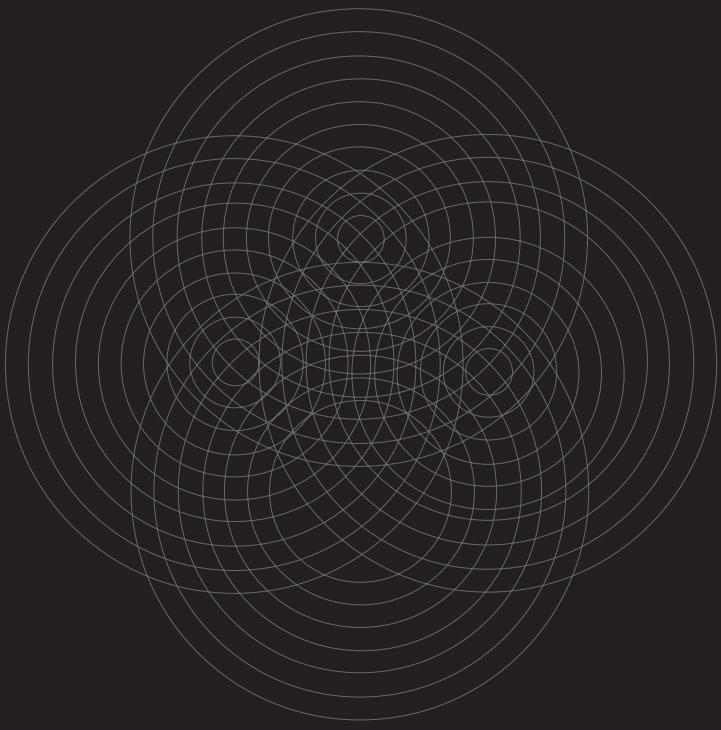
TRANSDISCIPLINARITY AND SUSTAINABILITY



Basarab Nicolescu (Ed.)

The Academy of Transdisciplinary Learning & Advanced Studies

Transdisciplinarity and Sustainability

Basarab Nicolescu (Ed.)
International Center for Transdisciplinary Research and Studies (CIRET), France

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Preface

Dr. Basarab Nicolescu

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What is future?

A unified complex theory of levels of Reality is crucial in building sustainable development and sustainable futures. The considerations made until now in these matters are based upon reductionist and binary thinking: everything is reduced to society, economy and environment. The individual level of Reality, the spiritual level of Reality and the cosmic level of Reality are completely ignored. Sustainable futures, so necessary for our survival, can only be based on a unified theory of levels of Reality.

The notion of "future" is connected with the understanding the notion of "time".

Was Saint Augustine truly wrong when he asserted that we are not able to represent time? Physicists, from Galileo onwards, have argued that time may be thought of mathematically. Einstein's genius led him to the inference that time is a dimension, like the three dimensions of space, of a larger space, with four dimensions.

The contradiction between these two views is only an appearance. In fact no one, not even mathematicians or physicists, can represent the reality of a space with several dimensions. The extraordinary adventure of the extra dimensions of the space began with a German mathematician, Georg Bernhard Riemann (1826-1866). In 1854, when he was 28 years old, he presented a thesis, *Über die Hypothesen, welche der Geometrie zu Grunde liegen*, which would influence not only mathematics, but also physics, until today. In this thesis, which was only published after his death in 1868, he introduced the concept of "differentiable manifold with n dimensions", which extends our ordinary conception about space. Riemann's thinking is actually guided by the principle that the laws

of Nature become simpler and unified when they are considered in a space with more dimensions than our usual space. Today, we find exactly the same idea in advanced physics – that of the superstrings.

For half a century after the formulation of Riemann's revolutionary mathematical ideas, nothing remarkable happened, in this context, in physics. All this tumultuous debate around the fourth dimension in the world of art, literature or philosophy proved to be completely sterile in terms of physics. Some cynical minds believed that this fourth dimension is good for ghost busters and for mathematical games, while having no real existence. At this time an obscure physicist named Einstein enters the stage.

Albert Einstein (1879-1955) demonstrates, beyond doubt, that this dimension is real, provided that we interpret it as a dimension of time associated with a very special geometry. Space-time hits the world's stage as a block-universe, where there is no place or time, but only events. Space and time are intertwined – they do not exist separately. "Time and space are but ''shadows"!" exclaims Minkowski. Only their union gives meaning to what we may call an independent reality. In the space-time continuum, there are neither space-like landscapes, nor temporal landscapes. In this block-universe no one can really say "now" just because "now" for one observer is not the same as "now" for another observer. Simultaneity does not exist. Our own lives certainly fill only a tiny portion of this space-time, but they only explore what is already there. They are only "universe lines". In this universe, becoming does not exist. A strange vision, completely at odds with our intuition! But this is how the world works, if the physics viewpoint is right.

The naïve point of view on what is future is based on the classical representation of time as a line, where a point is "the past", next to is "the present" and next to the present is a point called "future". They are united through an arrow – "the arrow of time". The powerful notion of "social progress" is, in fact, based on this representation of time. The explanation is relatively simple: a statistical kind of faith in what reality is at some moment is created as an effect of technoscience. Thus, the dominant concept of reality during the last centuries was based on classical science. It used to reinforce our belief that we were living in a deterministic and mechanistic world, destined to an endless progress.

The relativity theory of Einstein and quantum physics completely changed our views on *time*.

There is no time, but times, associated with every level of Reality of the Object and of the Subject. Therefore there is no *future* but futures, a spectrum of non-deterministic possibilities.

In the transdisciplinary approach, there is a fundamental openness of Reality, which involves the openness of the future. We are part of the ordered movement of Reality. Our freedom consists in entering into the movement or perturbing it. We can respond to the movement or impose our will of power and

domination. Our responsibility is to build sustainable futures in agreement with the overall movement of Reality. Transdisciplinarity indicate a realistic way in building sustainable futures.

Complex transdisciplinary Reality is *plastic*. We are part of this Reality that changes due to our thoughts, feelings and actions. This means that we are fully responsible for what Reality is. Reality is not something outside or inside us: it is simultaneously outside and inside. Transdisciplinarity is not neutral: it involves an ethical dimension. *Poethics* is inseparable from complexity and transdisciplinarity: 'poethics' means here ethics intertwined with analytical mind and with the imaginary of the 21st century.

The world moves, lives and offers itself to our knowledge thanks to some ordered structures of something that is, though, continually changing. Reality is therefore rational, but its rationality is multiple, structured on levels. It is the logic of the included middle that allows our reason to move from one level to another.

The world is at the same time knowable and unknowable. We cannot deal with reality in all its complexity. The irreducible mystery of the world, described by art and spirituality, coexists with the wonders discovered by reason. The unknown enters every pore of the known, but without the known, the unknown would be a hollow word. If we wish to ensure a sustainable future, we have to deal with all the aspects of knowledge and understanding which constitutes our humanity.

What could be really sustainable today: environment, economy, society, education, politics, religion, spirituality, future, nation, world order? No one can be sustainable in itself, because all of them are inter-related. Transdisciplinarity argues that the only sustainable system is the cosmic system, in all its dimensions, from the quantum particle till the most distant galaxy, going through the human being: every level of Reality sustains every other level of Reality.

Dr. Basarab Nicolescu

1 International Congresses on Transdisciplinarity:Their Importance for the Emergence of a Transdisciplinary Methodology

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Abstract

In this interview, Professor Basarab Nicolescu reveals important historical aspects on the emergence of an international community of transdisciplinary researchers, evaluates the role of different transdisciplinary meetings during the period 1986-2005, and analyzes the scientific and philosophical basis of the transdisciplinary methodology.

1. When did you begin to be interested in transdisciplinary thought?

Since my adolescence, even though the word "transdisciplinarity" had not yet been invented. My first book, published in Romania in 1968, just a few months before my definitive departure for France – *Ion Barbu, The Cosmology of the Second Game*, Editura pentru Literatura, Bucharest, 1968 - was devoted to the relations between mathematics and poetry in the work of a great Rumanian poet Ion Barbu, also known for being a mathematician of international reputation, named Dan Barbilian, who signed his poems using the pseudonym Ion Barbu.

2. How did you make this trajectory?

In a very natural way, I could even say "innate". As a student, I had solid knowledge in philosophy. My interest was concentrated on Schopenhauer and Hegel. Literature impassioned me, even if mathematics remained the center of my passions. Also, I

had, very early, from the time I was around six years of age, a well-developed orthodox Christian education, with a priest who was one of the greatest Rumanian theologians - Father Galeriu. He gave me the taste for apophatic thought (particularly, Pseudo-Dionysus, Gregory of Nyssa, and Gregory Palamas), a taste which was developed by my practice of quantum physics and which was a fundamental component of the methodology of transdisciplinarity that I worked out after my arrival in France. Quantum physics was, for me, a place of conciliation between all its apparently contradictory concerns. My major references in the philosophy of quantum physics and mathematics were - and still are - Werner Heisenberg, Wolfgang Pauli, Niels Bohr and Kurt Gödel.

3. When and how did you propose a transdisciplinary methodology based on three pillars: that of complexity, that of the various levels of reality, and that of the logic of the included middle?

I did not "propose" it: I worked it out. I formulated the methodology of transdisciplinarity in a series of articles published in the French review "*3rd Millenium*" (old series), which was included in my first book published in France *We, the Particle and the World (Nous, la particule et le monde*), Le Mail, Paris, 1985 (2nd edition: Rocher, Series "Transdisciplinarity", Monaco, 2002; translation in Portuguese: *Nós, a particular e o universo*, Colecção "Ciência e Consciência", Esquilo, Lisbon, 2005, translation in Portuguese by Isabel Debot).

