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Scientific Mind, Critical Mind and Complexity: Learning from a Scientist's Life History

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1. Promoting scientific minds, critical minds and complex ways of thinking

Among the complex issues scientists and non-scientists manage today, one of the most crucial may be the ambiguities of scientific production itself. Indeed, the history of the 20th Century has shown that scientific minds can produce both the best and the worst. The scientific process has then no value if it does not critically discriminate what it produces in order to evaluate and judge its own legitimacy. At the same time, its relevance also depends on the level of complexity it recognizes and tolerates. But what does it mean to have a critical mind, to recognize complexity, and how do we promote it?

This paper aims to question the way to conceive and to promote among scientists the development of a critical mind able to deal with the complexity of their personal and professional lives. Based on previous research exploring the way the concepts of "critique" and "complexity" have been conceived in the academic field (Alhadeff, 2004, 2005; Alhadeff-Jones 2006, 2007), the first part of this paper introduces some theoretical and epistemological considerations allowing one to question the meaning attributed to the notions of "critical mind" and "complex way of thinking".

In order to understand how scientists learn to deal with critique and complexity, the second part of this paper suggests a conceptual framework, inspired by the author's own experience of research, allowing to explore the development of a critical and complex way of thinking. The notions of "antagonism", "limit" and "mastery" are thus introduced.

Inspired by theoretical and practical approaches developed in the field of Adult education and lifelong learning, this reflection finally suggests the exploration of a researcher's life history as a way to explicit the heterogeneous antagonisms produced by scientific practice and the strategies developed to cope with them, both at an epistemic and at an experiential level.

2. Critique and complexity

The first part of this paper aims to introduce some theoretical and epistemological considerations allowing one to explore the meaning attributed to the notions of "critical mind" and "complex way of thinking".

2.1 Critical mind

2.1.1 Definition

As an adjective, the term "critical" (after "critic") comes from the Latin expression *criticus*, originally used in a medical context. This meaning is inspired by the Greek expression *kriticos* meaning "able to judge, to decide" and later used to refer to the crisis associated to a disease. *Kriticos* itself derivates from the Greek expression *krinein* (shared root with "crisis" and "criterion") which originally means sorting, separating and later, classing, arranging, organizing, deciding, and finally judging (Rey, 2000).

Refering to a capacity of judgement, being critical is originally associated with the action of criticizing the qualities or merits of anything. During the 17th century, one of its first uses refers in particular to the art of estimating the qualities and character of literary or artistic work. By extension, the word has been used to qualify a person, a faculty or a mind which does not accept any assertion without checking the value of its content, its origin or its manifestation (Institut National de la Langue Française, 2005, critique). In the scientific, philosophical and litterary fields, what is "critical" generally refers to a method of evaluation involving various criteria allowing to discriminate the merits or the faults of a project, work, or system of thought. The word is then used to qualify the product resulting from this method (critical essay). The notions of "critique" and "criticism" themselves refer either to the capacity of the mind to judge or to discriminate, a process of examination, or a judgement of value.

By extension from its medical meaning, "critical" also refers to the nature of, or what is constituting, a crisis. It qualifies what appears as having a decisive or crucial importance in relation to an issue (critical path), or what involves a suspense, a fear, associated with the uncertainty or the risk involved. During the 18th century the word is more broadly used to qualify what is determining or decisive, or what can bring change. Following this understanding, one of its contemporary uses in mathematics or in physics refers to what is "*constituting or relating to a point at which some action, property or condition passes over into another; constituting an extreme or limiting case*" (critical angle, damping, point, temperature, potential, pressure, state, volume, mass, size, etc.) (Simpson & al., 1989/2005, critical, para. 7).

This etymological exploration highlights the polysemy associated with the expressions "critical" and "critique". The various meanings carried by these words invite one to consider a "critical mind" as characterized by an ability to discriminate, to evaluate, to examine, to judge and eventually put in crisis a work, a phenomenon, an experience, either observed or lived.

2.1.2 Historical perspective around the idea of critique

From a philosophical and social point of view, the way to conceive what characterizes a "critical mind" has evolved following the history of ideas. During the Antiquity, Greek philosophers considered a critical mind through the art of maieutics (Socrates), the virtues of dialogue (Plato), logic and ethics (Aristotle), cynicism (Diogenes) or scepticism. It could also have supposed the capacity to study the literary canons (classical philology), to interpret founding religious writings (classical hermeneutics), or to develop the ability to be ascetic and challenge the established laws and wisdoms (stoicism).

With the emergence of Christianity, a critical mind supposed – among others – to find inner revelation and one's own personal responsibility (Saint-Augustine). With the reinforcement of theology and theocratic power during the Middle Ages, being critical could have appeared more related to the ability to discriminate what refers to human rationality from what is revealed from the knowledge of God (Saint-Thomas).

With the Renaissance and the 17th century, emerged new ways of conceiving the constituents of a critical judgement. With the rise of humanism, being critical meant to contest the power of divinity and reassert the value of the human mind (Montaigne). With Descartes, rationality and systematic doubt appeared at its core.

With the rise of empiricist and materialist thought, the 18th century revealed itself after Kant as the century of criticism. Being critical meant then to question what legitimates our own rationality, and what could be the extent of knowledge grounded in human experience. A critical mind would have then supposed a sentient being and a mind able to establish and evaluate the rules of its own actions.

With the French Revolution, new ways of conceiving the idea of critique emerged. From a positivist perspective (Comte), a critical mind grounded in the rigor of experimentation aimed to establish invariant laws allowing one to describe and to challenge relationships between observed facts. Stressing the fundamental transformation and historicity of rationality, Hegelian philosophy revisited the role of a critical mind by reconsidering the idea of emancipation and social justice. Following this path, Engel and Marx reinvented social critique. From now on, a critical mind appeared grounded in the capacity to read social, economical and political contradictions as being part of a broader historical process, moved by social struggles.

Through the turbulences of the early 20th century and the development of new knowledge, science itself appears at the core of a critical process. With the emergence of the Critical Theory of Frankfurt School, developing a critical mind suggested being aware of the risks inherent to the instrumentality of scientific rationality and the way they are inherent to our modern society. With psychoanalysis, being aware of one's own unconscious determinations.

During the second half of the century, new forms of critique appeared in reaction to the social changes affecting Western societies and the contemporary evolution of sciences. With the post-structuralist turn, having a critical mind meant being aware of the power of norms defined by scientific discourses and the ways they contribute to shape social

constrains (Foucault). With the emergence of postmodern positions, relativistic interpretations abandoned the desire to find an underlying order shaping universal principles. Following this perspective, having a critical mind would suggest refusing any transcendence or totalising view of the world. In parallel, with the rise of a second wave of feminist critique, and the reinforcement of the recognition of social, racial and sexual minorities, the last four decades of the 20th century have contributed to the emergence of critical minds reconsidering social justice through the lens of diversity, multiculturalism and the struggle of minorities (Alhadeff-Jones, 2007; Ruby, 1990/2004).

