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SPECIAL SECTION

Development of Professional Concepts Through Work Analysis: Tech Diving Under the Loop of Activity Clinic

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This article deals with conceptual development in an emerging activity, Technical diving. Tech divers are equipped with innovative, complex machines (the "rebreathers") to perform deep dives. The developmental methodology of cross self-confrontation was used to investigate the psychological dimensions of safety in diving with a group of volunteers (divers and instructors). One sequence of these data helps us analyze carefully the development of one concept in use in this milieu, the "confidence in the machine." Building on 30 years of French-speaking research in work analysis on conceptualization in the work activity, we highlight the conflicting nature of the professional concepts as well as their multifunctionality. In the sequence analyzed in this article, the conceptual development takes the form of the discursive discovery of this complexity, which may open new possibilities for action (here, through the transmission of renewed concepts to other practitioners). The argumentative logics of the dialogical framework requires from the participants that they go beyond well-established knowledge to be able to convince both the researcher and their colleague. However, the stabilization of the concept emerging in this debate is related to its double anchoring: anchoring both in the emotions of the participants and in the professional genre of the milieu. This article shows the potential of the developmental methodology of cross self-confrontations in conceptual development: combining careful observation of routine behaviors, comparisons of personal habits, and thorough discussion of convergences and discrepancies, the methodology encourages reflexive practice and conceptual renewal.

"An old Tech diver is a good Tech diver."
—Anonymous practitioner

This article deals with conceptual development in an emerging activity, Technical diving. Tech diving is driven by technological progress and passion for extreme submarine exploration (deeper than −60 meters, with a current record at −330 meters). Although Tech divers dive for their own pleasure, not as a profession, death is common in this activity. Accidents are most of the time serious. A short introduction in a recent manual dedicated to the training of Tech divers states that

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> among the 8 divers in the world who have reached a depth of more than −250 meters without technical assistance, the facts are overwhelming: three are dead (Sheck Exley, John Bennett and David J. Shaw); one is paralyzed (Jochen Hasenmeyer); two were seriously injured after DCI (decompression illness) accidents (Nuno Gomez and Jim Bowden). Only two, Mark Elyatt and Pascal Barnabé, have been safe so far. (Von Büren & Warrisse, p. 19)

In this context, some Tech divers interested in the psychological factors associated with safety in Tech diving requested our help to coanalyze their activity. The developmental methodology of cross self-confrontations (Clot, 1999; Clot, Faïta, Fernandez, & Scheller, 2001) was chosen to conduct this intervention. In the present article, some data from this research will be analyzed to contribute to a better understanding of a key point for researchers in the psychology of human action and development: conceptual development in human activity. Which concepts are used in an activity? How are they used and characterized? How do they evolve, develop, appear, disappear, or change? In what ways, and by which processes, do individuals and groups of individuals construct, use, and share new concepts to operate?

In the first part, we share the richness of the French tradition regarding the analysis of professional concepts. Different research streams operate in work psychology, ergonomics, or professional didactics, often inspired by the Russian cultural-historical psychology. They develop original understandings of the role and nature of "concepts" in human activity as *tools for action*.

The second part presents the context of the intervention, the divers' request, and the current state of the psychology of Tech diving. The role of *panic* in accidents is given special attention.

The third part describes the cross self-confrontation methodology in use. This methodological presentation highlights how the dialogical framework intentionally reproduces, simulates, and concentrates some of the mechanics of professional thinking, present (but usually dispersed and episodic) in the workplace, encouraging a reflexive attitude in the practitioners. Cross self-confrontation appears as *a reflexive experimentation space.*

The fourth part enriches the analysis of conceptual development and change by an analysis of our empirical data. We analyze *the discursive development of a professional concept*, the "confidence in the machine," in the dialogical framework of cross self-confrontation.

In the fifth, conclusive part, we discuss the relationship between discursive forms and conceptual change, and the role of cross self-confrontations as simulation spaces for deliberation.

PART 1. A FOCUS ON PROFESSIONAL CONCEPTS: FRENCH VIEWS

Human capacity for rich conceptual representation is anchored in evolution, arguably providing a core set of conceptual primitives such as object, people, cause, and number (Carey, 2009). The mechanisms by which it results in the formation of complex concepts to grasp new objects, such as global warming, radioactivity, or most recently, for example, "duty to protect," are under scrutiny in psycholinguistics and psychology (Engeström et al., 2005). In this article, we deal with a specific kind of concepts—professional concepts—which are interesting because they are reducible neither to spontaneous, everyday concepts nor to scientific concepts, as they were distinguished by Vygotsky (1934/1997).

Professional Concepts as Tools for Action

A professional activity creates a set of professional concepts, mastered by its practitioners, which may be learned through training, mentoring, or practice. The learning or *constructive* dimension (Rabardel & Pastré, 2005; Samurçay & Rabardel, 2004) of the professional activity (as opposed to its *productive* dimension) appears to be partly linked to the formation of professional concepts used as intellectual resources to face the demands of the activity. Each profession develops a heterogeneous set of professional concepts that are commonly shared among practitioners: These professional concepts are useful to perform the usual tasks but also to orient the way in which these tasks are understood, to communicate and collaborate with colleagues, to structure collaboration.