4. How is this process carried out?

Very slowly. It seemed important to me to formulate a methodology, because in absence of this methodology, transdisciplinarity is only frivolous talk, a momentary fashion. But this methodology should be open, not dogmatic. This is why it seemed to me crucial that transdisciplinarity is defined via its methodology. A single methodology, which is the logos of method, is compatible with a great number of different methods. In other words, transdisciplinarity is based on a single methodology, but there can be variations of transdisciplinarity. This point is not generally understood even today; because even educated people confuse methodology and methods. My approach to thought is built on the example of the methodology of modern science: the one and only methodology, that formulated by Galileo, Newton and Kepler, that proved to be compatible with extremely different theories, like, for example, traditional mechanics (the two theories of relativity of Einstein included) and quantum mechanics. Another essential difficulty in the formulation of the methodology of transdisciplinarity is related to the irreducible presence of the Subject in transdisciplinarity. This is why it was clear for me that the methodology of modern science, founded on the exclusion of the Subject, is not valid in the field of the transdisciplinarity. The unification between hard (exact) sciences and soft (human) sciences cannot be accomplished using the methodology of modern science. A new methodology was necessary and, over the course of a few years, I have adhered to this formulation.

The first axiom (or "postulate" or "pillar", according to popular terminology), that concerning levels of Reality, seemed to me obvious, since 1970, from my own practice of quantum physics. But the idea did not exist in the extant scientific corpus and I hesitated to publish it. Fortunately, during my post-doctoral training course at Lawrence Berkeley Laboratory (1976-1977) I was in contact with Geoffrey Chew, the founder of the bootstrap theory, and also with Henry Stapp, who both encouraged me to publish it. I finally articulated the first axiom in an article published in "3rd Millenium", N° 1, Paris, March-April 1982. Much later, in 1998, I learned that Werner Heisenberg had also proposed a formulation of the concept "level of Reality" (Werner Heisenberg, *Philosophy - the Manuscript of 1942*, Paris, Seuil, 1998. Translation from German and introduction by Catherine Chevalley. First German edition: *Ordnung der Wirklichkeit,* Munich, R. Piper GMBH § KG, 1989. Published first in W. Blum, H. P. Dürr, and H. Rechenberg (ED.), W. Heisenberg, *Gesammelte Werke*, Vol. C-I: *Physik und Erkenntnis*, 1927-1955, Münich, R. Piper GMBH § KG, 1984, pp. 218-306).

The third axiom, that concerning complexity was announced at the same time, in my book *Nous, le particule et le monde.* There are certainly a great many definitions of complexity, practically all incompatible with the concept of level of Reality. The only one which is appropriate for transdisciplinarity is that of Edgar Morin and Paul Cilliers.

Paradoxically it is the second axiom, that concerning the logic of the included middle, which was the most difficult to formulate. Of course, I had been working closely with Stéphane Lupasco since 1969. I knew also the considerations of Aristotle and, especially, Hegel, who applied this logic in his *Philosophy of the Spirit.* But it was obvious for me that a strictly formal logic was unsuited to transdisciplinarity, because it is very poor, and is limited to solving theoretical paradoxes. Moreover, the logic of the included middle of Lupasco did not take into account the existence of levels of Reality, but it had the capacity to be a true philosophy. This is why I extended and generalized the logic of Lupasco by introducing the levels of Reality of the Subject and the levels of Reality of the Object. The result was published, with the encouragement of Lupasco himself, in *Nous, la particule et le monde*. During the last few years, Joseph Brenner showed all the richness of such a logic in the study of the processes of Reality. Through this methodology, transdisciplinarity succeeds in becoming a *tour de force* that joins together ontology (the first axiom), logic (the second axiom), and epistemology (the third axiom).

I must affirm in all modesty (since I was the initiator or organizer of the majority of congresses) that I played a large role in the emergence of an international community of transdisciplinary researchers, brought together around an already extant methodology of transdisciplinarity. In this respect, one can certainly speak of a methodological consolidation. But it is not correct to speak of an "emergence" of methodology during these congresses, because this methodology existed already. It is true that I chose, for tactical considerations, to show this methodology gradually, the apogee being located at the 1st World Congress of Transdisciplinarity (1994) and the Congress of Locarno (1997). It should not be forgotten that the atmosphere in the academic milieu of the time was very

unfavorable towards transdisciplinarity and it was necessary to proceed with courage but also with prudence.

5. What do you think of the proposal that the three pillars considered in the official documents of the Congresses are of fundamental importance for the characterization of a methodology of transdisciplinarity? What are the possibilities and the challenges that this proposal brings, on the one hand, and, on the other hand, the limits that it presents?

I have already answered the question concerning the importance of these congresses. One of the limits of transdisciplinary methodology is that it does not allow us to do science, on the technical level: the methodology of science is largely enough for that. In this respect, transdisciplinary methodology and scientific methodology are complementary. It may be nevertheless that transdisciplinary methodology leads to great scientific discoveries, especially in the study of consciousness.

The essential limit of transdisciplinary methodology is that it does not constitute a spiritual way in itself. It is here where potentially huge deviations of transdisciplinarity reside. I observe an occultist temptation here and there, which is extremely harmful and must be fought by transdisciplinary researchers. One should not forget that even if transdisciplinary methodology is very different from the methodology of science, it nevertheless has the scientific spirit in its center.

6. Certain authors like Patrick Paul, of France, and Amâncio Friaça, of Brazil, argue the need for introducing a fourth pillar of transdisciplinarity to the three already allotted; i.e., the "paradox" (Formation of the Subject and Transdisciplinarity: History of Professional Life and the Imaginal. Paris: Harmattan, 2003, p. 401) and the "vacuum" (O vácuo e o espaço transdisciplinar in: Educação e transdisciplinaridade III. São Paulo: Triom, 2005, p. 439-451), respectively. Some others defend the need for non-centrality in the "logic of the included third" but in various nontraditional logics ("Message of Vila Velha/Vitória", Brazil, of the Second World Congress of Transdisciplinarity). What do you think?

It is not necessary to introduce a fourth axiom if it can be derived starting from the first three. The paradox and the vacuum are a consequence of the first three axioms. It is important to keep minimum axioms in the methodology of transdisciplinarity: if it leads to tautologies one obtains as a result of what one puts inside. Of course, the number three is neither magic nor sacred. If it is necessary, one can introduce a new axiom but, for the moment, it is not a necessity. I already answered the question of the "non-centrality" of the logic of the included middle. It is a question of confusion: the logic of transdisciplinarity, while including a formal logic is, at the same time, a philosophy, the philosophy of the included middle.

7. Among the congresses on transdisciplinarity enumerated below, in which have you participated?

- Conference of Venice "Science and the Boundaries of Knowledge," Venice, in 1986
- Congress "Science and Tradition: Transdisciplinary Prospects for the 21st Century," Paris, in 199l
- First World Congress of Transdisciplinarity, Convento da Arrábida, Portugal, in 1994
- International Congress of Transdisciplinarity "Which University for Tomorrow?", Locarno, in 1997
- Second World Congress of Transdisciplinarity, Vitória, Brazil, in 2005.

I participated to all of them.

8. Which is your perception of the importance of each congress in which you have participated for the emergence of transdisciplinary thought based on the three pillars?

- Conference of Venice "Science and the Boundaries of Knowledge": preparation of the emergence of a community.
- Congress "Science and Tradition: Transdisciplinary Prospects for the 21st century": preparation of the First World Congress.
- First World Congress of Transdisciplinarity: the core of the community is formed.
- International congress of Locarno: "Which University for Tomorrow?":

  participated of educators and students of the member states of UNESCO, in 1997.
- Second World Congress of Transdisciplinarity: With participation from the international community and a large number of transdisciplinary researchers in Brazil.

9. We affirm, in one article, that one can think that such Congresses supported the constitution of what we could designate as a "community of transdisciplinary thinkers", (to employ the terminology of Thomas Kuhn) This is because we consider that many of those who took part in these congresses became followers and started to defend the idea that this proposal of a transdisciplinary methodology based on three pillars should be employed, in reflections on transdisciplinarity, like a basic diagram, or even like a paradigm (also in the design of T. Kuhn), because it is formed with the best methodological strategy available. What do you think of this assumption?

I agree completely with this idea of a "community of transdisciplinary thinkers." But I have important reservations concerning the word "followers", with its connotation of the New Age. It is not necessary that transdisciplinarity gives rise to any kind of guru. I also have reservations concerning the word "paradigm", which was formulated by Thomas Kuhn in a precise context - that of science - and should not be used in other contexts.

10. In your opinion, which is the strong point (or points) of this (these) same Congress(es) in which you have participated?

- Conference of Venice "Science and the Boundaries of Knowledge": the word "transdisciplinarity" is mentioned for the first time in an institutional document.
- Congress "Science and Tradition: transdisciplinary prospects for the 21st century": the entry into the transdisciplinary movement of the great Argentinean poet Roberto Juarroz, who in this context also formulated an important expression of the transdisciplinary terminology: "the transdisciplinary attitude".
- First World Congress of Transdisciplinarity: adoption of the *Charter of Transdisciplinarity* which is, today still, the most important document of the transdisciplinary movement.
- International congress of Locarno "Which University for Tomorrow?": formulation of the recommendations concerning the higher education addressed to the Member States of UNESCO.
- Second World Congress of Transdisciplinarity: demonstration of the vitality of the transdisciplinary movement in Brazil.

11. And which are the weak point (or points) of this (these) same Congress(es), in your view?

- Conference of Venice "Science and the Boundaries of Knowledge": the conference was restricted to a small number of personalities of the cultural and scientific world.
- Congress "Science and Tradition: transdisciplinary prospects for the 21st century": mixed participation due to the double patronage by UNESCO and an association of engineers.
- First World Congress of Transdisciplinarity: no weak point. The organization this congress was ensured in an exceptional way by the great Portuguese painter Lima de Freitas and profited from the important intellectual contribution of the President of Portugal, Mario Soares.
- International congress of Locarno "Which University for tomorrow?": no weak point. This congress profited from the participation of very important personalities, like the Nobel Prize Werner Arber and the great architect Mario Botta.
- Second World Congress of Transdisciplinarity: The document that came out of this congress was backward compared to the *Charter of Transdisciplinarity.* Moreover, it is too specific to the Brazilian movement and less adapted to the international community.