2.1.3 The complexity of critique

Such a broad overview, far from being exhaustive (how could it be?) and in spite of being quite approximative, stresses the richness inherent to the idea of critique and the variety of discourses which feed its contemporary understanding. Three main stakes appears relevant to mention at this point. First, to be confronted to such a diversity of conceptions of critique – through their plurality of referentials, themes and concepts – can quickly appear as destabilizing. Trying to highlight the diversity of critical ways of being appears then as an initiative contributing to some kind of disorder. Because of the irreducibility of the underlying logics, such an approach may even appear as illegitimate. Would such a broad approach of the "critical mind" contribute to dissolve what makes the specificity of the idea of "critique"? The answer to this question should be affirmative if there was not some kind of regularity among these different positions. Here appears a second stake. In parallel with such a disorder, a form of order remains, allowing to conceive their mutual relationships, and some of their shared characteristics. The simultaneous presence of disorder and order among heterogeneous ways to define a "critical mind" finally involves the recognition of some kind of organization allowing one to understand the idea of critique as a complex one (Alhadeff-Jones, 2007). Although such a complexity is not going to be explored in this paper, it seems nevertheless relevant at this point to clarify the meanings associated to the idea of "complexity" itself.

2.2 Complex way of thinking

2.2.1 Definition

As for the notion of critique, the meaning given to the idea of complexity has evolved since its first use. The notion of complexity refers to the quality or condition of being complex. Adapted from the Latin expression *complexus* (14th century) or adopted from the modern French, the term derived from *cum* and *plectere*, meaning surrounding, encompassing, encircling, compass, embrace, comprehend, comprise. Originally referring to "*embracing or comprehending several elements*", its use in English tended to the sense of "*plaited together, interwoven*" (Simpson & al., 1989/2005, complex [adjective], etymology). Referring to things or ideas "*consisting of or comprehending various parts united or connected together*" or "*formed by combination of different elements*", "complex" is often understood as a synonymous either for composite and compound, or complicated, involved, intricate (ibid. para.1) Referring to a plural of quantity and a plural of quality, the adjective "complex" conveys during the past centuries various specific meanings. Sometimes they privilege the molar, holistic, global or non-linear form of intelligibility needed to comprehend a phenomenon; sometimes they stress a

pathological, dense, entangled dimension appearing as rebellious to the normal order of knowledge (Ardoino, 2000).

2.2.2 Complexity theories

The contemporary scientific understanding associated to the idea of "complexity" send back to the conception of a non-Cartesian approach of science, first formulated by Bachelard, in 1934, to legitimate epistemologically the role of complexity as the ideal for contemporary sciences (Le Moigne, 1996). If a Cartesian epistemology reduces complex phenomenon to the analysis of their components, understood as simple, absolute and objective ones, a non-Cartesian epistemology of sciences privileges a dialectical approach understanding phenomenon as a fabric of relations: "*There is no simple idea, because a simple idea* [...] *is always inserted, to be understood, in a complex system of thoughts and experiences*." (Free translation of Bachelard, 1934/2003, p.152) The recognition of complexity appears then at the roots of a new kind of scientific explanation which perceive simplicity as a specific provisional phenomenon. If complication refers to the idea of an intricate situation waiting to be disentangled, complexity supposes then the fundamental non-simplicity of studied phenomenon (Ardoino, 2000).

Without entering in the detail of the evolution of the concept of complexity (Alhadeff-Jones, 2006; Le Moigne, 1996, 2001a), it seems important to stress the fact that its contemporary use depends largely on the theoretical framework used to define it and the epistemological assumptions framing its understanding. Indeed, since the effective appropriation of the concept of complexity by the scientific community, initiated with the milestone paper written by Weaver (1948), an original but dispatched body of research emerged during the 20th century[1]. From an epistemological point of view, the development of complexity theories based on a set of heterogeneous assumptions carries, as a whole, several ambiguities.

For some researchers (e.g. Santa Fe Institute), complexity may be considered as an ontological dimension of the object of study, which can be reduced to specific characteristics and eventually represented through a set of all-embracing algebraic expressions. Its states and behaviours can be described and calculated with certainty, following a computing process. In this perspective, the evolution of this kind of system can be predicted, more or less accurately, through programmable algorithms. The possibilities are considered as knowable. The behaviours observed are considered as being explainable, and then predictable, by a theory, a rule, or an invariant structure. If the computation capacity of the observer may practically limit such a prediction, the development of more sophisticated computing devices allows its advocates to believe in the high potential of this position (Le Moigne, 1996). Today, such an approach is at the core of the development of various trends, recognized by many as "reductionist", whose limitations brought them to be associated to the notions of "complication" or "hyper-

[1] Mathematical theory of communication, automata theories and neural networks, cybernetics, Operations Analysis and Operational Research, computer sciences and engineer sciences, management sciences and Artificial Intelligence, systems sciences, self-organization theories, study of non-linear dynamics (dissipative structures, catastrophe, chaos and fractals theories), evolutionary biology, Complex Adaptive Systems, *Intelligence de la Complexité*, etc. (Alhadeff-Jones, 2006).

complication" (Ardoino, 2000; Morin, 1977/1980; Le Moigne, 1996, 2001a; Lissack, 2001).

On the other hand, with the dissemination since the 1970s of numerous books introducing theories related to complexity to a broader public, a "softer" position has emerged. Considering concepts associated with complexity as powerful metaphors to describe or understand socio-cultural phenomenon, this literature contributed to spread an original vocabulary feeding new interpretations of reality (information, feedbacks, network, system, self-organization, emergence, autopoïesis, chaos, etc.) Recognizing differences and similarities between various levels of organizations (physical, biological, social, etc.) this position contributed to the perpetuation of analogies between them. Because of the absence of reflection on the validity framing these comparisons, their epistemological legitimacy remains most of the time unchallenged, bringing some authors to identify them as "pseudo-scientific" (Le Moigne, 2001a; Phelan, 2001).

In parallel with these understandings, a third position may be identified. By contrast with "hyper-complication", it suggests that complexity is associated with situations where the observer is aware of the impossibility of defining the list of potential states of a system, or the ways to program them. It invites one to deal with complexity no longer as a matter of explanation or prediction. Conceived as an interpretation, complexity is a characteristic attributed by the observer to a phenomenon. It is, above all, a key element of a representation built by the researcher, and not necessary a part of the ontology of her / his object of study (Le Moigne, 1996). By contrast with a "pseudo-scientific" approach, such a constructivist position systemically questions the process of elaboration grounding the systems of representation it creates or manipulates. Its legitimacy involves both a methodology reflecting the way to build such systems and an understanding of how their representation affects the phenomenology of the "reality" studied as well (Le Moigne, 1979/1984, 2001a, 2001b, 2003).

