim was to increase fish production for purposes of sport and commercial fishing in local communities and amongst First Nations peoples. The object of salmon hatching is to rear various species of juvenile salmon from the egg stage until they are ready to be released to the wild; these releases are to restock natural systems and therefore prevent the species from extinction.

As part of our study of knowledge exchanges, we studied in detail one hatchery located on the west coast of Canada. It employed two managers, five fish culturists, and some support staff. The hatchery stands out in that scientists consider its personnel as highly competent. In the course of our study, we examined the work of three fish culturists in extensive detail and conducted numerous interviews with them—Gerry, Jack, and Kerrie.

After more than 20 years in hatcheries, Jack has a very intimate, embodied knowledge of the salmonids under his responsibility; his specialty species are steelhead trout and chinook salmon. A government support biologist commented that Jack deserved a medal for his (research) work on chinook; the numbers of adult returns in that area tremendously increased from near extinction so that scientific research on this species can be resumed. Kerrie had been a fish culturist for 13 years at the time of writing. Always eager to improve her work practices, and a self-confessed ‘geek’, she readily and fluently generated computer data to monitor the condition of her fish. In contrast, Jack was much less comfortable with technology and relied on his own rules-of-thumb and embodied knowledge to get the job done.

Data Collection

Our study of the hatchery is now in its fourth year. To understand the activity system of hatching, we draw on participant observation and apprenticeship as ethnographic methods (Coy, 1989). Collectively, we participated with the hatchery personnel in all of the relevant daily hatchery activities such as the taking eggs, seining in river, tagging, feeding fish, fertilizing lakes, taking measure-
ments on fish and in the environment, sampling returning salmon, and releasing smolt. Nearly all such events were either audio-, or more commonly videotaped. The transcriptions of these events as well as our field notes formed the basis for our analysis of the work of fish culturists. In addition, we interviewed members of the organization both formally (recorded) and informally (recorded in field notes) about various aspects of the work and workplace, collected and photographed artifacts (tables, notes on scratch pads, or forms), and copied the reports of studies, manuals, and info memos.

Data Analysis

After repeated reviewing of our artifacts, notes and transcripts, codes that emerged were further classified into categories that formed the basis for our tentative hypotheses. Our prolonged participation and engagement (Guba & Lincoln, 1989) in the field have mitigated the interactional processes that are implicit in all forms of research interviewing. We further adopted negative case analyses (revising hypotheses till they accounted for all known cases), progressive subjectivity (monitoring of the researchers’ evolving constructs) and more critically, member checking (verification of our constructs by the participants themselves). Being a longitudinal study, we were able to continuously check and modify our evolving hypotheses across multiple perspectives: fish culturists, managers, support biologists, and also the researchers themselves (Brickhouse & Potter, 2000).

Expertise and Identity in the Workplace—Being and Becoming

The fish culturists in our study displayed a high level of embodied, practical knowledge of fish farming that have continuously astonished visitors (and even scientists) to the hatchery. The origin and trajectories of such skillful behaviors acquired in the workplace are thus of great interest, for they hold lessons for the development of expertise and identity in organizations. In common with a cultural historical perspective of learning, our results not only show that expertise and identity are developed through the process of sustained participation in the community but more importantly, they show that the extension of practical and conceptual knowledge occurred when our participants engaged in reflective practices, specifically when they initiated and conducted scientific experiments. Here, understanding and explaining were in a dialectical relationship that additionally contributed to our participants’ growing identities as widely acknowledged experts in their work. Using activity theory, we understand that the engagement in reflective practices introduced contradictions into the system that
generated potential for development. Throughout these processes of learning, development and identity formation, mediation by other members in the community was integral—who one is in the workplace emerged from the mediated relationships with others. When aspects of that mediation were absent, contradictions again arose within the activity system that in some situations led to breakdowns.

*Being and Becoming an Expert through Participation*

Out of the many daily workplace activities that pre-occupy fish culturists, we highlight two important duties – feeding and disease management. Newcomers might have the ‘knowing-what’ whereby they can seem to perform these activities yet lack the prerequisite ‘knowing-how’ to do so competently (Brown & Duguid, 1998). For example, in our hatchery operation, they often understand feeding superficially as ‘throwing x kilograms of food per day per pond’ and likewise the state of health of fish is indicated by nothing more than a simple tally of mortalities per pond per day. The origin and trajectory of expertise in the workplace however transcends simple, formulaic expressions. The seemingly mundane tasks in the hatchery conceal high levels of complexity and require lengthy periods of observation and participation in actual work practices for expertise to develop.