12. In your opinion, what were the important challenges for the development and/or deepening of this proposal for transdisciplinarity, from the point of view of the methodological, epistemological and theoretical?

- *See the translation of the Charter in nine languages, on the CIRET page. http://basarab.nicolescu.perso.sfr.fr/ciret/indexen.html*

The challenges are unforeseeable. And the possible deviations are numerous.

13. Can you identify some work or author (man or woman) (yourself including) already progressing, that it is from the theoretical point of view or the methodological /epistemological point of view, toward the point of embarking on transdisciplinarity? In the affirmative, could you mention the name of the work and its author (man or woman)? Could you tell us in what respect you consider that this author was making progress? ((Note: In case there are many authors (men or women) make a list of them, one by one, below).

I do not like the spirit of lists. To see which are the important personalities it is enough to observe which are the books or the articles most quoted in the transdisciplinary literature.

14. In many published articles, it is usual that the proposal of this transdisciplinary methodology, based on three pillars, is considered as a "paradigm". If one considers how the term "paradigm" was used in the traditional work by Thomas Kuhn (Structure of Scientific Revolution), like a kind of "model" in which the problems of investigation are suggested by the paradigm and resolved by it, or, accepted as dominant by a given scientific community, whose function is to direct all research in a determined field, by furnishing problems and model solutions to a community of practicing scientists, what do you think about the nature and heuristic capacity of this proposal of "transdisciplinary methodology"? This proposal would be (or could be) in fact, a new paradigm, in the form of Thomas Kuhn, presenting itself as a hegemonic approach? Or should it be considered, considering the proper complexity of the topic, like one of the possible theoretic-methodologic propositions liable to be adopted by its followers and to contribute, with the extant or emerging others, to the study of transdisciplinarity? In the case of understanding it as a paradigm for the study of transdisciplinarity, what is your concept of paradigm?

I have already answered this question: in my view, one is not able to speak of a "paradigm" á propos of transdisciplinarity.

15. By way of a final point, we would ask whether you consider it important to add still more comments, in the form of other questions which you consider important on the theme/subject and which we have not mentioned. If so, what would you add and why?

I thank you for these very intelligent questions.

2 Place and Transdisciplinarity

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Abstract

This paper tendered a brief exploration of the synergy between place studies and transdisciplinarity. After describing the main tenets of transdisciplinarity and of place studies, a discussion teased out eight lines of synergy between the two approaches, each striving to ensure voices and perspectives are heard from different places during the solving of complex human problems. Both approaches strive to integrate many levels of truth while generating new knowledge or engaging in place-learning, place-making, even world-making. Place-conscious transdisciplinarians can be sensitive to insights gained from respecting the role of place in solving the problems of the world. They can scaffold TD ontology, logic, epistemology and axiology with dimensions and dynamics of place.

1. Introduction

Somerville, et al.[1] observed that "place studies has recently emerged as a significant transdisciplinary field." Already familiar with transdisciplinarity (TD), this was my first introduction to a link between place studies and TD. The more I read, the more it became obvious that Somerville et al.[2] were onto something quite interesting. I was further intrigued to read Lipsanen's[3] comment that place is an ontological category, that it has a fundamental place in ontology (reality). Transdisciplinarity, as a methodology,

[1] *Somerville et al., 2011, p.1*
[2] *Ibid.*
[3] *Lipsanen, 2001*

also is deeply concerned with ontology, as well as epistemology (knowledge) and logic[4], and some[5] say axiology (values). This paper tenders a brief exploration of the synergy between place studies and transdisciplinarity, especially in relation to Nicolescu's[6] notions of ontology, multiple Levels of Reality and the Hidden Third, and the Logic of the Included Middle as they inform the creation of complex, emergent TD knowledge (epistemology).

2. Transdisciplinary Ontology and Logic

Nicolescu[7] posited three pillars of transdisciplinarity. Epistemology is understood to be complex, emergent knowledge. Reality (ontology) is presumed to comprise multiple Levels of Reality (perspectives and world views) mediated by the Hidden Third. The logic of inferences is called the Logic of the Included Middle, the fertile middle ground or space among disciplines and between the academy and civil society. His approach to transdisciplinarity is based on quantum physics, chaos theory and living systems theory, as well as other new sciences, new relative to Newtonian physics and aligned classic sciences.[8]

Nicolescu[9] proposed it is essential to seek multiple perspectives on any human problem (or set of human problems) because the intent is to integrate many levels of truth while generating new TD knowledge. Succinctly, TD ontology respects the complex and dynamic relationships among at least 10 different realities organized along three Levels of Reality (see Figure 1): (a) the internal world of humans, where consciousness flows – the TD-Subject (comprising political, social, historical, and individual realities);

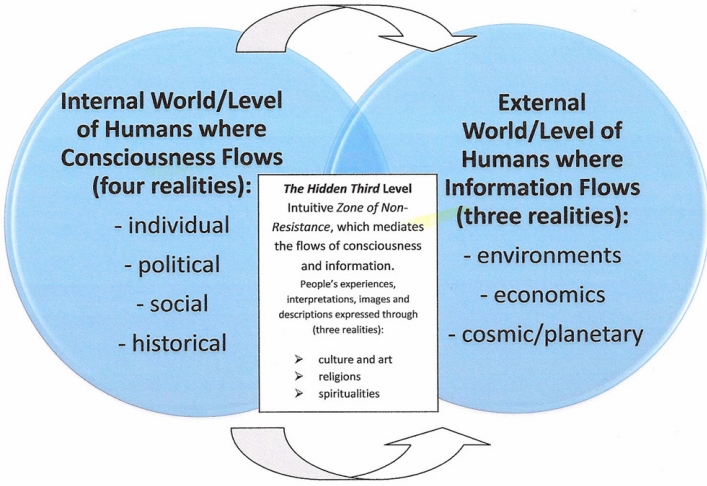

Figure 1. Multiple Levels of Reality.

[7] *Nicolescu, 2010*

[8] *McGregor, 2011b*

[9] *Nicolescu, 2010*

(b) the external world of humans where information flows – the TD-Object (comprising environmental, economic, and cosmic/planetary realities); and (c) the Hidden Third. Peoples' experiences, interpretations, descriptions, stories, representations, images, and formulas meet on this third level. Three realities exist in this intuitive zone of non-resistance, this mediated interface: culture and art, religions, and spiritualities. Together, the three overarching Levels of Reality form TD ontology.

Each of the 10 realities along the three levels is characterized by its incompleteness; yet, together, in unity, these realities generate new, infinite knowledge. TD ontology deals with the mediated flow of inner consciousness (perceptions) and technical information from different stakeholders' realities leading to a meeting of the minds in a zone of non-resistance (the Hidden Third). In this zone, people shed their resistance to truth informed by other stakeholders' realities and join these realities to generate complex TD knowledge. The Hidden Third connects all levels of reality. This zone of non-resistance allows for the unification of different realities (perceptions and notions of truth) while preserving their differences.[10]

In more detail, Nicolescu[11] proposed the Hidden Third mediates the flow of information with the simultaneous flow of consciousness such that divergent minds can connect and share information and perspectives so as to solve complex, emergent problems. Problem solvers have a means to integrate perspectives from different realities (e.g., economics with environmental), as well as to integrate consciousness and perceptions with information, while maintaining their differences. The resultant emergence of a temporary new T state (see Figure 2, used with permission[12]) represents the emergence of new insights and perceptions, made possible because of the temporary reconciliation of any contradictions or antagonism amongst various points of view (Levels of Realities) held by actors in the place. The results are the generation of emergent, integrated and integral TD knowledge about a complex, wicked problem (TD epistemology).[13]

The passage from one level of reality to another is ensured with the Logic of the Included Middle, which replaces the logic of exclusion espoused by the old sciences.[14] Newtonian logic assumes that the space (the place) between things is empty, flat and static; hence, people presume it is very difficult, if not impossible, to interface between disparate disciplines, the private and public sectors, and civil society. The TD Logic of the Included Middle is very powerful. This inclusive logic enables people to imagine that the space between things (especially between disciplines, different realities, and the academy and civil society) is alive, dynamic, in flux, moving and perpetually changing.

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[10] *Ibid.*

[11] *Nicolescu, 2011*

[12] *Nicolescu, 2008*

[13] *McGregor, 2011b*

[14] *Nicolescu, 2010*

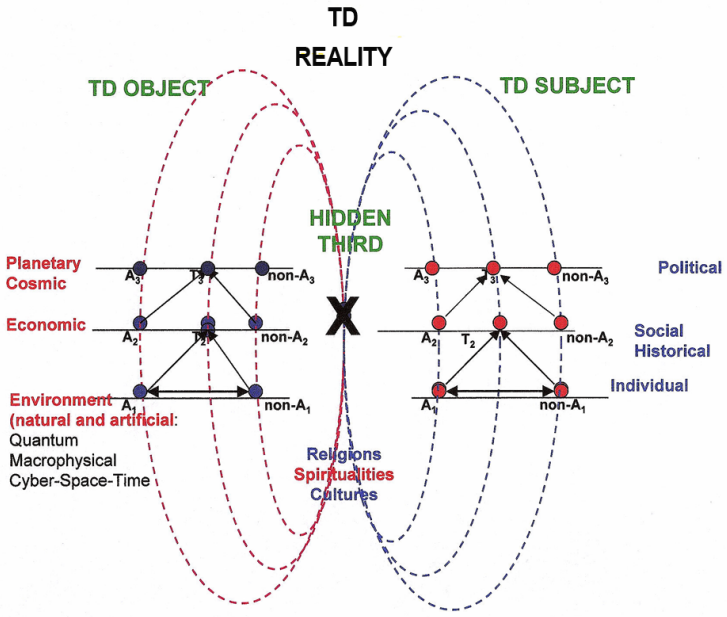

Figure 2. The Hidden Third.

It is in this place that everything happens.