2.2.3 Complex way of thinking

In spite of a rich proliferation of theories, the development of epistemological reflections around the concept of complexity is relatively recent. Between 1945 and 1975, the status and the epistemological legitimacy of sciences constituted by reference to the paradigm of organized complexity (Weaver, 1948) has been very rarely interrogated, the term "complexity" being itself not often used (Le Moigne, 1996). Publication during the late 1970s of several books, considered today as classics, contributed to the new breath of epistemological and conceptual research operated at this time. In France, the work of Morin is located at the core of these contributions. Appearing during the 1960s in his research on anthropology of knowledge (Morin, 1973, 1977/1980, 1980, 1986, 1991), the approach developed by Morin involved a reorganization of the various conceptions of complexity having emerged since the 1940s. Formulating significant epistemological critics on a narrow understanding of their contributions, and going beyond usual dualisms (positivist and realist versus constructivist; Cartesian versus non-Cartesian, etc.) he also used these contributions to reconsider the limitations of contemporary processes of knowledge production. Located at the junction between philosophy, physics, biology and human sciences, his reflection created an epistemic loop associating the emergence of "organized" knowledge (sciences) with the creation of "organizing" knowledge (Le

Moigne, 1996). Through his paradigm of "self-eco-re-organization" (*auto-éco-ré-organisation*), he provided a critique of contemporary sciences and philosophies denouncing their epistemological and institutional compartmentalization. Advocating for the emergence of a kind of science privileging an "en-cyclo-pedic" process (which puts in cycles instead of cumulating knowledge), he built an approach to relate fragmented scientific fields of study to each other. Grounded in an open network of concepts and principles of thought, Morin advocated for a conception of complexity through the antagonist, contradictory and complementary tensions, which shape its own understanding. Aware of its own biological, physical and anthropological foundation, a complex way of knowing involves the integration of both, the complexity of our identity as human beings (Morin, 2001), and the complexity of ethical issues involved by a conception of science understood through its own uncertainty (Morin, 1973, 2004). Reinterpreting the epistemological as well as the political nature of these theories, the work of Morin contributed to the legitimacy of several trends of research sharing the same ethical commitment in regard of the construction of new models of knowledge production (see for example, the European program MCX "Modélisation de la complexite").

3. Science, critique and complexity

Following a complex way of thinking (Morin), the position adopted in this section stresses the need to consider not only the complementarities and antagonisms associated with the practices of critique and science, but also the ways they are experienced by those who conceived them. In order to understand what involves the development of a "scientific mind", it is suggested to focus on three dimensions of the scientific activity. The first one explores its complexity through the identification of the antagonisms lived. The second one explores its critical component through the recognition of the limits raised or encountered. Finally, the third dimension explores the learning grounding scientific activity, and the potentialities to develop it, through the localization of the strategies of mastery adopted by researchers.

3.1 Exploring complexity by identifying antagonisms lived

3.1.1 Definition

From Heraclites to Marx, to Hegel, the idea of "antagonism" is recurring in the history of Western thought. However, in spite of some contemporary development – in cybernetics and in systemics for instance – the potentiality of such a notion still appears underdeveloped.

For Morin, the notion of "antagonism" appears at the core of a theory of organization: "[…] *Organizational equilibriums are equilibriums of antagonistic forces. Thus, every organizational relationships, and then every system, comprises and produces antagonism and in the same time complementarity*." (Morin, 1977/1980, p.118, my translation). Behind the apparent solidarity of a system (its associations, its organization, its functions), existing antagonisms carry a potentiality of disorganization and disintegration. Such a phenomenon is constitutive of what Morin describes as a principle of "systemic antagonism" describing the fact that: "*the complex unity of a system both creates and*

represses antagonism." (ibid. p.119-120). Thus: "*Every system whose organization is active appears as a system whose antagonisms are active*." (ibid. p.120). Indeed, the organization of every active system, as long as it carries diversity and differences, suggests the creation and the repression of antagonisms, which appear through the active play of interactions and feedbacks.

The main characteristic of antagonism appears through its disorganizing potentialities. It has then to be linked with the idea of disorder. As it is the case with physical systems (atoms, stars) or living organisms (animals, human beings, society), antagonisms perpetuate, as well as they are perpetuated by, potential crisis. As Morin formulates it: "*Every crisis, whatever its origin is, appears as a failure* [défaillance] *in the regulation and the control of antagonisms. Antagonisms appear when there is a crisis; they constitute a crisis when they are erupting. The crisis manifests itself through the transformation of differences in opposition, of complementarities in antagonisms, and when disorder spreads in the system in crisis. More the organizational complexity is rich, more there are possibilities and risks of crisis, more also the system is able to solve its own crisis, or to take advantage of them for its own growth.*" (Morin, 1977/1980, p.122, my translation).

Because the idea of antagonism cannot be simplified (by its reduction either to organization, or to disintegration), it constitutes a strong basis to ground a complex understanding of every system. Following this perspective, the main issue of a complex way of thinking is to be able to think together, without incoherence, two ideas that are contrary. Considering antagonisms first suggests adopting a meta point of view allowing to relativize the contradiction. Then, it needs to be inscribed in a loop interpreting the association of antagonistic phenomena as complementary ones. The recognition of antagonisms defines one of the main principles of a complex way of thinking: "[…] *the transformation of a disjunction or alternative* […] *in a complex connection or unity*." (ibid. p.379)

3.1.2 Antagonisms and scientific development

Antagonisms can be observed at every level of organization. Indeed, physical, biological, psychological, social, cultural, political and noological (ideas) systems evolve thanks to the antagonisms and complementarities which constitute them. On a human level, the phenomenology of antagonisms appears through oppositions, contradictions, dilemmas, dissonances, conflicts, tensions, struggles, or crisis, etc. as they can be experienced or observed. Such an assumption allows one to reconsider the epistemic as well as the experiential development of scientific activity. Following this perspective, scientists' as well as science's development can be interpreted as the product of antagonisms experienced following heterogeneous paths.

From an epistemic perspective, several important contributions in epistemology and in sociology of sciences have highlighted – among others – the role played by antagonisms. Bachelardian epistemology suggests understanding scientific development through a dialectical negativity. Science appears then as continuous self-correction of its own construction, directed by scientific minds. For Popper, science development is grounded in the ongoing confrontation between free theories and experimental tests binding their

legitimacy. Antagonisms appear between the formulation of hypothesis and their refutation through experiment. For Kuhn, the local coherence of scientific constructions, made by autonomous communities, evolves through crisis and revolutions, engendered by the logical contradictions of dominant paradigms. From a sociological point of view, as the one initiated by Bloor and Collins, antagonisms also appears through the understanding of scientific controversies, as struggles inherent to the disagreement, indecision, and doubt grounding the practice of sciences itself (Pestre, 2006).

From an experiential perspective, as it is suggested by several significant psychological, psycho-sociological, sociological and educational theories, antagonisms also play a crucial role in the development of the individuals and organizations producing scientific knowledge. Following a psychoanalytical perspective, every situation is determined by the ways the subject experiences – consciously or not – intra-psychic tensions or conflicts. Scientific inquiry involves then the experience of anxieties finding their roots in the individual psyche (Devereux, 1967/1980). The psycho-affective development of the individual or, at a collective level, the group dynamics experienced, appears then as crucial factors of individual and collective development. Following experimental psycho-sociology and developmental cognitive psychology (Pérez & Mugny, 1993; Bourgeois, 1999), antagonisms can be apprehended through socio-cognitive conflicts. Development is based on learning produced through the elaboration of explicit or implicit social influence, whose process depends of the nature of the source of influence and the kind of task elaborated. Following a communicational and systemic theory of change (Bateson, 1973; Watzlawick, Weakland & Fisch, 1975), various levels of learning can be observed, depending on the capacity of everyone to integrate logical contradictions (double binds) inherent to a specific environment. Sociological approaches of learning (e.g. *Critical Pedagogies*, *Analyse Institutionnelle*) also provide a framework to interpret the role of antagonisms in the development of individuals, groups or institutions. Following these perspectives, development depends on the way conflicts of interest, conflicts of values, or conflicts of loyalty, inherent to heterogeneous groups are experienced and managed in a context conceived as a learning environment (Lourau, 1997; Popkewitz & Fendler, 1999).