The role of professional concepts as social working tools, at the crossroad of individual and collective activity, has been repeatedly highlighted by the French tradition of work analysis. Currents of French research in work psychology, work analysis, and didactics took a careful look at the close analysis of concepts in real training and work situations. They showed the importance of concepts as *working tools*: *operative models* (Leplat, 1997; Ochanine, 1978) or *operational memory* (Bisseret, 1995) are efficient-enough distortions of reality to sustain professional reasoning and action. This research stream joins analysis of expert work (Randel, Pugh, & Reed, 1996) in detailing the role of *high-level concepts*, defined as concepts to reduce the complexity of the situation to its most significant variables for action. French researchers interested in professional expertise also insisted on the key role of concepts in work activity (Caverni, 1988; Rogalski, 2004). Empirical research in various dynamic environments, like conduct of blast furnace (Hoc, 1996), plastics (Pastré, 1992), and the fight against forest fires (Samurçay & Rogalski, 1992), for example, highlighted the operational role in the work activity of *pragmatical concepts* (Pastré, 1999). For example, the pragmatical concept of "stuffing" in the plastics industry was defined as follows (Pastré, 2002): "the state of balance or imbalance in the pressure of the machine and the reverse pressure of the plastic material, at the time when the injection process ends and the mould is full" (p. 12). And Pastré adds, "This concept is not limited to being a concept-in-action, insofar as practitioners in the shop talk about it and show it to novice workers" (p. 13). This concept enables the workers to diagnose the state of functioning of the machine. It is "central for an efficient action, adapted to the situation" (p. 13). Pragmatical concepts are therefore "schematic and operative representations, elaborated through and for action, produced by a collective and historical process, and mainly transmitted through experience and collaboration" (Samurçay & Rogalski, 1992, p. 232).

The power of pragmatical concepts comes from their multifunctionality: they are double-sided. One side is turned toward real time action, that is, diagnosing the situation according to specific objectives; the other side is turned toward cognition, the organization of the representations (Pastré, 1999; Vidal-Gomel & Rogalski, 2007). They are at the same time dynamic, operational representations of the process, reducing the complexity of the situation to its most significant variables for action, and long-term organizers of representations, integrating new observations into a consistent "conceptual structure" (Pastré, 1999, 2002) of the situation.

Conceptual Acquisition and Development

The key question regarding professional concepts is the question of their development. Following Meyerson (2000), the problem is to "approach (the transmission of) body techniques and

language with enough space for the renewal of techniques, thoughts, beliefs, for the historical dimension of societies" (p. 117). The question of the transmission of the professional concept is therefore simultaneously the question of its alteration, modification, and renewal. Researchers in professional didactics highlighted this social dimension: "Pragmatical concepts are not only built by the actor, they are also transmitted as work practices" (Pastré, 1999, p. 32).

In the Activity Clinic perspective, work is also seen as social and historical. The social is here defined in Meyerson's and Vygotsky's acceptation at the crossroad of the individual and collective dimensions (Meyerson, 2000; Vygotsky, 1934/1997). The way in which the individual workers get in touch with the collective dimensions of work is a complex, multilayered process that can be best understood by following the entry of a novice worker into his new professional milieu. This familiarization process is also a process of learning and identity building through participation (Lave & Wenger, 1991). In our perspective, the activity of the worker results from the integrative play of four dimensions (Clot, 2004). The role and place of these dimensions in the activity of the worker vary with his professional familiarity as shown next.

The work activity is performed by a given individual subject with his or her skills, knowledge, life and professional experience, preferences, moods, expectations, worries, goals, desires, and so on. This is the *personal* dimension of the work activity. Entering a new professional milieu, the novice worker is first confronted by the *impersonal* dimension of the activity: He has got a job to do, a position, with specific tasks and work relations, more or less precisely defined in organizational documents, procedures, structures, networks, division of labor. However, his acts and choices in the work situation are not driven only by these officially prescribed tasks. He works in a populated environment and his actions, as well as his words, are addressed to specific colleagues, work partners, customers. His work activity will be deeply dependent on this *interpersonal* dimension. Through these interpersonal exchanges, the novice worker will also be initiated step by step into the secrets of the work activity: implicit rules, expected or reprehensible behaviors, appropriate ways of acting and talking, of facing and solving problems, small habits, usual solutions to regular problems. He will learn by comparative exposure to the work activity of the other individuals in the work situation, and internalize all these informal dimensions crossing the professional milieu. This is what we call the *transpersonal* dimension of the activity, that is, the collective resources to conduct a specific activity developed through the history of a professional milieu. As stated by Bazerman (2012),

> Lawyers need to be able to see, speak, and argue as lawyers in lawyerly situations, which are themselves recognized and constructed in lawyerly terms. The field embodies concepts of how the work is to be communicated to whom, when, for what purposes. The social and institutional concepts (of rules, relations, forms, and tools) are as important parts of the field as the more direct epistemic concepts. (p. XXX)

These collective properties and resources form what we call *the professional genre* (Clot, 1999; Clot et al., 2001). The professional genre is a set of collective resources used by all workers to protect them from "wandering alone before the range of possible errors and nonsense" (Darré, 1994, p. 22). Its *transpersonal* dimension refers to the unofficial organization of work as constructed and transmitted in the culture and history of the work setting. The *professional genre* refers to the usual ways of acting and interacting, speaking, doing, relating to people and things in a professional way, established in a specific work environment. This historical heritage functions

both as a collective constraint on and collective resource for individual action. One's personal way of internalizing and externalizing these collective tools opens potential innovations, bringing renewal in the professional genre when these are accepted and shared in the working group. Therefore the professional genre is renewed by this interplay between personal styles, generic tools, and the contradictory demands of situations. The work activity is here conceptualized as a conflict between discordant dimensions, by which development (also conceptual development) may occur (Clot, 2004; see also Engeström & Sannino, 2011, on the driving role of historical contradictions in the activity system).

Professional concepts are a subset of the professional genre, which also includes bodily techniques, ways of acting together, words, and genres of discourse. These concepts are developed and used to face the impersonal dimension of the activity, at the interplay of its personal and interpersonal dimensions. They enter the transpersonal stock of collective resources, up to the point where they will be used by all without special notice. They may be renewed through the creative discordancy of the four dimensions.