In the feeding of fish, the primacy of the visual in building expert, practical knowledge is evident at all stages. The idea of what is sufficient food for a particular species of fish in a pond is not predetermined beforehand but is only available at the very moment of feeding itself—when the fish ‘say’ they have enough. Although fish culturists such as Kerrie calculate the amounts fish should be feeding given the water temperature, time of the year, size of fish, and size of food particles, what an experienced practitioner actually feeds is determined circumstantially. During feeding, the fish culturists are attuned to signs that the fish are satiated by looking at the amount of thrashing in the ponds and how they break the water surface. Experienced workers are sensitive to such communication with the fish while keeping attuned to environmental features such as temperature. For example, during colder temperatures feeding requires a certain embodied knowledge: although a newcomer may stop feeding because the fish does not take up the feed, practitioners know that the fish can be ‘coaxed’ into eating by patient offering a little food, stopping for a little while, offering again, and so on until all of a sudden, a feeding frenzy begins. One has to slowly increase the amount of feed thrown in the ponds until the initially sluggish fish are feeding normally once more. This coaxing process is a skill to be learned by watching the fish over long periods of time and is what distin-
guishes the novices from the old-timers. The former often despair easily and report that the fish are not feeding. Feeding times for these hatchery staff is like having a conversation with the fish as fish ‘tell’ them things. At times however, when fish are finicky with food due to colder temperature, fish culturists say ‘they [fish] can fool yer’!

Practical knowledge about fish health and disease is similarly engendered through sustained participation in actual work practices coupled with long periods of careful observation. Jack, for example, knows the optimal conditions for rearing his steelhead for

by experience... I know that I want twelve, the hottest time of the year I want fourteen degrees in morning when I walk in and no hotter than sixteen when I go out. And that's perfect for our steelhead.

In this hatchery, there are two water intakes from the nearby lake, one sampling water at the surface, the other at the ‘thermo-cline’, that is, near the bottom where the temperature stays at a constant 4 °C year round. By mixing water from the two intakes, Jack has control over the temperature. He could tell by experience when the water temperature was too warm for the fish without the use of a thermometer as ‘the next day would be puff s of cotton sticking out of their gills just like that ... just boom eh? It’s dramatic!’ Jack is thus navigating a narrow compromise between growth and disease when he rears steelhead, too low a temperature and he sees his fish grow too slowly and conversely when it is too warm he begins to see fungal outbreaks. A low temperature however, is a form of fish disease management by Jack, to be used to ‘knock’ any diseases out of them.

Jack: Now if I cooled down, I’m going to get less chance of getting disease but then even at sixteen, I don’t but then I loose my growth. So let's say I wanted to push my growth then I think well I go eighteen degrees I get gill fungus then I start getting mortality so I know at sixteen is perfect for here.
Researcher 3: So a lot of trial and error or (years)...?
Jack: Yeah, just observation.

Once when some research scientists visited the hatchery they had noticed something afflicting the eyes of the fish; they immediately concluded that it was due to cataract formation. As the problem occurred in about 95% of the juveniles sampled, the hatchery manager became understandably concerned. A senior scientist then became very interested and offered the hypothesis that over ex-
posure to sunlight in the hatchery was the root cause. The fish culturists, however, were not convinced as this particular pond with the afflicted fish receives the least amount of direct sunlight and is thus nicknamed the ‘ice-box’ among the hatchery staff. Jack felt that the artifacts were not cataracts but were in fact abrasions on the surfaces of the eyes. These phenomena had probably come about due to the high stocking density in the ponds, which meant that the chances of collisions between other fish were higher. Jack conceded that ultimately, he might be mistaken but this hypothesis of his was what he could offer given his years of practical experience of dealing with the fish. It is of interest to note that Jack was perhaps right after all when it was later found that the artifacts on the eyes cleared up soon after the fish were released in the wild. Sampling in the estuary, some hatchery workers had caught 20 coho smolt without adipose fins, the mark that they had been raised in the hatchery, and none had problems with their eyes. If the problem truly had been due to cataract this would have been a permanent damage.