Transdisciplinarity has people stepping through the zone of non-resistance (the Hidden Third) onto the fertile, moving floor of the included middle, where they generate new transdisciplinary intelligence and knowledge, together. When the separate bits of knowing and perspectives, and the people who carry them, came together to dance in the fertile transdisciplinary middle space, they move faster when they are exposed to each other than when they are alone, creating intellectual fusion.[15] The result is emergent, complex transdisciplinary knowledge (TD epistemology) that can be used to solve the pressing problems of humanity. The next section provides an overview of the concept of place, followed with an exploration of the synergy between place and transdisciplinarity.

3. The Concept of Place

The notions of space and place seem to be quite central to transdisciplinarity; hence, this paper's exploration of the possible synergy between place studies and trandisciplinarity. The concept of place also is central to the disciplines of geography, architecture (landscapes), literary and media theory, and environmental psychology, to name the most common disciplines.[16] Place studies, a subset of cultural studies, is a new transdisciplinary formation that focuses on new understandings of place, augmenting

[15] *McGregor, 2009*

[16] *Janz, 2006; Turner and Turner, 2003*

earlier work tendered between 1950 and 1970.[17] Places are filled with individual identities, languages, cultural reference points, societal rules, objects, non-human others and such,[18] whether real or virtual.[19] Place studies focuses on our relationship to place, paying special attention to how place affects knowledge making.[20] Gruenewald[21] posited that places, as centers of experience, teach people about how their world works, and how their lives fit into the spaces they occupy. He further presumed that "places make us."[22] Especially, place shapes possibilities.

Place is more than geography. It is a cerebral and emotional blend of associations, and awareness that is part physical, part science, and part history, culture and social memory. Place is subjective and very personal. Place is powerful because it reveals, as well as shapes, values and identity.[23] Somerville[24] referred to "the enigma and challenge of place," by which she meant the puzzling nature of place that baffles our understanding, and the demanding task we face while attempting to understand how people relate to place. She continued, "through place it is possible to understand the embodied effects of the global at the local level."[25] Place enables people to act on the local from the perspectives and understandings of others at the more global level (others' local places).[26] "Place knowledge" cannot be created unless there is a bridging of different disciplinary perspectives.[27] As a preamble to a discussion of place and transdisciplinarity (all about bridging perspectives), two approaches to conceptualizing the concept of place are examined: dimensions of place and dynamics of place.

4. Dimensions of Place

Gruenewald,[28] in a seminal article, developed a five-dimensional model of place. He posited that each of the five dimensions is both stand-alone and interrelated with the others. The five dimensions are perceptual, sociological, ideological, political and ecological (see Figure 3). He framed these as a collection of ideas for analyzing the "power of place" and for redirecting people's attention to the power of places where they actually live out their lives. Place studies urges us to "open our senses to the living

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[17] *Somerville et al., 2011*
[18] *Augé, 1995*
[19] *Varnelis and Friedberg, 2007*
[20] *Somerville et al., 2009*
[21] *Gruenewald, 2003a*
[22] *Ibid, p. 647*
[23] *Georgetown University, 2011*
[24] *Somerville, 2010, p. 329*
[25] *Ibid, p. 331*
[26] *Soja, 2000*
[27] *Somerville, 2010, p. 331*
[28] *Gruenewald, 2003a*

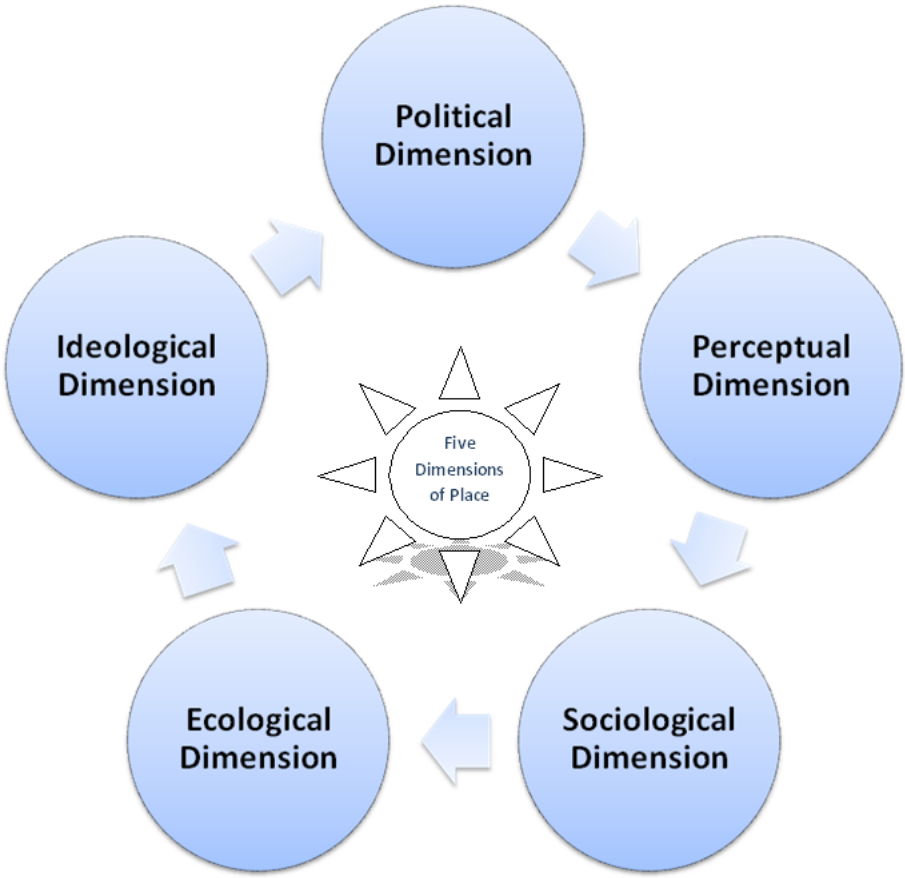

Figure 3. Five Dimensions of Place.

world of places," to "examine the impact of place on culture and identity," to "embrace our political roles as place makers," and to accept that "place making has become the ultimate human vocation."[29]

Drawing on phenomenology (the study of conscious experience and the phenomena that appear during acts of consciousness), Gruenewald[30] proposed the perceptual dimension of place. Places are not objects or places on a map. Places are alive and have lives. This mind-bending idea pries open a space to conceive of humans as being in relation with their world. Just as people are connected to places, places have cultural and ecological lives and one place is connected to other places. People's ability to perceive places in this manner has been blunted by society's isolation of people from ecosystems,

[29] *Ibid, p. 636*
[30] *Ibid*

viewing the latter as a resource to be exploited and used for human needs and wants. We need, instead, to view place as a complex of ecosystems and cultures by which humankind has evolved.

Second, predicated on the notion that place holds our culture and our identity, Gruenewald[31] tendered the *sociological dimension* of place. Humans construct places as expressions of their culture (akin to what he called "social landscapes"); that is, "places are social constructions."[32] Such places include schools, communities, workplaces, faith institutions, and governments. These places produce and reinforce particular ways of thinking about and being in the world. Consequently, selfhood (social and cultural identity) and placehood (social landscapes) are completely intertwined. Place roots people in their culture. It shapes their place stories and these stories shape the place. Human beings are responsible for place-making, even place-destruction (e.g., destroying the Earth and other species for their own ends).

Third, Gruenewald proposed an *ideological dimension* of place. Ideologies are a set of beliefs that characterize a social group. Ideologies are the ruling ideas of the time, and prescribe the preferred way to live our lives. They come with assumptions about what is worthy of belief and attention, what is accepted as true, and what is valued. The prevailing ideologies shaping contemporary society are neoliberalism, capitalism, consumerism, political conservatism, and patriarchy.[33] Gruenewald[34] posited that place "is alive, pulsing with beliefs, thoughts, and actions that shape who we are as people." Ideologies are often unexamined, leading to what Gruenewald[35] described as "often-unconscious experience of places." He continued, asserting that places are always inscribed with politics and ideologies, and these simultaneously reflect and reproduce social relationships of power and domination. Excessive power can lead to marginalization and *displacement*.

Hand-in-hand with the ideological dimension of place is the political dimension. Because place studies is a sub-field of cultural studies, it focuses on each of the politics inherent in the distribution of power and the politics of identity and differences. Power distributions and differences create spaces that can lead to "a life on the edge,"[36] to marginalization and oppression caused by cultural imperialism and violence. This situation screams for resistance to the hegemony, the dominance of social groups or the state over others. Those exercising hegemony live in the center places of society, at the core of political power. The resultant push back from the margins involves the creation of places of resistance, agency and solidarity.

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[30] *Ibid*
[31] *Ibid*
[32] *Ibid, p. 626*
[33] *McGregor et al., 2008*
[34] *Gruenewald, 2003a, p. 628*
[35] *Ibid, p. 629*
[36] *Ibid, p. 633*

Finally, Gruenewald tendered the idea of an ecological dimension of place. He referred to "an ecological consciousness of places" as he explained humans' lack of perception of their non-human worlds.[37] He called for people to align their cultural practices (e.g., production and consumption) with the ecological limits and features of places. Those concerned with the ecological dimension of place would give prominence to the relationship between the exploitation of people and of their environments, of their places. This foregrounding of the person-place ecological relationship is necessary because "places are the experiential center of patterns of both social and environmental domination."[38] Not only can people be exploited, but so can places containing ecosystems and species other than human. An "intense consciousness of places" can lead to ecological understandings, and deepened empathetic connections to places.[39]

5. Dynamics of Place

Somerville[40] has developed a pedagogy of place based on feminist post-structural and postcolonial theorizing. Her work, and that of her colleagues at Monash University in Australia, emerged out of many years of collaborative research with Australian Indigenous peoples. Although this paper is not about pedagogy nor a particular cultural collective, her three-pronged approach to place provides insights into dynamic transdisciplinary problem solving because of place studies' focus on intellectual and emotional borderwork involved when Western academic thought (the academy) meets subjugated knowledges and other ways of knowing outside the academy. She juxtaposed each of story, body and zone of contact to create a conceptual framework for a place pedagogy (see Figure 4), called dynamics of place in this paper.