The process just sketched is quite appropriate for established forms of activity, in traditional (even if constantly evolving) work situations like schools, churches, hospitals, courts, factories, public services, and so on. Going one step further, researchers may be interested in the creation of new social activities. These new activities are never performed from scratch; they inherit from concepts and logics of action created for former professional genres, imported and adapted by the various professionals involved in these new activities. Let's take two very different examples: at the very beginnings of the Internet in France, Carles and Broadbent (1999) discussed the role of analogy for new users in understanding the functioning of this new technology: New users attempted to conceptualize the nature and potential for action of new social and technical objects like "web sites," "hypertext links," and "e-mails" with older concepts derived from their understanding of phones, computers, French *Minitel*, and faxes. Regarding the new activity of VAE, or *Validation des Acquis de l'Expérience* (validation of professional experience) in France, Henry (2008) showed how interaction patterns inherited from popular education structured this new field and activity. However, analogies are modified; former professional experience gets renewed. The individual and collective transfer of former professional genres to new situations is known to be problematic (Prot, Reille-Baudrin, & Clot, 2007). What happens when jobs, objects, activities, networks change so much that workers have to invent new professional genres? When the objects themselves are new?

The Dialogical Nature of Professional Concepts

Vygotsky's (1934/1997) distinction between scientific concepts and everyday concepts highlighted the double source of concept formation. This distinction has been thoroughly discussed (Clot, 1995; François, 1999; Rochex, 1997; Vergnaud, 1999). In the French tradition, how scientific concepts collide with everyday concepts in the concrete activity of the subjects has been under scrutiny (Clot, Magnier, & Werthe, 2000; Prot, 2007). In this collision, the everyday concept may acquire a "whole series of new relationships with other concepts and transformation in its own relationship with the object" (Vygotsky, 1934/1997, §6.5). The use of the scientific concept to reflect on the action may open a development of one's everyday concepts. Conversely, the scientific concepts are altered in this interaction process: They

"germinate down," acquiring the richness of one's personal experience. Pursuant upon the work of our Activity Clinic team (Kostulski & Prot, 2004; Prot, 2007), we therefore highlight the dialogical nature of conceptual development. Specific dialogical frameworks have been designed in developmental interventions to sustain such conceptual development (Clot et al., 2001; Engeström, 1987, 1991). Reflecting on their activity under some well-designed methodological frameworks, practitioners may make explicit and even discuss some of their professional concepts.

PART 2. THE PSYCHOLOGY OF TECH DIVING AND THE CONTEXT OF OUR INTERVENTION

The psychology of diving began after World War II. Reporting a complete state of the art of this field is beyond the scope of this article. We limit our presentation to clarifying the reasons why we engaged as psychologists in a coanalysis of Tech diving.

Deep dives with normal air result in mild to heavy nitrogen narcosis. Time perception is altered, as well as vision and surface sensitivity. The performance is strongly reduced. Tech divers say that they turned to mixed gases for safety reasons, in order to "be able to do the dives they want to do." However, delivering the right mixed gases at the right time of the dive requires heavy technological support: Diving computers control the composition of gas at all times. Closed circuit diving requires a specific machine called a rebreather to recycle the expiration gases. Safety is therefore first a technical challenge in this activity, as technical problems occur. But the quality of the diver's reactions, in particular his ability to face these technical problems and to solve them quickly and correctly, is widely recognized as being the critical factor in death or health. Psychological factors have been investigated in different directions: personality factors, social and cultural factors, stress, and their role on the causality of accidents. Hunt's (1995, 1996) work in the psychoanalysis of safety examined the unconscious conflicts leading the diver to an almost lethal accident and the social factors associated with the perception of normal, necessary, or excessive risk. She pointed out the socialization processes in the divers' community that impact the individual appreciation of risk. Nevo and Breitstein (1999) pointed out that problems sometimes occur because of an incompatibility between some of the tasks needed for safe diving and the personality of the kind of person attracted to the sport. Many divers are attracted to the sport because of the challenges and proximity to danger. Yet safe diving can require meticulous attention to details such as checking the condition of one's gear or dive tables, which this type of diver is less likely to do. For Bachrach and Egstrom (1987), panic is the leading cause of diving fatalities. Panic can result from a gradual accumulation of events leading to anxiety (cold, tiredness, unfamiliarity with equipment, etc.) or from a single event that the diver feels unable to handle (regulator free flow, loss of a mask, etc.). Edmonds (1986) pointed out that fear alone, without the addition of any other stress, can cause death.

The notion of panic is very interesting for us in this research. Panic can lead to death in several ways. If the diver is breathing rapidly and shallowly, insufficient oxygen reaches the lungs, causing hypoxia and the buildup of excess CO_2. The diver thus tries to breathe even faster and may expel the regulator because he feels it is preventing him from getting enough air. Some divers in this situation bolt for the surface and expose themselves to the risks of decompression sickness.

Hypoxia can also lead to loss of consciousness. The increase in heart rate and sympathetic nervous system activity can cause a heart attack in someone with a weak heart condition. Panic also prevents the diver from thinking in a cool, patient, rational way. If the situation calls for rational thought—if the diver is tangled in a line or has an equipment malfunction, for example—panic can prevent the kind of reasoning that is needed to solve the problem and will often make it worse.

The time factor is critical. Any minor incident, like a leak in one's diving mask or losing a glove, may quickly have major consequences, as two more minutes spent to solve the problem at the bottom of the sea will require, depending on the depth at which the incident occurred, one more hour underwater, as decompression schedules have to be strictly observed. The stress here is double: The fear of not succeeding in solving the problem is coupled with the fear of exceeding the prescribed time. Time stress is ubiquitous, all the more as the activity is highly technical, based on equipment that is potentially defective.

Our first interviews with divers confirmed that point:

> Your state of mind puts you at risk or not. Anxiety grabs you by the throat. Suddenly you cannot bear it any longer, breathing that canned air, what you did before you can do it no longer, it is uncontrollable, you have to pop up to the surface like a float.