There was also an aborted attempt at coordinating information about the various diseases afflicting the fish. The original plan was to have each hatchery report in a brief manner any occurrences of new fish diseases that they experienced. Next, Jack’s task was to collate this information for re-distribution to all other hatcheries thus building up separate but identical databases in each location. Unfortunately, this plan did not take off as intended for some unknown reason. Jack nonetheless continued building up his own extensive database in his hatchery with photographs of diseased fish, which he took himself and supplemented with explanatory texts. Most of the time now, Jack accurately diagnoses fish diseases based on his extensive experience, though official policy still dictates that he send all diseased fish to the government laboratories for testing. This led to a tremendous, implication-laden contradiction in that this as other hatcheries had to wait weeks or even months for the official test results, which only confirmed Jack’s diagnosis, before decisions can made about the correct medication to administer, while fish continued to die by the thousands. Much of the decimation to the population could have been avoided if the managers and scientists had trusted in Jack’s assessment and started to take action immediately. The rationales given for the delay were the dangers of antibiotic resistance or incorrect medication.

From these brief accounts of hatchery activities—feeding and disease management—we come to understand how workplace expertise is the result of sustained participation in the everyday practices of a hatchery and cannot be acquired in short periods of time despite their apparent simplicity. No existing textbook or short-term training program is able to achieve what these fish cul-
turists have gained through many years of experience. For our fish culturists, there was an element of careful observation as well that led to that embodied expertise. And in the process of learning in their workplace, their identities of an expert fish culturist were increasingly being reinforced. As demonstrated by Jack being vindicated over the cataract incident and oftentimes in disease diagnoses, the scientists that have had dealings with the hatchery have acknowledged these fish culturists as among the best that they have encountered. We realize that the fish culturists are ultimately both the process and product of the hatchery as an activity system for while successfully performing their jobs, the fish culturists define, and reify what good fish farming practices are.

Extending Knowledge: Dialectic of Practical Understanding and Explaining

It is commonly assumed in organizations that expertise develops in the course of a practitioner’s participation in relevant work (Jordan, 1989). Although this was also the case in our study, expertise and practical understanding were both extended as hatchery personnel engaged in activities that reflexively elaborated existing practical understanding. This was itself a prerequisite for the activities in which this elaboration occurred.

Although none of the fish culturists had any formal training in science after graduating from high school, they initiated scientific experiments to find explanations to phenomenon that had intrigued or puzzled them in their workplace. They had already enacted high levels of embodied, practical understanding when they reared fish successfully. Yet, they felt that their gut-feeling kind of knowledge was insufficient for answering some of the questions they had. For example, is it better to combat diseases by rinsing the growing eggs with hydrogen peroxide, salt, or the effective though carcinogenic chemical called formalin? Although some research showed that peroxide worked in a scientific laboratory, which quantities were required when there was not one tray of eggs but eight trays mounted as a stack? That is, some of the problems that they encountered were not amenable to resolution by mere observation. Furthermore, to convince hatchery management in particular that some practice ought to be changed, they needed more than their embodied knowledge as evidence. Scientifically acceptable experimentation responded to these needs, and throughout our presence, there were experiments that fish culturists planned and implemented. Without their prior practical understanding however, it was inconceivable that the fish culturists could even begin asking questions, initiating experiments in the first instance, and finding explanations. And in understanding, in participation of hatchery activities, new challenges surfaced which demanded
explanation. This was particularly so in the early years of the hatcheries for they were, and still are, characterized by a learn-by-doing approach (Wood, 2002).

There was therefore an interplay between the practical understanding of everyday hatchery operation and the scientific explanations that they achieved by designing and conduction formal experiments. In fact, practical understanding and generalized understanding (explaining) constitute a dialectical unit (Roth, Lawless & Tobin, 2000) in that ‘understanding precedes, accompanies, concludes, and thus envelopes explanation. Explanation, in turn, develops understanding analytically’ (Ricoeur, 1991, p. 142). Practical experience and theory building on hatchery practices therefore constituted the dialect of understanding and explaining that led to the development of practical understanding, which in turn allowed new levels of experimentation to emerge. Multiple tensions co-exist here: embodied knowledge with scientific knowledge; the practical, experiential with the abstract, universal. Reflective practice, which has as its foundation this dialectic of understanding and explaining, became the basis for development and expansive learning (Engeström, 2001). In the case of our hatchery staff, it was a movement towards being and becoming widely acknowledged expert fish culturists that individually and collectively exceeded—as acknowledged by several research scientists—individual and collective expertise in the other hatcheries.