First, she posited that people's relationship to place is communicated in stories, with stories understood to be basic units of meaning making. Stories ascribe meaning to places, at the same time that they shape places. If people want to change how they relate to place, they have to change their stories about place. This change cannot happen unless they remain open to other people's place stories. Together, they become "responsible for place making" because they have "become conscious of themselves as place makers."[41] She believed it is possible to co-create alternative storylines that have the power to replace the old stories, opening the door for creative problem solving.[42] Indeed, "extending the concept of story this way enables the possibility of different ways of knowing places to come into conversation with each other."[43]

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[37] *Ibid.*
[38] *Ibid, p. 635*
[39] *Gruenewald, 2003b, p. 8*
[40] *Somerville, 2010, Somerville et al., 2009, Somerville et al., 2011*
[41] *Somerville, 2010, p. 336*
[42] *Somerville, 2010*
[43] *Somerville et al., 2011, p. 4*

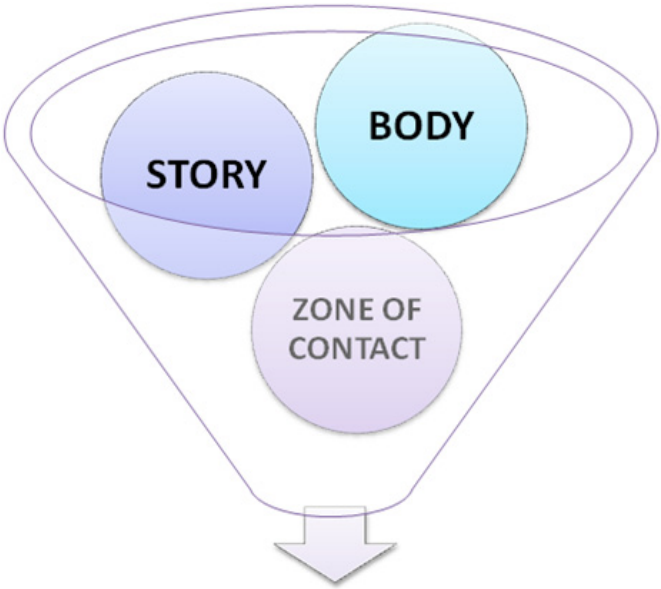

Figure 4. Dynamics of Place (Extrapolated from Somerville's 2010 Place Pedagogy).

Second, she proposed that place learning begins in the body; place is necessarily embodied and local. Arguing that modern day, objective science has distanced people from being able to recognize that they are connected to place, Somerville et al.[44] invited us to rethink place relative to our bodies. They recommended placing our bodies at the center of place, asserting that place-learning derives from a deep, embodied sense of connection. Part of this place-learning entails paying special attention to the landscape, the locale (hence, the notion that place is embodied and local). Somerville et al.[45] explained that landscapes and country are living entities, with a yesterday, today and tomorrow. Being conscious of the positioning of the body in relation to 'the country' or landscape (a form of non-human-other, material terrain) enables us to conceive of the local country or landscape as being deeply enfolded into our bodies, memories and imaginations. Somerville[46] referred to "the body-in-place at any particular moment" and suggested that the body, a "meta-category," can identify absences in dominant storylines and help to construct new stories of place.

The third dynamic of place is a contact zone of cultural contestation. The basic premise of the zone of contact is that place provides a site of intersection of multiple and contested place stories, a space for telling and listening to a multiplicity of different

[44]*Somerville et al., 2009*
[45]*Somerville et al., 2011*
[46]*Somerville, 2010, p. 337*

stories about the same place (embodied life experiences).[47] The function of this contact zone is to preserve differences while remaining willing to suspend meaning. This dynamic opens the way to possibilities for deep engagement across the differences and for transformation in the future.

Somerville et al.[48] explained that each person brings his or her story to the contact zone, to the present. Each person and his or her story has trajectories to the past. A meeting of the past and the present in the zone of differences opens towards the future. Moving back and forth within, between and across the mobile and shifting boundaries in the "zone of discomfort"[49] involves "continuing engagement with difficult questions, moving beyond a personal comfort zone to refuse easy answers and often to dwell in a space of unknowing."[50] The in-between space of the contact zone, "a fraught political terrain," is a space of transformative potential where new possibilities lie.[51]

6. Relating Place to Transdisciplinarity

Varnelis and Friedberg[52] proposed that place is in a process of deep transformation. This paper builds on that momentum and brings the concept of place to bear on transdisciplinary problem solving, mainly because Somerville et al.[53] viewed place as being able to generate conversations across disciplinary boundaries. Transdisciplinarity's main focus is to solve the problems of the world through transcending the boundaries within the disciplines and between the academy and civil society.[54] This intent is akin to place studies' concept of world-making tendered by Somerville et al..[55] Making new worlds requires openness to new directions and possibilities emergent from the specificity of particular places. It involves engagement with *the other*, understood to include humans, more-than-humans (other species), and the earth. When world-making, the people involved anticipate the eruption of the new, which requires a space for construction and negotiation of meanings as well as a space of relationality (things 'take place' as they unfold).

Those embracing transdisciplinarity can enrich their understandings of the complex solving of wicked world problems by drawing on the insights of place studies. Wicked problems, such as climate change, health pandemics or water resource management, are viewed as ill-structured social issues that have human and social interactions at their

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[47] *Somerville, 2010*
[48] *Somerville et al., 2011*
[49] *Somerville, 2010, p. 338*
[50] *Somerville et al., 2011, p. 6*
[51] *Ibid.*
[52] *Varnelis and Friedberg, 2007*
[53] *Somerville et al., 2011*
[54] *Nicolescu, 2010*
[55] *Somerville et al., 2011*

centre. Each stakeholder has radically different views and understandings of the problem and of what constitutes a viable solution. Within the immense space for options, those impacted by the problem have to negotiate and collectively exercise judgement while juggling conflicting interests and priorities.[56]

During the process of solving complex human problems (i.e., making new worlds), many personalities and world views will come into contact. Each person at the table comes with his or her own stories of the place under contestation (i.e., the wicked problem). Place studies takes up the complexity of contested place stories.[57] Place studies presumes that "syncretic beliefs about places are possible".[58] By this, Scully meant it is feasible to combine different schools of thought and beliefs, striving for underlying unity through diversity. Transdisciplinarity strives for the same thing. Other examples now are shared of the exciting synergy between (a) the dimensions of place,[59] (b) the dynamics of place,[60] and (c) transdisciplinary axioms or pillars. Several similar and/or parallel concepts thread their way through each approach.

First, each approach references zones, with transdisciplinarity focused on zones of non-resistance while place studies is focused on contact zones of cultural contestation. The intent of both is to find a way for diverse peoples to talk with each other while maintaining their differences. Place studies' focus on respecting contestation, and TD's concern for a place of non-resistance to other's worldviews and perspectives, strongly complement each other. Place can be a meeting ground for these diverse perspectives and the ensuing TD problem solving can be place-responsive (see Gruenewald and Smith).[61]

Second, both are interested in the interplay between different disciplinary perspectives, exemplified in Gruenewald's[62] five dimensions of place and Nicolescu's[63] 10 different realities (many with disciplinary origins) organized around three overarching levels of reality. Together, they encompass political, social, historical, economic and environmental disciplinary orientations as well as ideology, perceptual (consciousness), spiritual, religious and cultural dimensions. The synergy between the two approaches is obvious. Both approaches are concerned with ensuring that differences are maintained while people strive to weave these diverse dimensions and perspectives together to problem solve.

Third, because place is a concept that operates at the crossroads of current social, political, economic and environmental issues, places are locations imbued with human

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[56] *McGregor, 2011a*
[57] *Scully, 2011*
[58] *Ibid, p. 3*
[59] *Gruenewald, 2003a*
[60] *Somerville et al., 2011*
[61] *Gruenewald and Smith, 2007*
[62] Gruenewald, 2003a
[63] Nicolescu, 2010

values. Place reveals and shapes values.[64] Transdisciplinarity work is back dropped by values, which play a key role during complex problem solving. Attention to value premises in places where people are problem solving enhances people's ability to determine the deep, underlying causes of the world's crises, to understand these crises and, most significantly, to overcome them.[65]

Fourth, place studies assumes that if people want to change how they relate to place, they have to change their stories about place. This change cannot happen unless they remain open to other people's place stories.[66] To reiterate, place is not just a geographic location. It also is a cerebral and emotional blend of associations and awareness. Transdisciplinarity strives for opportunities to hear as many versions of the truth as possible from diverse voices. Those truths are often shared through narratives, discourses, dialogues and conversations, and TD would hold they are shared in the Hidden Third space. Truth-sharing is not an easy task. Remaining open to many perspectives and diverse voices, expressed through lived experiences with a place and its attendant pressing issues, is the intent of both place studies and transdisciplinarity.

Fifth, Somerville et al.[67] recommended placing our bodies at the center of place, asserting that place-learning derives from a deep, embodied sense of connection. Transdisciplinarity urges people to embrace the idea that complex, emergent TD knowledge is generated in the fertile middle space, that place among disciplines and between academic disciplines and civil society. In this space, when divergent bodies interface and interact, fusion occurs through the place connections. Both place studies and transdisciplinarity are concerned with the synergy generated when deep learning and sharing (world making) happens in a shared place of knowledge creation. Being conscious of the positioning of the body in relation to place enables us to conceive of the place as being deeply enfolded into our bodies, memories and imaginations. TD also assumes that knowledge is embodied, becoming part of everyone during the knowledge creation process in the middle ground.