One interesting point in these first interviews of Tech divers was the recurrent following statement: "She wanted to go too quick, too far." That is what Tech divers told us on the death of Brigitte Lenoir, one of their friends and a female colleague, who died in Egypt in May 2010 while trying to break the world female record of depth (at −230 meters). The "refrain" that introduces this article—"An old Tech diver is a good diver"—is also present in the form "I do not know if I am good but I am still here," or in this even more explicit one: "To last in this milieu, one must take the time to build one's own experience." Experience is directly related to risk management and problem solving in emergency situations.

Our intervention as Activity Clinicians was driven by questions from the field. The field demand can be stated as follow: A good preparation is critical in Tech diving. It is thought to be a triple preparation: material preparation, physical preparation, and psychological preparation. But the psychological part is rarely documented. Some Tech diving teachers question this topic in their courses: Are you aware of the risks you take? Is your family aware also? Are they OK with that? Tech divers say that if an incident happens when you are at the bottom of the sea, the difference between a dead diver and a live diver is related to one's psychological ability to deal with this unexpected situation. One challenge from this research was to investigate the psychological ways of staying in control of a difficult situation. The Tech divers who volunteered for this research were interested both as individual practitioners and as trainers and teachers. Reflecting on their own practice was a way to help their students better manage these psychological aspects to practice more safely.

In that sense, the challenge of course for them is to take the time to build their own experience, but also to share it. As it is more deeply incorporated, the experience usually also become less visible and more difficult to formalize (Leplat, 1995). Routines may hinder both critical thinking and efficient transmission. Our bet was that risk management was strongly incorporated in all the small, repetitive, most common gestures of the expert divers and that working on their everyday practice was an indirect means to make these psychological aspects visible and to put them under discussion.

PART 3. CROSS SELF-CONFRONTATIONS IN ACTION: A DIALOGICAL FRAMEWORK SUPPORTING CONCEPTUAL DEVELOPMENT

We document this question in a specific developmental setting intended to support professional reflexive analysis and development of work activity, the clinical methods developed in Activity Clinic (Clot, 1999; Clot et al., 2001). Inside these developmental frameworks, professionals come to discuss in a structured way some salient (i.e. representative, significant, surprising or problematic) characteristics of their work activities. They use argumentative tools to express and defend their points of view, including some professional concepts. Used at first as argumentation tools, these professional concepts may become the focus of the analysis (Kloetzer & Henry, 2010). Professional discussions and controversies in these frameworks take the operating concepts to their limit. By means of this dialogical, developmental methodology, we get a chance to witness and analyze the development of professional concepts in the wild.

Cross Self-Confrontation Methodology Step by Step

The cross self-confrontation methodology is a dialogical and developmental methodology of work analysis, or to be more precise: of work *coanalysis* with the professionals. It goes through different steps. First, we observe and interact with the professionals for a long time and create a group of volunteers involved in the research, called "associated research group" (Oddone, Re, & Briante, 1977/1981). We put them in an observer position of their own activity with our questions and our way of observing (Wallon, 1983). We then set up work analysis meetings with the associated research group to decide which tasks they want to study in depth. Second, some professionals, mandated by the research group, analyze their activity with our support during simple and cross self-confrontations interviews based on video films of their actual activity (Clot et al., 2001). Third, we organize meetings with the research group to discuss these data and deepen the coanalysis. We select together video clips of their work and interviews where they debate about professional gestures, professional concepts, or organization problems. We point to the collective conflicts solved in the course of the activity, collective resources to face them, and professional skills used. These videos are commented upon, and the final product (report of film) is presented to the other colleagues, managers, and the steering committee.

The practical steps in the cross self-confrontation methodology are described below more precisely:

Framing the research within the organization

- First encounters, observations, interviews
- Building and animating a steering committee for the research within the organization
- Building a group of volunteers to co-analyze their activity, professionals tightly associated to the research called "associated research group"
- Working on the command and on the demand of the professionals and institution
- Organizing the research: people, objects, steps, calendar

Data collection and co-analysis

- Selecting activity sequences to be recorded and analyzed with the associated research groups

- Video recordings of the activity
- Choosing video material for the simple self-confrontation interviews
- Conducting simple self-confrontations (each practitioner comments the film of his activity with the researcher)
- Choosing video material for cross self-confrontation interviews
- Conducting cross self-confrontations (two practitioners cross-comment the film with the researcher: Professional controversies emerge)
- Selecting video material for the group discussions (from the films of the activity, of the simple cross confrontations and cross self confrontations)
- Conducting co-analysis and group discussions in the "associated research group"

Building artifacts to expand the discussion on the field: films, presentations and reports

- Selecting video material for the managing committee and for the professional environment
- Conducting discussions around presentations of the co-analysis
- Producing long-lasting artifacts: final report, video . . .

Researching the intervention process and its effects

- Analyzing the whole data set, processes and effects of the research

As it appears here, focusing on the interviews reduces artificially the scope of our interventions, whereas the concrete intervention begins a lot earlier and ends a lot later and may be iterative, as these interviews are not the goal of the research project but a tool to impulse thinking, development and organizational transformation.

The Situation Analyzed

To analyze Tech diving activity, we focused on three sequences of activity: (a) the preparation phase, where the divers unpack, prepare their material, control it, install it, dress, pack, and get ready for diving; (b) the first moments of the dive, from the surface to −30 meters below, going down, which is usually done quickly with a few stops for tests; and (c) the last moments of the dive, including decompression phases, from −30 meters to the surface, which take a lot longer. These choices were partially constrained by technical possibilities for filming: Filming under water requires a heavy material (underwater camera) and specific skills but also light, as the waters quickly become dark. In order not to constraint the movement of the divers, we chose to keep the film in natural light; therefore, our investigation range was limited to 30 meters under surface on a sunny day with clear, quiet waters. And the images are still saturated by a milky blue.