Based on such contributions, scientists' and science's development can be interpreted as individual and collective processes mobilizing heterogeneous forms of antagonisms including epistemic and experiential ones.

3.2 Exploring critique by recognizing critical limits encountered

3.2.1 Working at the edge of one's own limits

My own experience of working on my doctoral dissertation in Educational sciences[2], from 2001 to 2007, brought me to elaborate a reflection on the role played by

[2] Taking as a starting point, the diversity of conceptions of critique developed in the academic field (in philosophy, sociology, literature, esthetics, etc.) this thesis aims to reconsider the assumptions, which ground the understanding of this notion and the fragmentation of its study in Educational Sciences. Based on a constructivist, complex and multireferential epistemology, two perspectives are proposed. First, notions associated to the idea of critique are macro-conceptualized and organized through a model (teleology, ecology, ontology, fonctiology and genealogy of critique). Second, the biographical experience of the author is considered in order to make explicit the learning involved in the process of conjugating

antagonisms before and during the process of writing my thesis (Alhadeff, 2005; Alhadeff-Jones, 2007). An autobiographical narrative exploring the motivations grounding my research, as well as notes taken in my journal of research, brought me to question the way I experienced the limits of knowledge produced in my field of study (critical theories in Educational sciences and a complex way of thinking), as well as my own limits in the process of producing knowledge. Doing so, I progressively came to reflect on the functions of what I identified as "working at the edge of one's own limits" (*travail aux limites*). It progressively appears relevant to assume that working at the edge of one's own limits represents a strategy adopted to cope with the critical and complex dimension of antagonisms, characterizing knowledge production, my self-development, my environment's own evolution, as well as their interrelations.

From the beginning of my research, my reflection aimed to challenge the limits of the writings I had to explore and the conditions of research I had to experience. Most of my PhD dissertation appears then grounded in the need and the desire to transcend some of the boundaries encountered, as well as building some practical strategies and a narrative allowing me to cope with antagonistic phenomena experienced (including theoretical, epistemological, psychological, social, political and cultural ones).

Among the various critical limits encountered through my environment of research, it seems relevant to mention the following issues.

On a conceptual level, the first limits encountered in my study were related to the implicit nature of my object of research, as it has been tackled in the French-speaking field of education: until recently – as surprising as it can be – the concept of critique has never been explicitly developed and problematized in French, in spite of a rich and old tradition of critical approaches (*De la Critique en education,* 2002). On the contrary, the explicit nature of this theme of research, as it has been developed in the English-speaking field of education, also raised critical concerns: in spite of an extensive literature (Alhadeff, 2002; Alhadeff-Jones, 2007), the conceptualization proposed around the idea of critique are indeed most of the time compartmentalized, reducing the idea of critique to some dominant trends of research.

On an epistemological level, I experienced first the limits inherent to the way the debates raised by critical theories in education were framed in the English-speaking field: discussions often appeared reduced to some binary oppositions (including the ones between subjectivist and objectivist approaches, or modern versus post-modern ones) preventing one to embrace the complexity of the various traditions of critique promoted. Privileging a position inspired by Morin's French-speaking philosophy, I experienced, then leaving in New York, another set of limits when I realized that his work was not really known and recognized in the English-speaking field, but also that it did not match the conceptions of complexity generally provided in the English-speaking literature (Alhadeff-Jones, 2006).

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heterogeneous conceptions of critique. Such an approach provides a point of view allowing for a consideration of both the plural development of critical frames of thought and the development of those who participate in their production.

On a practical level, the scarcity of available resources limited my investigations. Although the computer based databases facilitated my attempts, when I was living in Europe, to map the English-speaking literature I was exploring, they did not allow me to access it. I was then confronted with a geographical limitation, eventually related to an economical one, the alternative being either to order books or to travel to the U.S. On the contrary, because of the tacit dimension of my topic of research, as developed in French, French-speaking computer databases were not particularly helpful to map the field I was trying to explore. The limitation here was related to the keywords used and the culture of research itself.

On an institutional level, I experienced when I started my PhD another kind of limitation, inherent to the ways of knowing available in my initial environment of research at the University of Geneva. Most of my colleagues only had a partial knowledge of the theories on which I was working. Some of them expressed cultural resistance as a way to avoid having to explore such contributions. Others hid themselves behind scientific compartmentalization, in order to avoid having to confront a topic of research (the concept of critique) inviting one to cross disciplinary borders and embracing a transdisciplinary approach.

From a political point of view, the limits encountered also brought me to challenge the coherence of the positions defended by the members of my own department. I was particularly struck by the gap I observed between the positions defended by some of my colleagues (supposedly critical ones) and the lack of commitment shown in regard of political actuality reality (namely, the beginning of the second war in Iraq in 2003). My environment of research brought me then to realized how deep the discrepancy was between the epistemic and political positions adopted by some colleagues and the way they were (not) ready to assume them in their work environment, especially with colleagues and with students.

From an interpersonal perspective, I experienced some of the limits inherent to the relationships I had with those who were supporting my process of research, or between them, including my initial director. Cultural and generational differences, as well as gender, were contributing to feed both mutual interest and misunderstanding.

Finally, from a personal point of view, as I was discovering the extent of the field I was trying to embrace, I was progressively confronted to my own limits. If I was able to raise relevant questions, produce original knowledge, favour creative connections and, at the same time, challenge colleagues, all of that had a cost. By confronting some of the limits of my environment, I was regularly confronting myself to some of my own limits, including psychological and physical ones.

The limits just evocated are not exceptional at all. They belong to the scientific field and to its human (and non-human) nature. Neither are they neutral. Discovering them and taking them in consideration affect the experience lived by the researcher, consciously or not. In my case, they confronted me to the resources I had to mobilize in order to acknowledge them, to integrate them, to respect them, or at the opposite to try to transcend them.

3.2.2 Between growth and disintegration

As it has been suggested above, the presence of antagonisms represents both a catalyst of growth as well as a threat for the development of an organized system. Because they involve the potentiality of a crisis, which may be fatal for the system itself, antagonisms have to be regulated and controlled. In the same time, because they allow to grasp the fundamental complexity characterizing the scientific system at every level (conceptual, epistemological, practical, institutional, political, interpersonal, personal, etc.) their recognition constitutes a crucial step in order to develop a complex and critical understanding of the process of knowledge production itself.