Sixth, place studies conceives the in-between, contentious cultural contact zone as a place of transformation where possibilities lie. This place is described as a zone of discomfort because people who hold different experiences of the same place have to try to talk and listen to each other. Place studies presumes this zone is replete with possibilities for deep engagement across differences leading to alterative place stories and futures.[68] Transdisciplinarity ontology draws on a very similar concept called the quantum vacuum. As does place studies, transdisciplinarity also assumes that this space is not empty, but is full of potential. It contains fleeting electromagnetic waves and particles

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[64] *Mayhew, 1977; Ngongkum, 2008*
[65] *McGregor, 2011c*
[66] *Somerville, 2010*
[67] *Somerville et al., 2009*
[68] *Somerville, 2010*

that pop into and out of existence, just like insights, hard lessons and growth emerge and retrench during complex problem solving. When applied to human problem solving, trandisciplinarity assumes that, as people cross through, and temporarily live within, this vacuum (place) full of potential, TD knowledge is generated, mediated by the dynamics of the Hidden Third.[69] Both place studies and transdisciplinarity are concerned with accommodating the tensions that emerge when differences collide, anticipating transformation and world-making if the process is properly respected and mediated.

Finally, both place studies and transdisciplinary are deeply concerned with accommodating the border work that occurs as people cross within, between and beyond place boundaries. Place studies envisions border work to involve human interactions that occur during story telling and listening at the mobile and shifting boundaries of the zone of discomfort.[70] Transdisciplinarity posits that intellectual border work unfolds as people living and working on the borders of the academy (university disciplines) and civil society engage in complex problem solving after passing through the zone of non-resistance. Through a lengthy and complex process, academe knowledge and action-relevant, local, place-oriented knowledge are integrated. This integration further entails transborder value work. The requisite knowledge integration (place knowledge)[71] cannot occur unless values, and their contentious role in problem solving, are duly accounted for during border work.[72]

7. Conclusion

Place is a construct of growing interest outside education[73] and other disciplines. This paper tendered the idea that the concept of place has a place within transdisciplinarity. Transdisciplinarians that are place-conscious can become sensitive to the insights to be gained from respecting the role of place in solving the problems of the world. They can scaffold TD ontology, logic, epistemology and axiology with dimensions and dynamics of place. Story, body and zones of contentious cultural contact, informed by politics, ideology, perceptions, ecology and sociology, can be aligned with multiple perspectives (many stories, disciplines and realities), zones of non-resistance for meetings-of-the-minds, embodied knowledge generation in the fertile middle ground (place), and integral value premises. The synergy between these two approaches warrants further consideration as both place studies and transdisciplinarity continue to evolve.

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[69] *McGregor, 2011b*
[70] *Somerville, 2010*
[71] *Ibid*
[72] *McGregor, 2011c*
[73] *Gruenewald, 2003a*

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3 A Transdisciplinary Approach to Mechatronics

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Abstract

The emergence of mechatronics acts as a proof that the research and education of the future must be modeled by complex and non-separable lines of force. Consequently, it's imperative to elaborate a new approach to mechatronics, from the perspective of transdisciplinary methodology, whose purpose is the understanding of the world through the unity of knowledge. Mechatronics, through its integrative, synergic character, is an open field that transcends the limits of a single discipline. The identity of mechatronics is a trans-thematic one, founded on the thematic concept of complexity. In this context, the paper suggests the hexagonal model for integral mechatronic education using the lupascian logic. According to this model, mechatronics is symbolically positioned in the region of maximum resistance, corresponding to a triple T-state, state in which that which is contradictory does not oppose anymore, because of the conciliating role of the principle of the included middle.

1. Introduction

Based on the belief that "entering the complex and transdisciplinary thinking in structures, programs and areas of influence of the University will enable progress towards its mission forgotten today - the study of universality" (Nicolescu, 1999), and that "mechatronics is a global vision on technology'' (Mătieş, 2002), we propose through this works, a new approach to mechatronics, the transdisciplinary perspective (Berian, 2011). The appearance of mechatronics was a natural result of evolution in technological development. The backbone of mechatronics is the mechanical technology that was developed independently at first. Subsequently, advances in electronic technology, es-

pecially the emergence of integrated circuits, small in size, cheap and reliable, have enabled the integration of electronic products in mechanical structures. Thus, the first step is performed: electromechanical integration. The next step was triggered by the birth of microprocessor which, with similar structural features of integrated circuits, was included in the electromechanical structures previously made (Măţieş, 2002). Consequently, have resulted complex systems – the mechatronic systems -, able to acquire information on their internal status and external environmental conditions and from processing the information acquired to make decisions on their behavior.

2. Integration, Synergy, Complexity and Mechatronics

The first definition of mechatronics was given in 1969 by the Japanese company Yasakawa Electric and was approved and published as a trademark application in documents in 1972: "The word, me chatronics, is composed of «mecha» from mechanism and «tronics» from electronics. In other words, technologies and developed products will be incorporating more an more electronics into their mechanical structure, intimately and organically, and making it impossible to tell where one ends and the other begins'' (Mori, 1969). Chronologically, Harashima et al. were among the first (Grimheden, 2006) who emphasized that the terms synergy and integration are at the foundation of mechatronics, defined as "the synergistic integration of mechanical engineering with electronics and intelligent computer control in the design and manufacturing of industrial products and processes" (Harashima, 1996). Thus, a mechatronic system (from appliances or video camera to cars and modern robots) should not be regarded only as a set of mechanical and electrical components provided with one or more controllers (Bolton, 2003), but as the result of synergistic integration of all these components (Grimheden, 2006). Mechatronics, through its integrative nature, goes beyond a single discipline (Berian, 2007): "mechatronics has come to mean the synergistic use of precision engineering, control theory, computer science and sensor/actuator technology design to design improved products or processes" (Erkmen, 2001). To be a mechatronic engineer today means to understand and exploit the synergistic relationship between precision engineering, control theory, computer science, sensor technology and actuators.

Achieving this goal requires a change: the transition from sequential engineering to concurrent engineering (Berian, 2011; Măţieş, 2002), which requires a systemic mainstreaming: "mechanical engineering professors teaching design must teach an integrated approach to design – mechanical, electronic, controls and computers…" (Craig, 2001). This approach cannot exist without the ability to establish bridges between different disciplines (Nicolescu, 2002), finding and extrapolating meanings of the acquired knowledge.

Integrative potential of mechatronics is clearly revealed in the definition formulated in 1986 by the Advisory Committee for Research and Industrial Development of the European Community (Doc IRDAC PM 10/17/86 /3): "Mechatronics is a synergistic combination between: precision mechanical engineering, electronic control and systemic

thinking in designing products and processes. It is an interdisciplinary technology that unites these basic disciplines previously mentioned and includes both mentioned areas, which otherwise normally would not be associated "(Mătieș, 2002). In the years that followed, in almost all EC countries have launched programs aimed to promote mechatronic philosophy in education, research and technology. A representative example is the project regarding mechatronics education in the ADAPT program, initiated in 1995 by a group of universities from several community countries (Mătieș, 2002). The project aimed primarily at promoting interdisciplinary education and training: initial training, continuing education and professional conversion.

As a result of technological developments, the term mechatronics constantly enriched with new meanings: mechatronics philosophy, science of intelligent machines, the science of motion control, learning environment for the development of integrative thinking in the knowledge-based society. Mechatronics is present in various fields, including agriculture and construction. Terminology established in the literature - hydronics, pneutronics, termotronics, autotronics, agromecatronics etc. Is relevant in this direction (Mătieș, 2002). In our opinion, with the integration and synergy, the key concept in understanding the deep nature of mechatronics is complexity (Berian, 2009a). According to Hawking, the century just started will belong to complexity (Goldstein, 2008), which is closely related to the idea of non-separability "essential principle of all that is profound in the world" (Patapievici, 2005). Taking into account the consistency and, at the same time, the integrative and creative valences of the transdisciplinary approach (Berian, 2007), we consider that the identity of mechatronics can be enriched through revealing its transdisciplinary character. An important aspect in articulating a transdisciplinary perspective on mechatronics is the familiarization process with the specific terms of Stéphane Lupasco epistemology and logic, with grounding roin transdisciplinary vision proposed by Basarab Nicolescu.

3. The Included Middle between Paradox and Reality

Given that Gottlob Frege tried to prove that mathematics is just a branch of logic by building a symbolical and formal language of pure thought, Bertrand Russell discovered, at the foundation of Frege's system, a contradiction, a logical paradox: the set (class) of all sets that do not contain themselves as members, contains itself when it doesn't contain itself, and reverse. (Russell's paradox or the paradox of classes) (Berian, 2007; Botezatu 1973). Several solutions have been proposed for the paradox of classes. The most known one is the theory of types (Dumitriu, 1969), suggested by Russell himself, who started from stating the law of the vicious circle (Russell, 1910), and according to which whatever involves all of a collection must not be one of the collections. Thus, the set of all sets that do not contain themselves as members cannot be defined, as it introduces a new member (the set) with the help of the collection from which it belongs (the sets that do not contain themselves) (Berian, 2007). Although the theory of types is considered as the most important outcome of the logical paradoxes, there are voices that

claim that Russell rather avoid the vicious circle created, the vulnerability theory itself is recognized by Russell (Dumitriu, 1986).

Special kinds of paradoxes, which cannot be applied to the classical theory of types, are semantic paradoxes. The solution for the semantic paradoxes was found with the contribution of Alfred Tarski and Rudolf Carnap. Semantic paradoxes happen, says Tarski, because there is no distinction done between the situation in which a statement is used in order to talk about an object independent of it and the situation in which the statement itself is the object of the formulation. For instance, if we say "the horse is an animal", we designate the horse as object, while in the sentence "the word «horse» has five letters" the object is the expression itself. The closed nature of language generates confusion. In order to "open" it, Tarski introduces language levels. Thus, we are to distinguish between object-language, meta-language (which refers to the object-language), meta-meta-language (in which we speak of the meta-language), etc. The concepts of "true" and "false" can't be defined within the framework of the same language S, but only as part in a meta-language S1, as these concepts belong to the meta-logical system S1 which talks of the language of the S system. Likewise, a meta-meta-logical system S2 will exist, which talks of the S1 system, etc (Berian, 2007, Carnap, 1988, Tarski, 1956).