The sequence analyzed in this article is extracted from the cross self-confrontation of two experienced divers, who have been practicing Tech diving on a weekly basis over the last 10 years, are trained in specific advanced modules, and are involved in transmission of the activity (as Tech diving instructors). They are partners ("dive buddies") and close friends. They were volunteers for this research, because they consider that the psychological factors are critical for the safety of Tech divers and that they are globally unknown and underestimated in the milieu. This research was an opportunity for them to document and discuss these psychological dimensions.

The sequence we focus on is related to the preparation phase (out of water): In this sequence, D1 is preparing his stuff near his car. When he arrives at the divers' car park, his car trunk is

full of expensive material, carefully packed in big plastic boxes. Unpacking his car trunk, he organizes a working space around him in a very structured way. In the cross self-confrontation, he was asked to comment his actions and react to the comments of his colleague, D2, and we discussed how he proceeds in comparison to his friend and colleague.

PART 4. WATER DROP: CONCEPTUAL DEVELOPMENT IN THE WILD

The discussions presented next are initiated by the video film of the preparation sequence of D1 in and around his car. In this article we turn our attention to one dimension of this exchange: the discursive development of the concept of *confidence in the machine*. In the first excerpt, the video film shows D1 putting his rebreather in function. This piece of material is the core of the Tech diving equipment, as it enables the use of gas in closed circuit. It delivers to the diver an appropriate mix of gases at any time of the dive. It is controlled by a computer worn on the wrist. Redundancy is guaranteed for most pieces, including the hand computer. However, there is no redundancy for the rebreather itself. In case of trouble, the diver is to switch to security systems, here, traditional scuba tanks ("bailout"). The "*level of confidence in the machine*" as a means to reduce the psychological pressure appears in the first minutes of the discussion:

Excerpt 1: "I know my rebreather is fine."

1. D1: First I put the equipment in place at the level of the physical place to move it as less as possible.
2. R: You proceed that way for . . .
3. D1: Not to forget anything. Thanks to my preparation sequence, I am sure not to forget anything. I know it has been checked, it is done.
4. R: You check first the most critical material?
5. D1: No first I arrange everything then once I have arranged everything, I prepare my re-breather. I have it work a little. The batteries, the oxygen injection are going to work. I have already done a series of preliminary tests and I leave it quiet. It blinks. It is also psychological. If my re-breather has been working for some time, if the batteries have been in operation already for 5 minutes, I assume that they are going to function also underwater. When I put my re-breather on my back, the psychological pressure will be lower because I do not know if my re-breather is working well or not. Here my re-breather has been working for 5 minutes, so I know it is fine.
6. R: It's really here **your level of confidence in the machine**.
7. D1: Exactly. (looking back at the video film) Then I let my re-breather function and I carry on preparing the material.

This notion of *level of confidence in the machine* is introduced by the researcher in an attempt to understand what the divers mean by the expression of the milieu "you have to *build your*

confidence in the machine." The "machine" here is double: rebreather and computer. Breathing is their main concern. Having the machine work for some time "blankly" (with no gas request) is a way to build this confidence in the machine: trusting the machine, but also knowing that you trust the machine. The temporal organization of the preparation sequence is here used by the diver as a psychological tool to *control both his equipment and himself in his relation to his equipment*. We find this double movement (building confidence in the machine thanks to routine checks; building parallel confidence in one's control of the machine) in the beginning of the second excerpt presented next: Here the spatial organization of the divers preparation sequence is used as a way to control progress (things done, checked) and build one's own confidence in progress, up to the point where it will be possible to dive: when the *confidence level of the diver both in his equipment and in his own processes and control of his equipment* will be sufficient.

Excerpt 2: "I agree moderately"

1. D1: Here my scuba tank is ready, **I put it out of my working space**, and **I know I don't have to check it again**. When it is ready I put it out so that I can't cross them. For a very simple reason: these gas mixes are not breathable at the same depth. Crossing tanks is OK in one sense, but not in the other. It is an oxygen-enriched mix and one should not breathe that in high depth. That is why the configuration is different, the taps are different, the regulators are different. As it is dangerous, the regulator itself is put in a space where one can-not get it immediately.
2. R: Yes you put it in a pocket here
3. D1: It means that if I want to take it, something will get in my way and bother me, which means I will smell a rat: I have put here something constraining for me, maybe it is dangerous.
4. D2: I had a pocket, too, and eventually I got rid of it. The reason is if I must take that mix, if under stress I still have to open the pocket and pull the regulator, for me it could be dangerous.
5. R: What if you have to take it in very quickly?
6. D2: In this kind of dives we are looking for the best compromise: **what is the more dangerous, what is the more important?** Point to the right mix, or loose time in getting the air one needs. **I chose, we have only two mixes, only an idiot would do a mistake. But under stress one easily becomes an idiot, one hardly thinks.** I think right is rich, left is less rich. I need air quickly (*he says so with a gesture to cover his nose with his hand*).
7. R: For you, right or left is enough.
8. D2: Rich, right, oxygen enriched.
9. **R: What do you think D1?**

10. D1: I agree moderately because . . . Taking a gas mix quickly, yes, but taking a rich gas mix, no. Because . . . Taking a rich gas mix . . . If I am in hyperoxia, a rich mix will not help me. If I am in hypoxia it will. If I am in hypercapnia, it will also. With limited depth, if I take that gas mix to solve my problem, I have one chance out of three that it will indeed aggravate my problem. I have a problem and this gas mix will make things worse. In higher depth, I have a 100% chance to increase my problems if I take that mix. Below −30 meters, partial pressures are already high. So I don't take that risk and I constrain myself . . . not to dunking but I am not a fish . . . **and in my head it is a means to condition myself**. I know that on the right side I should not take it. I know that so doing it will be constraining to take it and if I have to take a mix I will take the left one, because on the right side the door is closed.