In order to understand the stakes involved by such a double bind (Watzlawick, Weakland & Fisch, 1975), the next section proposes to explore the necessity to reflect on strategies of mastery used to control antagonistic forces shaping individual as well as collective scientific development.

3.3 Exploring scientific experience by locating the strategies of mastery adopted

3.3.1 Strategy of mastery

It seems rational to consider that every conception allowing to represent the emergence of a specific form of antagonism also carries – explicitly or not – a specific representation of the way to master its opposite and complementary forces, including the risks of crisis associated to them. Such an idea of mastery has to be understood broadly, as the faculty to dominate, to control, to rule, or to be skilled enough in order to be able to cope with the experience of antagonistic forces. Depending of the nature of the antagonism, such a mastery could involve rational or irrational, conscious or unconscious, individual or collective, free or compulsory, soft or hard, legitimate or illegitimate strategies or skills allowing to dominate, control, or rule antagonistic and complementary forces.

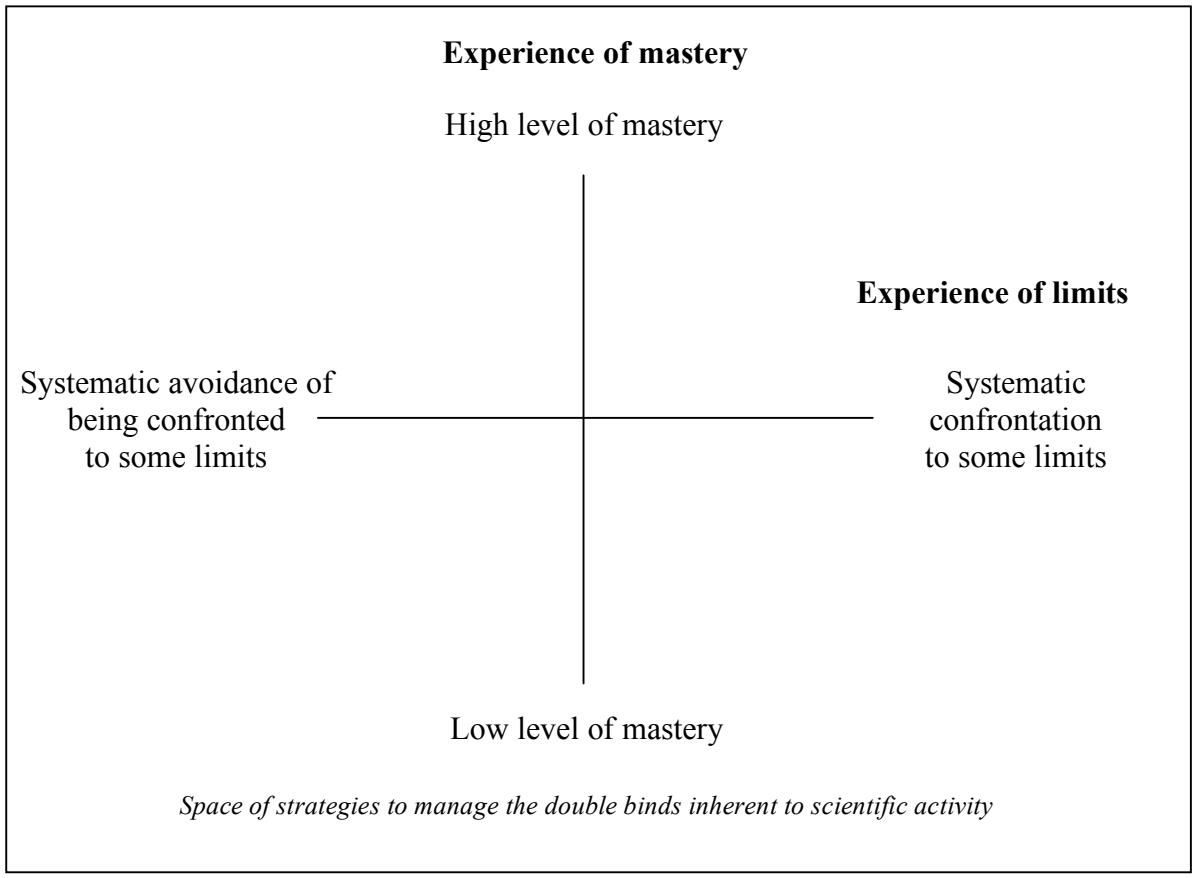
Questioning the strategies of mastery developed to cope with the antagonisms involved by scientific activity allows to reinterpret the experience of doing research and the level of critique and complexity tolerated. From this angle, the work of a scientist can be understood as the result of a combination of strategies of mastery allowing to manage the conflicts, dilemmas and contradictions which can be encountered at every level of the research process (conceptual, epistemological, institutional, political, relational, etc.) At a personal level, strategies of mastery depends on personality, cognitive styles as well as gender, social or cultural belonging. At a collective level, the development of science depends on assumptions and principles carrying specific strategies of mastery, including social and epistemic rules legitimizing how knowledge production and scientists' interactions should be controlled. From this point of view, every research is the expression of a combination of strategies of mastery developed by both, the scientific field as a whole and the scientists involved themselves.

3.3.2 Locating scientist's strategies to cope with critique and complexity

Face to the double binds raised by the need to keep both a feeling of mastery as well as the ability to work through the critical dimension of antagonisms, it seems reasonable to consider the development of various strategies aiming to reduce the discomfort experienced by the researcher.

My personal experience, the observation of some colleagues and my understanding of the scientific field brought me to consider at least four kinds of prototypical strategies to cope with the double binds inherent to scientific activity. Such strategies can be located through the combination of two dimensions: (a) the way to experience limits; (b) the way to experience mastery. Each of these two axes is polarized from a minimal experience to a maximal one. Four kind of strategies can then be defined: (1) avoiding systematically to be confronted with the limits raised by antagonisms and the risks of crisis; (2) confronting systematically the limits raised by antagonisms and promoting crisis; (3) experiencing a high level of mastery in the way to manage antagonisms; or at the opposite (4) experiencing a low level of mastery.

Crossing these two axes allows to represent strategies experienced by scientists:



Space of strategies to manage the double binds inherent to scientific activity

In spite of its simple construction, such a schematic representation allows to locate various kinds of strategies, which can be adopted to reduce the perception – and even the experience – of the double binds characterizing the scientific activity.

Thus, avoiding confronting oneself with the limits experienced at an individual, interpersonal, or institutional level, from an epistemic or relational point of view, constitutes a strategy reducing the discomfort generated by conflictual, dissonant positions or dilemmas. Because it avoids the recognition of the possibility to experience a crisis, such a strategy appears as a non-critical one. At the opposite, confronting systematically some of the forces shaping the process of knowledge production, challenging their legitimacy without considering their complementarities, also constitutes a strategy of denial. The latter appears as hyper-critical, because it privileges the play of antagonisms through the experience of a crisis instead of experiencing the tensions inherent to the simultaneous presence of antagonisms and complementarities.