Based on whether it was possible for one of the languages to be its own meta-language, Kurt Gödel has shown that mathematics can be its own meta-language and proved that one of the undecidable sentences (of which one cannot say whether it is true or false) is precisely the one that states that the system is non-contradictory. By stating his famous incompleteness theorem, according to which in any class of non-contradictory systems there are undecidable sentences (Dumitriu, 1969), Gödel concluded that any non-contradictory formal logic system (complex enough for arithmetic to be formalized in it) is incomplete (in the sense that it can rigorously build undecidable sentences), outlining as clear as possible the limits of the formalization of a logic-mathematical system (Enescu, 1973).

Two observations are necessary here. First, we note that paradoxes were perceived for long time as an anomaly, a negative phenomenon, which was meant to be suppressed (Berian, 2011). After Gödel's theorem formulation, the paradox cannot be regarded as a limitation of thought, but rather as "the heart of any creative thinking", as a possible opening to the investigation of a new reality in which "we cannot find a logical non-contradictory system which is consistent with everything we see or we will observe "(Marcus, 1984). With the development of quantum mechanics, the paradox, who dispelled the illusion of mathematical perfection of any abstract formal system, entered the real world and not just anywhere but right at the foundation. For Bsarab Nicolescu, quantum particle itself is a "contradictory unity" that "is neither particle nor wave" being "more than the sum of its classic contradictory parts (for classical representation) and approximate (with respect to quantum representation) "(Nicolescu, 2002). Transdisciplinary methodology of Basarab Nicolescu will just exploit these new values of the paradox arising through openings made by Gödel's incompleteness theorem, meanings which, as will be seen below, proved to be particularly useful in our rigorous development of a transdisciplinary approach to mechatronics (Berian, 2011).

Secondly, we want to emphasize that for Carnap and Tarski, as for Russell,ontological dimension of logic is ignored in favor of an abstract formalism (Berian, 2010]. Hence, the contempt shown by Carnap to traditional logic - which he calls "anemic" - and Russell's opinion, that syllogism is a "solemn humbug" (Dumitriu, 1969). Anton Dumitriu is convinced that this misunderstanding shown by quoted logistics above from Aristotelian logic "have its origins in the loss of contact with reality and therefore logic to ontology "(Dumitriu, 1969). In conclusion, the progressive dissociation between formal logic and ontology has led to the separation of logic from reality.

In view of Stéphane Lupasco, the true science must have, necessarily, an ontological foundation (Nicolescu, 2009a). Seeking to articulate a non-Cartesian epistemology (Berian, 2010), Lupasco noticed the huge creative potential paradox, also managed to significantly close the ontological to logic (Berian,2011). Starting from the seemingly contradictory nature of reality, emphasized by the recently stated quantum theories, Lupasco comprehends that the sign of the existence of a phenomenon is precisely its contradiction. The philosopher learns that matter is subject to such antagonistic dynamism that the actualization of one implies the potentiation of the other one; the two dynamisms must tend towards a state of equal and mutual potentiation and actualization, thus achieving a dynamic equilibrium. The more difficult it is for the antagonistic forces get free from the equilibrium the longer the endurance of a system (Lupasco, 1982).

Any quantum event simultaneously embodies itself both wave and particle, which sends to the continuous-discontinuous dualism. There are continuous energies of homogenization, that are represented by photon particles, that do not respect Pauli's exclusion principle, and antagonistic energies, discontinuous, of heterogenization, retrievable in the electronic type of particles, that submit to this principle. Starting from here, Lupasco discovers another antagonistic dualism: homogenization (identity) – heterogenization (diversity), which makes life possible: both extreme differentiation and also absolute uniformization would lead to an eternal immobility, to cosmic death (Nicolescu, 2002).

Lupasco postulates that to each logic event e there has to be a logical anti-event ē accompanying it, the actualization of e establishing the potentiation of ē, and reverse, without either one of them being able to reach absolute potentiation, thus disappearing through the absolute actualization of the other. When e and ē reach the same level of actualization or potentiation, they will not mutually cancel each other (as in classic logic) but will be reduced to T state, in which it is considered that both e and ē are, each towards the other, semi-actual and semi-potential in the same time; T state corresponds to a maximum antagonism, to a maximum density of energy or, informationally speaking, to a maximum systematization. Non-contradiction can't actualize itself in a perfect, absolute way, because of the residual contradiction, that can't be null, thus no logical event can be absolutely non-contradictory. Therefore, we can't talk of an absolute truth and an absolute false, neither of them being able to perfectly and rigorously actualize themselves. T state is that third value of the Lupascian ternary logic, the 'nor true nor false' value (Lupasco, 1982).

The Lupascian ternary logic has a strong ontological feature, replacing the Aristotelian principle of the excluded middle with the so called principle of the included middle, which allows the conciliation of the opposites, because of the existence of the T state. Starting from the observation that not any ternary or triad involves the included

third party, Nicolescu points out that included third party has a paradoxical nature to the extent that necessarily involves the unification of the contradictory couple mutually exclusive (A, non-A) (Nicolescu, 2009b). Through this constitutive relation of contradictory complementarity the rational and the irrational, identity and non-identity are linked together (Lupasco, 1940). Thus a synergic relation is established between the opposites. Through its implications the philosophy of Ştefan Lupasco has proven to be a conciliatory, integrative one, his role in the substantiation of the transdisciplinary vision suggested by Basarab Nicolescu being a decisive one (Berian, 2011). According to Basarab Nicolescu, lupascian philosophy, unique in the way that started from modern physics and axiomatic logic, proves to be also a great novelty, "opening a road whose importance cannot yet be assessed"(Nicolescu , 2009a).

The transdisciplinary methodology elaborate by Basarab Nicolescu facilitates our exit from a world in which thought is fragmented by the scalpel of the indisputable dichotomy of binary logic, crushed under the load of excessive specialization, a "disciplinary big-bang" (Nicolescu, 1999). As finalities of pluridisciplinarity (the study of an object that is specific to one discipline by more disciplines, simultaneously) and of interdisciplinarity (the usage of the methods that are specific to one discipline in the territory of other disciplines) remains on the disciplinary investigation, they are unable to answer the human beings unitary need of knowledge (Nicolescu, 2002). Therefore, Basarab Nicolescu introduced a complementary concept, transdisciplinarity, defined as "what is, in the same time, in between disciplines, inside different disciplines, and beyond any discipline"; the finality of the transdisciplinary measure is the understanding of the world through the unity of knowledge (Nicolescu, 1999).

Transdisciplinary methodology is based on three postulates. The first postulate (ontological) states that in nature and in our knowledge of nature there are different levels of Reality and perception. The level of Reality is defined as "a gathering of systems invariant to the action of general laws" (Nicolescu, 1999) such as quantum entities that obey laws totally different from the ones encountered in the macro physical world. According to the second postulate (logical) the passage from one level of Reality to another is done using the logic of included middle (Hidden Middle) (Nicolescu, 2006). Passing from one Reality level to another, the laws and concepts change, and there is a fracture, a discontinuity (an essential concept to quantum mechanics) between two neighboring levels. The unification of A and its opposite non-A on the same level of Reality is accomplished on the next higher level of Reality through the T state, of the Hidden Middle. As it is impossible to construct a complete theory that describes the group of Reality levels, their structure is an open one, in accordance with Gödel's theorem (Nicolescu, 2002). According to the third postulate (epistemological), each level of Reality is what it is because all other levels of Reality exist at the same time. The roots of this postulate are in the bootstrap principle from quantum mechanics, which reveals that a particle is what it is because all other particles exist simultaneously. The bootstrap principle reveals that complexity is an essential characteristic of the world (Nicolescu, 2002). Hence, we consider that the transdisciplinary approach of mechatronics requires the study of complex systems, defined as a numerous ensemble of simple interactive entities which allow the appearance of emergent phenomena, with a strong synergistic nature.

4. Complexity, Self-Organization and Emergence

In classical mechanics, solving a dynamic problem (the Hamiltonian formalism) is reduced to choosing a set of canonical variables for which the Hamiltonian of the system has the most appropriate structure (canonical Hamiltonian form), followed by writing the canonical equations. Canonical equations, once established, containing a priori properties of the whole dynamics evolution. That means that if the initial conditions of the system are known, further evolution of the system is completely determined. In conclusion, canonical form of the Hamiltonian contains the whole truth of the dynamics of the system (Prigogine, 1986). According to the second principle of thermodynamics, any isolated thermodynamically system irreversibly evolves towards the macroscopic state with the highest probability of realization. The expression of statistical entropy is:

$$S = k \ln \Omega, \tag{1}$$

where Ω represents the number of the system's microstates that are compatible with a given macrostate. Consequently, the state of equilibrium is characterized by the maximal value of entropy, the fluctuations of the system being relatively small and forced to rapid regressions around the state of equilibrium (Heylighen, 1990).

The infinitesimal variation of total entropy of an *open* system is:

$$dS = d_i S + d_e S, \tag{2}$$

in which $d_e S$ is the entropy exchanged with the environment, while $d_i S$ is the irreversible change of entropy within the system (Prigogine, 1978). Prigogine showed (Prigogine, 1947) that the *P* function, called "production of entropy", has the following expression:

$$P = \frac{d_i S}{dt} = \int_V \sigma dV, \tag{3}$$

where σ represents the local production of entropy per unit of volume in unit of time, while *V* is the volume of the system. The local production of entropy is the result of the contributions of all the products between generalized forces, X_i , and the corresponding flows of the various irreversible processes, J_i , specific to the particular process being studied:

$$\sigma = \sum_i J_i X_i. \tag{4}$$

In the state of thermodynamic equilibrium, the flows and the forces are, simultaneously, null (Nicolis, 1977). If the system is near equilibrium, where the thermodynamic forces are relatively weak, there is a linear dependence between the flows and the forces. In this region, according to Prigogine's theorem of the minimum production of entropy (Prigogine, 1993), any system evolves to a *non-equilibrium steady* state in which the production of entropy reaches the minimum value. The steady state, in which the system transfers entropy to the environment, is stable with regard to the local perturbations. In conclusion, the systems described by equilibrium thermodynamics and by the lin-

ear non-equilibrium thermodynamics do not allow spontaneous manifestations which would enable patterns of increased complexity to appear.