The fish culturists had conducted a variety of experiments over the years. Jack, who was the longest serving staff with over 25 years of service had been involved in numerous experiments ranging from water quality, feed quality, egg incubation techniques, optimum release dates for fish, fish anesthetics, and fish diseases. Less run of the mill research questions have also included investigating the effect of air pressure and lunar cycles on feeding responses of fish. Though with less years of service in the hatchery, Gerry had also been actively involved in manipulating the early life stages of coho species to obtain better adult returns while Kerrie was involved in a long-term study on feed quality. As the hatchery does not have the facilities for expensive or high-tech equipment, nor the space and manpower to conduct experiments generally, the fish culturalists have concentrated instead on questions directly related to their hatchery operations and practices: optimizing feeding, rearing conditions, health management and release times for juvenile fish. These vitally important questions impact survival of the fish which the hatchery aims to maximize, or as Kerrie says, ‘we do experiments to suit our purpose’. Conceived, planned and executed by the fish culturists, these were doable experiments (Fujimura, 1987) that share likeness with other instances of practical problem solving characteristic of, for example, action research in educational contexts or projects initiated on the shop floor in a
variety of organizations (e.g., Whyte, 1991). Importantly, the experiments were initiated by fish culturalists themselves rather than being ordered by government biologists or hatchery management. Sometimes, management encouraged the fish culturalists by sending them materials that they thought fish culturalists might be interested in, or, more subtly, by leaving readings in the common lunch areas for everyone to peruse. Hatchery management was indeed supportive of these experiments as they resulted in improvements to work practices, and participated in the meetings where the fish culturalists collectively elaborated and critiqued one another’s initial ideas.

What possible rationale can be offered for these non-science trained fish culturalists to pursue scientific experiments that drained so much time and effort? Our data suggest the existence of tremendous curiosity to know and better understand all aspects of fish culture in this hatchery. In fact, there were both official and unofficial cultures supportive of curiosity, making improvements, and creating knowledge. For the fish culturalists, devising scientific experiments began with observing the fish in the course of daily work practices and asking questions.

It’s at first you start to notice a few things, it’s usually and it, you have to pay attention, which a lot of people are too busy to do. And we all get too busy to do to, you know, just take five minutes and go and sit and take a look at your pond full of fish and see what they’re doing. And, and so it’s starts with a gut feeling… (Gerry)

We look at visual things and we’re with the fish everyday and if somebody’s with something everyday they’ve gotta learn something unless they’re just out to lunch… it’s mostly visual how the fish react at times and it’s just a gut feeling over time. (Jack)

Many of the things Jack ‘knew’ germinated while he keenly observed fish and subsequently developed as he, mediated by his peers and support biologists, designed and conducted controlled experiments, which deepened his practical understanding. In fact, when Jack first started out working in this hatchery, he demanded that his hatchery manager give him freedom to do what he wanted with his fish or else he would quit right away!

In the process of our research, we have been able to uncover much of the invisible work that makes the expertise we observed. It took our own stumbling attempts at participating in the daily work routines to render visible the practical understanding that the fish culturalists have acquired of fish farming. Jack, for example, willingly offers sound critiques when he reads scientific papers in terms of their inherent biases or errors. All our fish culturalists are also deeply mindful of the importance of rigor and control experiments that they have to build into their research methodologies.
Learning and Identity are Mediated by Others

Our activity-theoretic perspective presupposes that all practical actions are mediated by the social and material setting in which it occurs. The subject of the activity transforms the object by means of practical actions, and in each practical action changes itself even if unnoticeably, leading to the emergence of practical expertise over the course of a career. With each practical action, practitioners ‘become more skilled’, which means there participation changes as their actions change the world. Changing participation in a changing world, however, is co-extensive with learning (Lave, 1993). Furthermore, all practical action is mediated not only by the tools but also, and perhaps more importantly, by relevant others who are part of the organization more narrowly and the community of practice more broadly. Our ethnographic research revealed that expertise and identity in the fish culturists did not develop in solo contexts but occurred through the mediation by others in the hatchery organization and by support biologists, whose mandate is to support relevant activities within the hatchery and the interaction of hatcheries with research scientists. These mediations enabled participation in and reflection through scientific experiments. That is, the development of expertise, learning, and the development of identity, becoming, came about through the mediation by others. Because of these mediations, Jack became a little more of the organization, and the organization became a little more of Jack. From this perspective, we are not surprised then that outsiders attribute many of the accomplishments of the hatchery to Jack—Jack’s learning and identity have become indissociably linked to the organizational learning and identity of the hatchery. Jack became an institution and the institution, from the outside, became Jack.