From the point of view of mastery, the discomfort of the researcher can be managed thanks to a position of hyper-mastery bringing to adopt behaviours characterized by a high level of control of the process of knowledge production. Among others, such strategies would include methodologies of research favouring fragmentation and isolation of the object of study, privileging the repetition of conditions of experimentation and the avoidance of specific topics. At the opposite, a position of low mastery would privilege eclectic and touch-and-go approaches, whose superficiality would contribute to reduce the discomfort experienced, thanks to the dispersion of the knowledge or the methodology used.

Obviously, such strategies do not exist in such a prototypical way. Nevertheless, it seems reasonable to think that every scientist has learned to develop combinations of strategies allowing to cope with the various risk of crisis inherent to the experience of the antagonistic and complementary forces shaping the scientific activity.

4. Beyond scientific experimentation, considering scientist's experience

4.1 Challenging scientist's experience

One can choose to accommodate to some of the various strategies available to manage scientific double binds. One can also choose, or being brought, to make them be explicit, to consider them as matter of knowledge and learning to promote, and to evaluate how to transform them in order to increase the level of critical and complexity awareness they favour.

Because the experience of antagonisms constitutes a first step towards a complex way of thinking, and because the recognition of the potential crisis they carry constitutes a first step towards the elaboration of a critical position, it seems particularly relevant to question how do we learn to work at the edge of one's own limits. Following what has been shortly introduced in this paper, it seems relevant to consider the development of a scientific and critical mind, able to recognize complexity, through a reflection on the strategies adopted to master the antagonist and complementary forces, as well as the double binds, inherent to knowledge production.

The paths of reflection opened in this paper suggest at least three possibilities to do so:

1) To explicit antagonisms experienced by researchers.
2) To explicit the risk of crisis they carry and then the limits and the edge that should be considered when tackling them.
3) To explicit the strategies of mastery developed or privileged to cope with the antagonistic forces considered, without reducing or denying them.

If the argument developed in this paper legitimates such prescriptions, it does not provide an educational framework allowing for the implemention of them. Indeed, the question remains to determine how to promote among scientists and non-scientists the conditions to reflect on their own experience, integrating reflections about the way to deal with antagonisms, working at the edge of one's own limits and adopting specific strategies of mastery.

4.1.2 Bridging the gap between knowledge production and scientists self-development, a "no man's academic land" ?

As suggested previously, from a theoretical perspective, there are many ways to tackle the series of issues raised in this paper. On one hand, the scientific field is full of researches highlighting the processes of knowledge production, including the role played by antagonisms (philosophy and history of sciences, sciences and technology studies, etc.) (Andler, Fagot-Largeault and Saint-Sernin 2002; Dubois 1999; Pestre 2006). On the other side, studies in adult education, higher education, psychology and sociology (among others) provide many insights about how adults and researchers develop themselves, individually and collectively (Tennant, 1993). What appears as striking is that in the middle of these two sets of approaches, remains a "no man's land" of the scientific field. Indeed, beyond the general evolution of concepts and technologies, the decontextualized theories of self development, the specificity of scholars career, and the biographies of a handful of famous scientists, what do we know today about the mutual influence between the lifelong development of researchers and the evolution of scientific knowledge?

From an experiential perspective, every day, among the thousands of universities and centers of research worldwide, millions of scientists build up knowledge in the same time they develop their own personal and collective skills. The ability to deal with antagonisms (on one's own, in a team, in a department, in a faculty, in an institution, or with outsiders) is part of such a process. What do we know about these experiences? How can such experiences be used to understand and improve knowledge production and scientist's lives without compartmentalizing them?

4.1.3 Scientific activity as a lifelong learning opportunity

During the past 30 years, "lifelong learning" has progressively emerged as a core concept in educational sciences, allowing to describe and to promote new solutions to cope with social changes and the contemporary reconfiguration of adult life (Medel-Añonuevo, Ohsako, and Mauch 2001). In many ways the multitude of antagonisms experienced by researchers today can be interpreted as the fruit of the evolution of society and knowledge. Because such social and professional changes affects scientists, their ways of thinking, as well as their practices, it seems relevant to question the way researchers learn

to cope with their changing work environment and the new demands of knowledge production. Among others fields of research and practice, Adult education provides various resources to deal with the stakes mentioned above.

Informed by some of these contributions, and based on my own experience as a practitioner in the field of Adult education, the next section proposes to explore "Educational Biography" (Dominicé, 1990, 2000) as a research-training methodology allowing to reconsider science as a process of knowledge development, as well as an opportunity of personal transformation.

4.2 Learning from a scientist's life history

The emergence of biographical approaches in the French-speaking field of Adult education occurred in the middle of the 1980's in France, Belgium, Switzerland and Québec. Initially perceived as marginal practices, eventually introduced in "smuggling", they contributed in twenty years to the development of a broad institutional field of practice and study (Alhadeff & Le Grand, 2004; Dominicé, 2000; West & al. 2007).

4.2.1 The emergence of biographical approaches as research methodologies and learning opportunities

Today, biographical approaches are used by social workers, career counsellors, educators, human resources specialists, environmentalists, religious educators, teachers, trainers, writers, therapists, nurses and doctors to better understand the people with who they are working and to help them becoming more aware and able to enhance their own potentiality in regard to specific contexts.

On one hand, they provide a way to perform research on specific topics (social issues, illettrism, vocational guidance, self-development, career assessment, working environment issues, learning, medical care, ageing, alcoholism, writing practices, intergenerational relationships issues, etc.) taking in consideration the complexity of life experience. From this perspective, they appear grounded in a long tradition of qualitative methodologies developed for instance in anthropology and sociology (West & al., 2007).

On the other hand, biographical approaches are constituted by specific training practices allowing a specific public (marginalized people, working community, professional in transition, young adults or students, managers, patients, alcoholics persons, writers, aged people, etc.) to consider one's own past experience in regard of a present situation or an expected one. Because of their anchorage in the reality of the learners, they share some similarities with action-research methodologies (Dominicé, 2000).

4.2.2 Locating Educational Biography

As various words are used to describe biographical practices, it seems important to make some distinctions. In French, the differences between "*autobiographie*", "*biographie*", "*histoires de vie sociales*", "*récits de vie*", "*histoire de vie*" are often stressed. In English,

such differences exist between "narrative", "tale", "story", "biography", or "autobiography", etc.[3]

More specifically, the approach developed during the last twenty-five years at the University of Geneva by Dominicé and his colleagues – Marie-Christine Josso and Matthias Finger among others – is usually labelled as "Educational Biography": "[It] *is an adult education approach that emphasizes the subjective meanings and the developmental process of adult learning. In this approach, adult learners prepare and share life histories that become vehicles through which these learners can reflect on their educational experiences. Through oral and written narratives, educational biography offers the values of reminiscence and the interpretation of experience and influences upon that experience. It is a distinctive approach to teaching and learning because its main purpose is to help adults deepen their understanding of their own ways of learning and of their existing knowledge. It is a narrative research method that helps people identify their learning processes in adulthood.* […] *Educational biography is neither an instrument for collecting data nor a new model for teaching. Instead it offers a way for an adult education practitioner to incorporate a modest and often exploratory inquiry project into an educational program for adults.*" (Dominicé, 2000, pp. xv-xvi). In the perspective developed by Dominicé each learner belongs to a small group in which group members will interpret each other's educational biographies, and each learner also relates to the instructor. The created life histories are always singular, focused on each author's learning, not simply any aspect of life that he / she would choose to develop.