The second excerpt presents a tough discussion between D1 and D2 initiated by the observation of a detail of the activity: In the preparation of the bailout, D1 covers one of the regulators with a protective pocket, whereas D2 does not take such a precaution. Introducing physical barriers requiring workarounds to constraint emergency actions, prevent automatic dangerous actions, and trigger thinking and control from the operators is a classical trick of risk management. However, it usually does not appear in situations where the time factor is critical for life and death. This balance between security and life emergency is well synthesized by D2 in turn taking 9: "What is the more dangerous, what is the more important?" The comparison of the two different ways of D1 and D2 for solving that conflict supports the discussion. Speech turns 1 to 3 present a first explanation by D1 of his way of doing, protecting the regulator in a pocket. Speech turns 4 to 8 present an alternative view of D2, who explains why he got rid of the pocket (to gain time in an emergency situation). This opens a potential controversy between D1 and D2, nourished by the researcher with her question on speech turn 9. Contrasting two different ways of proceeding, comparing these choices, requiring a different point of view from the other diver, open a dialogical space where points of view can be, first, expressed and explicated and, second, discussed.

This excerpt is interesting for us in many ways. First, it highlights the richness of their professional concepts related to breathing and, more specifically, to oxygen: "hypoxia," "hyperoxia," "hypercapnia" are medical terms translated into the divers' experience, the meanings of which are continuously negotiated at the intersection of medical science and diving practice. Similarly, the scientific concept of "partial pressures," defined in chemistry, is put to work at an operational level for the divers. Breathing is their core business in this activity; therefore, their professional concepts integrate a lot of scientific concepts related to the chemistry of gas mixes and human body. Second, it highlights how the material dimension—here, preparing the security tanks—is used as a psychological tool for self-control, as stated by D1 at the end of the sequence: "in my head it is a means to condition myself." The sentence "Right, rich," which functions for D2 as a reminder,[1] plays the same role. Therefore, the notion of confidence is once more double-sided: confidence in the system, but also confidence in one's way of handling the system.

[1]This kind of simple, repetitive sentences, widely asserted and shared in a professional milieu, have been called "professional refrains" (in the musical sense; Kloetzer, 2008). They point to important generic dimensions of an activity, most of the time conflictual, that the history of a milieu has grasped through these dense, opaque formulae, which are fully understandable only by the professionals of this milieu. Each profession has its set of professional refrains.

The third excerpt highlights why this confidence in the machine is so critical. The quality of the preparation guarantees two things: well-tested pieces of equipment, and a quality of mind, a peaceful state of mind, in which the diver is "confident in the machine" because he is confident in the tests and preparation of the machine he did. This peace of mind is very important for two reasons: First, it restricts vicious internal dialogue, which may drive to "escalation," with the risk in the end of "active panic," in which the diver pulls all his equipment away and goes directly back to the surface, with lethal consequences; second, in case of trouble underwater, it helps to quickly eliminate impossible hypotheses, focus on the most probable reasons, speed up the diagnosis and find one's way out of the problem.

In the discussion, the divers experience that a good preparation is used as a psychological tool to control one's internal dialogue underwater. D1 states,

> I have different tests. Testing the oxygen injection, testing the pressure, testing the sealing. . . . This procedure is standard. These phases are very important for me because . . . I mean . . . if these kinds of controls are done under time pressure. . . . I mean . . . All the confidence we have in the machine will not be there. And afterward during the dive, one may wonder, maybe one pipe is not fine. . . . And for me it may be a stress factor and one consequence is . . . that it increases my internal dialogue. And in the end it can be the escalation. (he remembers a concrete incidental case) I heard a small noise, maybe it is the pipe that I did not replace. . . . My heart began beating fast, because I was entering into a passive panic state, generating stress, I had a heavy internal dialogue, tcht tcht tcht, which tells you that something is wrong, you check your material, tcchhht tcchhht tcchhht, check again and again. And then it is like needles. One could panic, pull everything out and go up. I mean active panic, in which one pulls everything out. And then an accident happens.

In this last excerpt, the dispersed discursive exploration of the notion of confidence for Tech divers conducted so far is finally brought in focus. D1's first speech turn expresses very clearly the two concomitant directions of this confidence building: My machine is fine and I know that my machine is fine. Once this double confidence is built, "I can dress up, put my rebreather on and go." In the discursive flow, the researcher chooses to focus attention on the notion of confidence in the machine and does so by questioning the other diver on his own understanding of this term: "is it a term you also use D2?" Therefore, this last excerpt makes explicit, at the discursive level, dimensions already expressed conversationally before.

Excerpt 3: "what do I breathe?" "we need a trust relation (. . .) we are a pair"

1. D1: Now I have finished the control phase of my rebreather, **my rebreather is working**, it is checked, it is fine. **And I am in a state of confidence towards my machine**. I can get dressed up, put my rebreather on and go.
2. R: **D1 you have been mentioning the term confidence in the machine many times, is it a term you also use D2**?
3. D2: **We need a trust relation**. **In case of doubt, big doubt, we do not dive.** One more time there is a lot of technology . . . galvanic cells to measure the oxygen. . . . If there is a problem with them, one more time, no dive. Yes it is advantageous to trust our machine.