Jack began his career learning on the job, at the elbow of others, and, vicariously, from fellow fish culturists, for very little was known about salmon rearing in the early years of the salmon enhancement program. As he gained expertise, Jack became a mediator himself, directly and indirectly mentoring others, including the younger fish culturists Gerry and Kerrie. He encouraged and facilitated the new generation to become as reflective, as inquisitive, and as curious as he had been throughout his career. As Jack put it,

But I’m the devil’s advocate; I’m the hardest one to convince sometimes eh? I like to, I like to stir the pot up, I like to get people thinking, and get them, get them going, and that just makes them think better.

With respect to conducting scientific experiments, the fish culturists often sought the assistance of support biologists who helped conceptualize the ex-
periments with rigorous controls. The writing-up and dissemination of the reports, however, were usually left to these scientists, for often fish culturists perceived themselves as lacking the capabilities and expertise to do these tasks. They had frequently insisted that they were not scientists but were just fish farmers. Overall, the fish culturist-support biologist collaborations were the result of divisions of labor that allowed a synergy to emerge; the fish culturists performed the actual running of the experiments with their vast numbers of fish at their disposal while the biologists guided and monitored the situation at regular intervals. The usual outcome of this was a joint scientific paper that was presented at a conference for fish culturists or a brief scientific memo circulated to all the other hatcheries. According to our informants, these events that have ceased about a decade ago, were eagerly anticipated and attended by all fish culturists.

The reports were written mainly by the support biologists, but this activity itself was mediated by fish culturists such as Jack. His identity is confounded with the production of the reports, which he showed and talked us through with pride. It was also tied up with the many studies that had not been written up, or that had not been published in formal journals. Although Jack had the required background understanding and knowledge of the experiment and its procedures, he deplored the lack of personal development that came along with the lack of mediational resources that would have allowed his now forgotten work to be made known more broadly. This lack of mediational resources, or ‘lack of support from the organization’ as he called it, ultimately led to his withdrawal from active experimentation and going beyond requirements. We therefore found a continuous tension operating in Jack, between his commitment the fish, which he treated like children, and his disavowal of the organization and the management in particular.

The support biologist played central roles as mediators in the development of expertise and identity of the fish culturists. Among several support biologists, mentioned during our interviews with a wide variety of individuals, Bob stood out for special mention by all the fish culturists for his patience and willingness to help. In the words of Kerrie, he was one that would not ‘neglect you by choice’ but would get back to you by e-mail or phone at the earliest opportunity. The professional relationship with Bob and the other fish culturists was very close; ‘he was our book, our set of encyclopedias, our brain, that’s where we got everything from’ according to Jack. Kerrie concurred that it was Bob’s expertise, his unassuming personality and clear love for the salmon that made him so well liked amongst all the fish culturists that he worked with. Bob was not the authority in every field of salmon biology so when Gerry and Kerrie had prob-
lems in their experiments, he connected them with experts elsewhere that he knew were working on those same issues. The fish culturists were thrilled and felt part of the excitement of working in the scientific community where they were treated as equals with something worthwhile to share. On the whole, the fish culturists did not feel inferior or second-best to the formally trained biologists like Bob for there was a great deal of mutual respect for the different domains of knowledge that each possessed. For example, Gerry suggested,

The one thing that I liked about it is that, they weren’t kind of callin’ the shots from afar, because sometimes you know working right there, your kinda goin’ well, you can do it this way and they, they call, you know, it’s it’s not a bad thing, it’s just it was nice to run it on my own for the first time and find out.

Another time, she stated,

You start dealing with them and your thinkin’ oh my, you know this is a he’s he knows so much, he’s been at this for twenty-five years and I don’t wanna look like a stupid, you know I don’t wanna look stupid, it’s a big thing and they don’t treat you like your stupid, they never do and they eventually, I mean I have no problem, anytime contacting them or phoning them if I need a piece of equipment, they just go out of their way they just you know and it’s it’s so I feel really comfortable with them now.

In the system of hatcheries that we investigated, the successful conduct of scientific experiments depended on the mediation by support biologists. Bob had been in the system for as long as anyone could remember; he had been closely involved in nearly every major project with the fish culturists. When this mediation with a more experienced and willing person was absent however, the system faced breakdown. This could be seen in the following exemplary episode.