4.2.3 Educational Biography as a methodology to understand and to develop a scientific mind, a critical mind and a complex way of thinking

My interest for Educational Biography started when I was a student in the Faculty of Psychology and Educational Sciences in Geneva. As I got an opportunity to work for a couple of years as a full time teaching and research assistant in the team of Pierre Dominicé, I progressively consolidated my belief in the relevance of this approach, in the same time that I built my own way to practice it. Initially, this approach allowed me to critically reflect both on my motivations as a young researcher, and the assumptions framing the way I was conceiving my topic of research (why do I want to make a PhD? why am I so interested by the notion of critique? what can I learn from my life, which can help me understand the process of learning critical skills? how did I learn to understand the idea of critique?) As I am currently providing this kind of seminar at Teachers College (Columbia University), such a practice allows me to continue learning how

[3] Dominicé (2000) proposes the following distinction: "autobiography" refers to a writing process following an individual choice; the work belongs to the author from the beginning to the end; it can be written for private testimony, for a book, etc. It can take the form of a diary, a novel or a more formal story. In some specific cases, "autobiography" can be the result of a collaboration: some sociologists using this approach as a methodology see themselves as public writers helping for example illiterate persons to write their own life (Catani). "Social life history" refers to narratives grounded in a social practice or related to specific social phenomena. Here the life history is attached to more broader issues (e.g. understanding specific social trajectories attached to a specific category of population – unemployed people, migrants, specific workers, bakers, active citizens, etc.) (Dubar & Demazière, Catani, Bertaux). "Biography" refers to a text resulting from an order, supposed to meet some negotiated expectations (e.g. the biography of famous people, actors, politicians, etc.)

students of every age build their own way of knowing through their school, familial or professional lives.

In regard of the theme of this paper, such an approach of learning seems finally relevant for at least four reasons. The first one is that it provides a framework conceiving the development of a scientific mind as a lifelong process and not as the result of specific operations, concentrated during a specific time period. It allows then to build a dynamic representation of the scientific mind which does not reduce it to the assimilation of some specific knowledge, but extends it at every area of human experience (including artistic and spiritual ones).

A second reason is that using life history promotes fundamentally a critical understanding allowing one to grasp the way everyone has learned or is learning what s/he knows. Through the process of self-reflection promoted (Mezirow, 1991), the instructor / researcher, as well as the participants, learns to question and continually reinterpret the assumptions framing the meaning they give to their own lives.

A third reason is that using a narrative approach contributes to the development of a complex way of knowing. Because biographies do not compartmentalize experiences lived, they allow to understand the ordered as well as the disordered connections remaining between the various sides of our lives.

Finally, the last reason justifying for me the legitimacy of such an approach comes from the fact that it does not separate learning and research about learning. By conducting this kind of seminars, the trainer / researcher collect knowledge about the way everyone learns in the same time that s /he provides an opportunity for participants to learn about themselves.

5. Synthesis

The main intent of this paper was to locate a theoretical and practical framework to conceive and promote the development of a scientific mind able to question and explore its own relationship with critique and complexity.

To do so, it appeared relevant to locate first the heterogeneity of meanings associated to the idea of "critique". It has been suggested to conceive a critical mind as characterized – among others – by an ability to discriminate, to evaluate, to examine, to judge and to put in crisis a work, a phenomenon, or an experience, observed or experienced. Considering a short overview of some major conceptions of critique, these considerations opened the need to question how one conceives the complexity inherent to the idea of "critique", including the order, disorder and organization shaping its understanding.

Considering the meanings associated with the idea of "complexity", and the diversity of theories produced around it, brought then the questioning of assumptions through which one understands this notion. Following a brief overview of three main interpretations – reductionist, pseudo-scientific, and constructivist – the choice has been made to develop the last one, mainly through the work of Edgar Morin on a "complex way of thinking".

The following section of the paper proposed to explore the experience of critique and complexity in the practice of science, through the reference to three new notions. Because it cannot be simplified (either to organization or to disintegration), the idea of "antagonism" has been first considered as a strong basis to ground a study of the complexity inherent to scientific activity. An overview of the heterogeneity of antagonisms relevant to scientific development has been then proposed, considering both an epistemic and experiential angle.

In order to highlight the critical dimension of scientific activity, the notion of "limit" was then introduced. Based on the author's own experience of research, several examples have been given to illustrate how the experience of working at the edge of one's own limits constitutes a dimension characterizing scientific practice. Experiencing the limits encountered on conceptual, epistemological, practical, institutional, political, interpersonal and personal levels allows researchers to confront the antagonisms shaping their own lives and their own knowledge.

In order to understand the stakes involved with the scientific double bind (the critical need to experience tensions and crisis, as well as the complex need to control the play of antagonistic forces), the idea of "strategies of mastery" has been introduced to name the faculty to dominate, control, rule or be skilled enough in order to be able to cope with them. It appeared then relevant to identify various strategies developed by scientists, depending on the way they learned to relate to the experience of mastery and limits.

Because the experience of antagonisms constitutes a first step towards a complex way of thinking, and because the recognition of the potential crisis they carry constitutes a first step towards the elaboration of a critical position, it appeared particularly relevant to question the learning developed by scientists to work at the edge of their own limits.

Observing the lack of literature related to the relationship between knowledge production and scientists' self-development, it has finally been suggested to explore scientific activity as a lifelong learning process. This last proposition locates the use of biographical approaches in Adult education – and Educational Biography in particular – to conceive both a methodology of research and training exploring the development of a critical mind and a complex way of thinking as two crucial dimensions of scientific minds.

6. Conclusions

Through this paper, I have tried to illustrate how science appears as being not only a process of knowledge construction, but also a human adventure and a lifelong learning process for those who produce it. It involves organizational and personal dimensions, as well as epistemic and experiential ones, whose recognition does not happen automatically. In a period of time, when scientific discoveries tend to be reduced to their instrumental and technological advances, the recognition of the human dimension of knowledge production should not be taken for granted. The development and the relevance of such a reflection depend on the availability of a receptive environment. I can only wish that the framework provided by the organizers of this conference would continue to find a stronger echo among the scientific community. By bringing people to

share the same humanist values, I wish it would help promote an interpretation of science involving more than just epistemological, theoretical, methodological and technical considerations. I wish it would help to restore an understanding of science, which recognizes and values the learning experienced by those who build it, a vision of science rehabilitating the fundamental human nature of knowledge production.

7. Bibliography

Alhadeff, M. (2002). Les enjeux de la critique dans le paysage anglo-saxon de l'éducation: petite course à travers champs. *Pratiques de Formation / Analyses, 43*, 131-144.

Alhadeff, M. (2003, October). *Rethinking Transformative Learning and the concept of "Critical Reflection" through the Paradigm of Complexity.* Paper presented at the 5th International Transformative Learning Conference "Transformative Learning in action: Building bridges across contexts and disciplines", Teachers College, Columbia University, New York.