4. D1: These machines give us incredible capacities, capacities you can barely imagine when you do recreational diving. And all that power is linked to this machine. This machine is physically limited. As D2 says, there are procedures, we teach them, there are series of problems one can have, there are problems one does not want to have, and when it happens, having checked carefully your material helps a lot. **This confidence will play a key role in case of a problem to quickly eliminate suspicions of problems. That and that, cannot be. It can be only that or that. Being able to eliminate hypotheses very quickly has a decisive impact on your way out of the water.** We can see that with our students. We create problems for them. They solve them by the book with their little procedures, tac tac and then we tell them the problem is not solved, because it is possible that the problem is still there. Then the students are lost. We tell them to think. You must get out of that problem. For me, being able to solve a strange problem underwater depends on your confidence in the machine.

Most accidents happen when divers cannot solve problems arising underwater in a satisfactory way, which means calmly, quickly, and correctly. The two divers will say later in the excerpt that this capacity makes the difference between a good diver and a bad diver, and therefore in the end between a diver who stays alive and a dead diver. The confidence in the machine, defined as double-faced as we did so far in this article, plays a fundamental role in problem solving and crisis management. Knowing that you did right and that your material is fine and therefore, cannot be wrong now, helps you eliminate hypotheses and discover the real sources of a problem.

5. D2: We teach that kind of diving, but we cannot teach trust. It develops gradually. One has to be humble, we tell our students **you will build your experience,** it takes time, little by little you will get confidence in this machine, this machine is essential for you, don't worry, it will require the time it will require. One has to be humble and smart enough to accept that it takes time, to accept that it will take the time that it will take. **After the diving school, one has to build one's experience**.

6. D1: What D2 says is very important. We have seen that . . . People who wanted to go too fast, who acquired a confidence in the machine too quickly, and rely too much on it. And that doesn't work. If your machine gives you a wrong signal . . . what happens? Sometimes we have seen students react in a completely irrational way underwater. What are you doing? Why? But it gave me this information! No problem, you press here and here, think! And this confidence develops gradually, with time and practice. Before we said **we have a form of relation with the machine. This means that this machine delivers a gas mix which changes all the time. It is almost alive. It is not "it works or it doesn't work". And the question to ask is always: what do I breathe. Because one can very well die with air in his tanks, because one is doing a lime intoxication. This is a set of things that one has to interpret. It is a diagnosis. Problem solving.** If you consult a doctor, he will try to understand where the problem comes from. We do the same, we have to understand the problem on the rebreather. And I repeat: people who went too fast, who relied fully on the machine. . . . Because these machines are brilliant. It works by itself. You turn your computer on, you dive, it tells you what to do, when to stop. But this doesn't work. **It is a relation. I don't let the machine decide for me.**

The divers bring back into the discussion a "professional refrain" (as previously defined, see footnote 1): "one has to build one's own experience." The discussion allowed them to "unpack," make explicit, develop the content of this dense formula widely shared among Tech divers. This experience to build is related to the notion of confidence in the machine that we have investigated so far. Building one's own experience means building one's confidence in the machine, which doesn't mean that one relies fully on the machine: Trusting the machine means knowing up to which point it can be trusted, and which are its most probable expected failures. This requires background knowledge, both on the technical functioning of the machine and on the body state of the diver.

At the end of the discussion, the divers state very clearly the content of the notion of confidence: "I never fully rely on my rebreather. I do not go underwater if I do not trust it." The divers experience this understanding of confidence in the machine as being new for them: "I am just thinking aloud. . . . Because here these things are new . . .", "It is interesting because some things emerge, and those things I did not think them before. I appreciate what you say. We dive as a pair. It is something that we can teach to our students. It is a very good point. We dive as a pair. I did not think about it before but that kind of reflection we can transmit it to our students. This quality of relation has to be present, if not it can screw up." And as a conclusion: "I was often upset with people who rely fully on their machine. But I didn't know why. Today I realize why. Because we really dive as a pair."

All these expressions indicate that some kind of conceptual development happened in this sequence. We will now try to characterize it more precisely.

PART 5. DISCUSSION: DISCURSIVE FORMS AND CONCEPTUAL DEVELOPMENT

In this sequence, we witnessed an example of conceptual development, not by creation of a new concept to grasp new professional realities but by the *dialogical unpacking, unfolding* and therefore, *reconstruction*, of a professional notion, the idea of "confidence in the machine."

Conceptual Development as Unfolding of the Underlying Complexity and Conflictual Dimensions of a Professional Concept

The notion appears first through the careful observation of the preparation sequence of one of the divers, in the expression "a level of confidence." The diver explains that putting its rebreather in operation sometime before the dive enables him to reduce the psychological pressure. Temporal and spatial organization of the routine preparation sequence enables the divers to reach a state of peace of mind, which makes diving possible. This temporal and material organization, as well as physical barriers, are used as *psychological tools to control not only one's behavior underwater, but also one's internal dialogue*, which could, if not controlled enough, drive them to panic and then to an accident. In that context, the "confidence in the machine" appears less as a level to be reached than as *a work in progress*, to be built thanks to careful, routine, but conscious preparation processes. The comments, answers and thinking aloud of the two drivers, addressed as much to the researcher as to their colleague and friend, make explicit many times that this "confidence in the machine" is indeed a capacity *not to trust fully the machine*: to be able to dive, with my life

depending on the good functioning of my rebreather, I need to know (a) that my rebreather is fine, and (b) that I know that my rebreather is fine (and therefore, that I trust myself to know what could be wrong). Trusting the machine means indeed *not* trusting the machine blindly. The expertise lies in the capacity to be able to control the process, interpret the information in a dynamic way, integrating a set of heterogeneous information (contextual information; good knowledge of the machine; perceptions of one's own reactions, sensations and body; classical symptoms of disorders, etc.). The divers approach this double-sided confidence with the formulas "*a quality of relation has to be present*" and "*we dive as a pair.*" So doing they grasp dimensions of the relationship to their equipment that were heavily present, but tacit, underlying, in their practice. They put into light something that was important for them but not conceptualized so far. Finally they relate this new understanding with emotional feelings: what upsets them with some divers, what is important (the need to build slowly, at one's own pace, one's own experience). And to the professional refrain widely shared in the milieu: "one needs to build one's experience." The new understanding of a classical and quite fuzzy professional concept gains strength and precision thanks to these emotional anchors and generic echoes. The floating notion that emerged in the careful observation and thorough discussion of the routine activity of the Tech divers is nourished by former emotions, to which it gives a form by forging terms, expressions that encapsulate its meaning (here, "we dive as a pair").