A persistent problem in the hatchery is a disease called ‘crib death’ where juvenile fish suddenly die in large clumps in the incubation trays. Being eager to conquer this problem, Jack had spent a total of five years investigating this phenomenon with the assistance of Bob. Rather than writing up the results himself, Bob instead hired a person to do it. Unfortunately, the person left before completion and the data was never published nor shared in a conference. There were a few similar occasions whereby the results of Jack’s experiments were not published but this particular incident stood out as one of the biggest disappointments in Jack’s career because of his intense involvement in the project. Therein lies a contradiction for despite generating a huge amount of scientific knowledge and thinking about issues that scientists had not even imagined about, the fish culturists seemed unable to transcend the hatchery activity system on their own to
participate in the activity system of the scientific community. Without the mediation of the support biologists, fish culturists appear to become little more than fish farmers no matter how well they are respected for their practical understanding of rearing fish.

We thus observe that when instances of mediation were absent, contradictions arose which led to breakdowns in the system. Jack, for example, had deep practical knowledge of rearing salmon but not of writing scientific papers. Due to the lack of mediating agents at various times in Jack’s career, the actions that would have allowed the object of publishing a scientific paper did not unfold. Consequently, Jack’s identity did not develop other than being just a fish culturist. The implications for workplace learning are clear; learning and identity are products of social mediation in an activity system. At certain times contradictions allow for growth and change though they can allow for negative or inhibitory consequences to the entire activity system as well. Fish culturists in our hatchery ultimately depended on a few skillful ‘brokers’ (Wenger, 1998) like Bob to allow them to develop and (briefly) display their scientific knowledge during conferences or scientific memos. Recent budget cuts decreased the number of support biologists, increasing the workloads of those who remain. These stresses have been felt at the hatchery, as there are now fewer opportunities for biologists to work with the fish culturists. For the fish culturists, a degree of disidentification with the organization has been observed though they have consistently claimed that their job is the ‘greatest except for the politics’.

Discussion

The fish culturists in the hatchery gained their extensive, practical knowledge of fish farming from long term participation in the hatchery. Combined with careful observation of fish behavior, the fish culturists achieved such familiarity and embodied understanding of their work practices that these were often articulated in terms of the fish now being able to speak to them. As experts who act with full participation in the community, they possess greater room for maneuver and thus are the engines of change and innovation in workplace practices. We further showed that individual identity and organizational identity stand in a dialectical relationship for as the fish culturists learnt what was involved in being a competent member of that community, they simultaneously defined or reified those practices and thereby the organization. It follows then that their growing identities as expert fish culturists were manifest from their active participation in the activity system. Rather than an unraveling of the construct of an expert worker in those individuals, their evolving identities as expert fish culturists
were located within the social practices of the hatchery. Learning in this hatchery is indistinguishable from living and functioning in a socially mediated world. Those who therefore seek quick or easy solutions to the problem of expertise in workplaces (deskilling) may be disappointed, for our results add to the literature that this growth of expertise takes place over extended periods within networks of complex, mediated relationships. Old but prevalent metaphors of learning in terms of a banking model have to be discarded in favor of one which seeks to describe among other things, what are the most conducive social engagements or means of access to old-timers in that community (Hanks, 1991).

Our data supported the notion of a dialectic unit linking practical understanding and theory-seeking explaining, which played a critical role in extending our fish culturists’ embodied and conceptual knowledge. Without such opportunities for reflexivity, our fish culturists would not have achieved the level of competency nor their widely acknowledged identity as expert fish culturists that they now enjoy. Indeed, this desire to gain conceptual understanding through workplace experiences emerged as a central concern for workers across a variety of occupations (Billett, 2001b). The implication for workplace learning is that sustained participation is insufficient for expertise; reflective practices are also necessary. During these instances whereby practical understandings are tested and thus elaborated upon, the status of identity becomes salient both for the individual and for the organization.

Finally, we stress the significance of mediation by other people in issues of learning and identity. Without the help of support biologists as in the case of our fish culturists, people like Jack were unable to achieve the object of sharing their experiences of reflexivity in the form of scientific papers to a wider audience. The absence of mediation and access to activities in workplaces are critical questions though learners ultimately determine in their unique ways who they consider to be experts or if they wish to align themselves with the organization in the first instance (Billett, 1995, 2001a). The conception of identity as an innate psychological construct therefore needs revision in favor of one which views identity as a negotiation and contingent achievement within activity systems (Roth et al., in press). By this we foreground the fact that people produce their identities as part of ongoing practical activities, and in doing so they constitute and (re-) produce the very structures that gave rise to the practices themselves.
References