Alhadeff, M. (2004). Conjuguer l'hétérogénéité de la critique en sciences de l'éducation: de l'hypocrit(iqu)e à l'hypercritique. In R. Arce, Farina, F., Novo, M., Egido, A., Ardoino, J., Berger, G. (Ed.), *La pensée critique en éducation* (pp. 34-46). St-Jacques de Compostelle: Universidade de Santiago de Compostela.

Alhadeff, M. (2005). Complexité de la critique et critique de la complexité en formation. In J. Clénet & D. Poisson (Eds.), *Complexité de la formation et formation à la complexité* (pp. 227-242). Paris: L'Harmattan.

Alhadeff, M., & Le Grand, J.-L. (2004). "Life History and Education" Significant Bibliographical References in the English-speaking Field of Education (version 1.1; 6.7.04). Teachers College, Columbia University.

Alhadeff-Jones, M. (2006). Three Generations of Complexity Theories: An orienting history for disorienting contributions. Manuscript submitted for publication.

Alhadeff-Jones, M. (2007). *Education, critique et complexité: modèle et expérience de conception d'une approche multiréférentielle de la critique en Sciences de l'éducation.* Doctoral dissertation in Educational sciences. Paris: University de Paris 8.

Andler, D., Fagot-Largeault, A., Saint-Sernin, B. (2002). *Philosophie des sciences (Tome I)*. Paris: Gallimard.

Andler, D., Fagot-Largeault, A., Saint-Sernin, B. (2002). *Philosophie des sciences (Tome II)*. Paris: Gallimard.

Ardoino, J. (2000). *Les Avatars de l'éducation*. Paris: PUF.

Bachelard, G. (1934/2003). *Le Nouvel Esprit Scientifique*. Paris: PUF.

Bateson, G. (1973). *Steps to an Ecology of Mind*. London: Paladin.

Bourgeois, E. (1999). Interactions sociales et performances cognitives. In P. Carré, Caspar, P. (Ed.), *Traité des Sciences et des techniques de la formation* (pp. 223-244). Paris: Dunod.

De la critique en éducation. (2002). *Pratiques de Formation / Analyses, 43*.

Devereux, G. (1967/1980). *De l'angoisse à la méthode dans les sciences du comportement*. Paris: Aubier.

Dominicé, P. (1990). *L'Histoire de vie comme processus de formation*. Paris: L'Harmattan.

Dominicé, P. (2000). *Learning from our lives. Using Educational Biographies with adults*. San Francisco: Jossey-Bass.

Dubois, M. (1999). *Introduction à la sociologie des sciences*. Paris: PUF.

Institut National de la Langue Française (2005). *Le trésor de la langue française informatisé* [Electronic Resource]. Paris: Centre National de la Recherche Scientifique & Editions Gallimard. Consulted at : http://atilf.atilf.fr/tlf.htm

Le Moigne, J.-L. (1979/1984). *La Théorie du Système Général. Théorie de la modélisation*. Paris: PUF.

Le Moigne, J.-L. (1996). Complexité. In D. Lecourt (Ed.), *Dictionnaire d'Histoire et Philosophie des Sciences* (pp. pp. 205-215). Paris: PUF.

Le Moigne, J.-L. (2001a). *Le constructivisme. Les enracinements (tome I)*. Paris: L'Harmattan.

Le Moigne, J.-L. (2001b). *Le constructivisme. Epistémologie de l'interdisciplinarité (tome II)*. Paris: L'Harmattan.

Le Moigne, J.-L. (2003). *Le constructivisme. Modéliser pour comprendre (tome III)*. Paris: L'Harmattan.

Lissack, M. R. (Ed.). (2001). *Emergence, A Journal of Complexity Issues in Organization and Management* (Vol. 3(1)). Mahwah, NJ, London: Lawrence Erlbaum Ass.

Lourau, R. (1997). *La clé des champs. Une introduction à l'analyse institutionnelle*. Paris: Anthropos.

Medel-Añonuevo, C., Ohsako, T., Mauch, W. (2001). *Revisiting Lifelong Learning for the 21st Century*. Hambourg: UNESCO Institute for Education.

Mezirow, J. (1991). *Tranformative dimensions of adult learning*. San Francisco: Josey-Bass.

Morin, E. (1973). *Le paradigme perdu: la nature humaine*. Paris: Seuil.

Morin, E. (1977/1980). *La Méthode (vol.1) la Nature de la Nature*. Paris: Seuil.

Morin, E. (1980). *La Méthode (vol.2) La Vie de la Vie*. Paris: Seuil.

Morin, E. (1986). *La Méthode (vol.3) La Connaissance de la Connaissance*. Paris: Seuil.

Morin, E. (1990). *Introduction à la pensée complexe*. Paris: ESF.

Morin, E. (1991). *La Méthode (vol.4) Les Idées. Leur habitat, leur vie, leurs moeurs, leur organisation*. Paris: Seuil.

Morin, E., Le Moigne, J.-L. (1999). *L'intelligence de la complexité*. Paris: L'Harmattan.

Morin, E. (2000). *Les sept savoirs nécessaires à l'éducation du futur*. Paris: Seuil.

Morin, E. (2001). *La Méthode (vol.5) L'Humanité de l'Humanité, l'identité humaine*. Paris: Seuil.

Morin, E. (2004). *La Méthode (vol.6) Ethique*. Paris: Seuil.

Morin, E., Motta, R., & Ciurana, E.-R. (2003). *Eduquer pour l'ère planétaire. La pensée complexe comme Méthode d'apprentissage dans l'erreur et l'incertitude humaines*. Paris: Balland.

Pérez, J. A., Mugny, G. (1993). *Influences sociales. La théorie de l'élaboration du conflit*. Neuchâtel: Delachaux et Niestlé.

Pestre, D. (2006). *Introduction aux Sciences Studies*. Paris: La Découverte.

Phelan, S. E. (2001). What is Complexity Science, Really? *Emergence, 3*(1), 120-136.

Popkewitz, T. S., Fendler, L. (Ed.). (1999). *Critical Theories in Education. Changing Terrains of Knowledge and Politics*. New York: Routledge.

Rey, A. (Ed.). (2000). *Le Robert - Dictionnaire historique de la langue française*. Paris.

Ruby, C. (1990/2004). *Histoire de la philosophie*. Paris: La Découverte.

Simpson, J. & al. (ed.) (1989/2005). *Oxford English Dictionary Online* (2nd edn.) [Electronic Resource]. Oxford: Oxford University Press.

Tennant, M. (1993). Perspective Transformation and Adult Development. *Adult Education Quarterly, 44*(1), 34-42.

Watzlawick, P., Weakland, J., Fisch, R. (1975). *Changements. Paradoxes et psychothérapie*. Paris: Seuil.

Weaver, W. (1948). Science and complexity. *American Scientist, 36* (536).

West, L., Alheit, P., Andersen, A.S. & Merrill, B. (Eds). (2007). *Using biographical and life history approaches in the study of adult and lifelong learning: European perspectives*. Frankfurt am Main: Peter Lang.