However, the terms they use in the end of the sequence show that this emergence of a new understanding is not yet a full new professional concept. It may become one, if these new ideas circulate in the professional milieu and get an audience, if as they say they transmit them successfully to their students and bring them into discussion with their experienced colleagues and friends.

Here the development is related to the unfolding, to the making explicit of the underlying complexity, even of the conflictual dimensions, of a professional concept. The conceptualization is progressing also thanks to the *liaison work* (Vygotsky, 2003) between individual and collective emotions, internal dialogue and external dialogue.

Internal Dialogue, External Dialogue, and Conceptual Development

This conceptual development is enabled by a kind of discursive activity strongly structured by the developmental methodology of cross self-confrontation. We would like to point to some dynamics enabling this conceptual development.

We would like to emphasize firstly the *interfunctionality of observation and dialogue* in this framework. This framework supports a careful observation and comparison of individual ways of performing a similar activity (here, preparing oneself for diving), which triggers comments or questions. In parallel, the researcher tries to nourish a professional controversy, as defined by Kostulski (2011): "a kind of discursive, deliberative and reciprocal activity, in which opposite arguments are used in the dialogue, these arguments being picked among the generic and historical topics of the professional milieu" (p. 83). The analysis performed is enriched by the dialogical activity of the participants, as the argumentative logics of the dialogical framework requires from the participants that they go beyond well-established knowledge to be able to convince both the researcher and their colleague. They use and question what they see to support their point of view in the discussion. Reciprocally, the observation of the activity questions some simple statements,

like in the pocket example of the second excerpt, leading to a controversy ("I agree moderately") on the correct compromise between emergency and safety.

We would like then to emphasize the *interfunctionality of internal and external dialogue*. These dynamics of external dialogue nourish the internal dialogue of each of the participants. For example in this same second excerpt, in speech turn 6, D2 says on this same compromise emergency/safety: "I chose, we have only two mixes, only an idiot would do a mistake. But under stress one easily becomes an idiot, one hardly thinks. . . ." This last sentence is a counterargument to himself, opposed to his own choices. Either it represents the voice of D1 in this dialogue or it realizes one alternative of his internal dialogue regarding emergency and safety. Our hypothesis is that the external discussion with D1 reactivates D2's internal dialogue on this professional dilemma between emergency and safety. D1's voice (Grossen & Salazar Orvig, 2011) or perspective (Fernyhough, 2004, 2008), mostly concerned with safety, is first expressed by his author (D1) in the external discussion, then internalized by D2 in his own internal dialogue, and finally reexpressed by D2 in the external dialogue with D1 and the researcher.

These interfunctionalities are put at the service of conceptual development in so far as these professional concepts become the object of both the activity of analysis and the discursive activity. The discursive form of professional controversy, as defined in the cross self-confrontation framework, is efficient in opening opportunities for conceptual development as it supports these interfunctionalities of observation/dialogue, and internal dialogue/external dialogue.

CONCLUSION

We were lucky enough to conduct a developmental psychological intervention with people who depends on a machine for living, as it enables them to breathe underwater. This enables us to understand the man–machine relationship in a quite renewed way. Emotions play a role in this relationship, but the emotional link is not between the diver and the machine (the rebreather), as we initially thought. It is between the diver and the professional concepts that the machine is related to. The sequence we presented in this article highlights some interesting points, in particular the importance of professional concepts in this activity that are related to breathing and oxygen, derived from human physiology, chemical and physical science (partial pressures, hyperoxia, hypoxia, etc.) and adapted to the practice. The divers are not emotionally engaged toward the information delivered by the machine; however, they are emotionally engaged toward the meaning for their breathing, body and lives, of the information it delivers.[2] Underwater, the diver functions in informational "closed circuit," where he is both the source of the information and the recipient of these same information, all the more as these information are emotionally loaded. No wonder then that the internal dialogue develops strongly in that situation. Former researchers in the psychology of diving emphasized the role of panic in dive accidents. This research brings some insights on the links between panic and internal dialogue dysfunctions. It also enables us to understand how experienced divers use the temporal and physical logics of the preparation sequence of their material as psychological tools to control their own internal dialogue underwater. This is a direction to explore in order to improve Tech diving safety. Regarding conceptual

[2]As we are usually not emotionally engaged toward our clocks (except collectors) but toward the concept of *time*. The man–machine relationship is first a man–concept relationship, mediated by a machine.

development, our analysis underscored the conflicting nature of these professional concepts as well as their multifunctionality. This sequence shows that conceptual development sometimes takes the form of the collective demonstration of this complexity, especially at its operational dimensions, which may open new possibilities for action (here, in the transmission of experience to other practitioners). It also emphasizes the discursive dimensions of this conceptual development. The argumentative logics of the dialogical framework requires from the participants that they go beyond well-established knowledge to be able to convince both the researcher and their colleague. The article also relates the stabilization of the new emerging concept to its anchoring both in the emotions of the participants and in the professional genre of the milieu. Finally, it shows the potential of a developmental methodology of cross self-confrontations in conceptual renewal: combining careful observation of routine behaviors, comparisons of personal habits and thorough discussion of convergences and discrepancies, the methodology encourage reflexive practice and conceptual renewal. However, the perimeter of conceptual change is larger than the developmental research frame, and long-lasting effects require further shared experimentation in the professional milieu.

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