The adaptable behavior of mechatronical open systems, integrated in the world through continuous exchange of matter, energy and information with the environment has proven to be similar to that of the living systems, which are being led by more complex laws than those offered by Newtonian mechanics or by the thermodynamics of equilibrium (Heylighen, 1990; Prigogine, 1986). The system's level of adaptivity is measured by the capacity of the system to self-organize itself. Self-organization is an interdisciplinary key concept that describes the formation of specific patterns in the presence of unspecific driving forces (Prigogine, 1978). Further on, we will explain the meaning of complexity starting from the roots of selforganization: the nonlinear thermodynamics (Berian, 2008).

For the systems from the linear region, whatever the limit conditions are, δ2S is a Liapunov function (Prigogine, 1993), namely it satisfies the two mathematical conditions (the necessary and the sufficient one) which ensures the stability of the system, due to the amortization of the perturbations (Berian, 2009a). Nonetheless the same thing doesn't happen in the case of thermodynamic systems that are far enough from equilibrium for the relations between the flows and the forces to become non-linear. In this region the sufficient condition for stability is not satisfied, the system becoming unstable and is therefore lead by laws specific to itself (Nicolis, 1977).

The prototypes of far from equilibrium thermodynamic systems are the chemical reactions in which autocatalization appears; if the value of a control parameter changes progressively, beyond a critical threshold, the system reaches, through the amplification of fluctuations, to a bifurcation, beyond which appear oscillations of the products of chemical reactions. These oscillations represent *stable spatio-temporal structures* (called *dissipative structure*), the emergence of a *global order*, at a macroscopical level. The bifurcation points are situated in the proximity of unstable regions in which the far-from-equilibrium open system "chooses", through *symmetry-breaking*, between its multiple possible future evolutions. Several successive bifurcations are possible, as the value of the control parameter increases (Prigogine, 1978). The appearance of patterns at a macroscopic level arises in the absence of any external constraint; therefore, the system self-organizes itself. This phenomenon also occurs, for instance, in the case of spontaneous magnetization or of Bénard cells (Prigogine, 1986). The systems that are in the non-linear region become, near the bifurcation point, extremely sensitive to small external fluctuations, perceiving differences that are impossible to distinguish by systems that are in equilibrium or in its nearness. These small differences lead to the process of self-organization, by selecting certain external perturbations which, through positive feed-back (autocatalization), are amplified, leading to *multistability* (the coexistence of stable spatio-temporal structures).

What the self-organizing systems have in common is the fact that the activity at microscopically levels spontaneously generate patterns at a global level in the system (Berian, 2008). *Emergence* represents this manifestation of certain coherent patterns at the level of the whole system, which, although being the result of the interactions between the systems' components, cannot be deduced by studying these isolated parts apart from each other (Casti, 1997). *Complex systems* are often defined as a numerous ensemble of simple interactive entities, which allow the appearance of emergent prop-

erties (Boschetti, 2005). The emergent properties transform the system not just into a larger entity than the sum of its components but the system enriches itself with new valences, previously inexistent (Kauffman, 1995, Mătieş, 2002). In conclusion, we can state that emergence is the product of the self-organization of far-fromequilibrium systems (Berian, 2008; Holland, 1998).

5. The Transdisciplinary Nature of the Homeokinesis Concept

The coherence specific to open systems that are far-from-equilibrium is found at the *edge of chaos*, that is, in a narrow intermediary area situated in between the chaos of thermal equilibrium and the turbulent chaos of non-equilibrium (Berian, 2008). Thus, a complex cybernetic system must, on one hand, produce a sufficiently high variety of actions in order to cope with the possible perturbations (that is, the system must be kept sufficiently far from equilibrium for there to be enough tangible steady stable states), while selecting the most appropriate state for counteracting the destructive effect of the perturbations (the steady states of the systems mustn't be too many, or too unstable, so, the system mustn't be "pushed" too far from equilibrium), which can compromise the existence of the whole system (Heylighen, 2001). The
emergence of the spatio-temporal structures is, therefore, the consequence of the flexibility of complex systems when these are subjected to the influence of the fluctuations of the environment under the action of the cause-effect circularity (the effect of a cause influences the cause itself) represented by the two feed-back mechanisms: positive and negative (Berian, 2009a). Thus, selforganization is a result of the "compromise" between a driving force (positive feed-back) which amplifies external perturbations and a regulating force (negative feed-back) which tries to stabilize the system (Martius, 2007)

In the field of artificial intelligence, particularly in evolutionary robotics, the adaptivity is the main goal of an autonomous agent. Adaptivity means much more than stability: the system must operate in a regime situated somewhere between the chaotic behavior and the ordered state of homeostatic equilibrium (Berian, 2009a). In this edge of chaos regime the robot is able to adapt his behavior to changing external condition searching for new functionalities (Der, 2000). The behavior of a robot can be considered as a spatial-temporal pattern which is formed in the complex interaction between the robot and its environment. Thus, true autonomy must involve the emergence of self-organized behaviors for robots, through symmetry-breaking (Berian, 2009a, Der, 2002). The self-organization of the robot means that its evolution must not be driven into a desired direction by a semantic introduced from outside, like in supervised learning or in reinforcement learning. In other words, a self-organized robot must adapt to the environment by developing functional behaviors which do not depend on an imposed target or a reward signal. The principle of homeokinesis, the "dynamical pendant of homeostasis" (Der, 2004), provides a
mechanism for the self-organization of the robot, in which the goal of the agent is not to remain in a stationary state (i.e. homeostatic equilibrium), but to attain a definite internal kinetic regime. The robot, endowed with an adaptive, internal representation of its behavior (self-model), is able to discover its own semantics, using the misfit between the behavior predicted by the model and the true behavior as the learning signal for the

adaptation of both the model and the controller.

The experiments show (Der, 1999; 2000; 2002; 2004) that the mechatronical complex system (the robot) governed by the home kinetic principle adapts its exploration according to the knowledge of the world: as long as the misfit is small the knowledge is large, the prediction quality of the system increases, favoring the explorative mode. If the misfit increases, the predictability decreases and leads to the avoidance behavior. In other words, the environmental changes generate changes in sensor values, which progressively destabilize the robot, leading it towards a chaotic regime. So, the robot is in harmony with the environment, providing a counteracting effect: the requirement that the effects of the robot's actions must remain predictable.

In conclusion, learning under the principle of home kinesis drives the mechatronical complex system (the robot) towards the edge of chaos, a working regime where the system is characterized by the "optimum payoff between creativity and stability" (Der, 2000). The mechatronical system's behavior is explorative (the robot is creative, exploring sometimes risky regions) but remains, in the meantime, predictable (is able to adapt to slow environmental changes, keeping a stable, non-chaotic behavior).

Using the Lupascian logic language, the actualization of the pure explorative behavior means reaching maximum heterogenization, and the robot will move chaotically. Reversely, the actualization of the pure predictive behavior means reaching maximum homogenization: the robot gets stuck in a sterile stable state. For the mechatronical system to function the actualization of explorative behavior means the potentiation of predictive behavior and reverse, without either one of them being able to reach absolute potentiation or actualization. According to Lupascian logic, the maximum antagonism, or, informationally speaking, the maximum complexity is reached in T state in which the two behaviors are both semi-actual and semi-potential. Thus, we can now claim (Berian, 2009a) that the T state represents, in the case of the studied mechatronical systems, the edge of chaos, the state in which certain explorative-predictive behavioral patterns emerge.

The home kinesis principle ensures the functioning of the mechatronical system on the edge of chaos, reaching its autonomy through realization of a dynamic harmony between the "interior" and the "exterior" world of the system. , in Basarab Nicolescu's transdisciplinary approach (Nicolescu, 1999), knowledge is, simultaneously, external and internal, the study of the Universe and of the human being complementary supporting each other (Berian, 2009a).

The contemporaneous growth of interest in mechatronics has identified a need for a new educational paradigm, which favors the formation of engineers and teachers endowed with a comprehensive, creative, integrative thinking in the technological area. In this context, the necessity to transcend the limits of a single discipline becomes an imperative educational request. Therefore, after I proved the transdisciplinary character of mechatronics, by highlighting the links between the Lupascian logic, the nonlinear thermodynamics, the self-organization of complex systems and the emergent robots behavior derived from the home kinetic principle, we will exploit further the integrative valences of the Basarab Nicolescu's methodology, proposing a new transdisciplinary approach of mechatronics.

6. Grimheden's Position on the Nature and Evolution of Mechatronics

According with Grimheden's approach (2006), any analysis of an educational subject (teaching, didactic subject) X (as it is mechatronics) involves four aspects. First, we have to ask the question of what exactly is X, namely to put forth the *identity* of the subject. The identity can be described in terms of the two extremes: disciplinary identity and thematic identity. The identity of the subject is a disciplinary one if a strong consensus exists regarding the definition, content and structure of a subject, and also regarding its classification, organization or curriculum. This is the case of mature, traditional subjects, such as mathematics, physics, biology, etc. In the absence of this consensus, one can only speak (usually with regard to recently developed subjects) about the existence of a theme that is at the origin of the subject, its identity being therefore a thematic one. For example, this is the case of systems engineering, which is founded on the idea or theme of system. Therefore, according to Grimheden, mechatronics has a thematic identity, idea also defended by the fact that there is no universally accepted definition of mechatronics or a common curriculum. Grimheden's suggestion is that of looking for the common denominator among its varied definitions, as these elements are important clues regarding the theme that gives identity to mechatronics. Consequently, Grimheden identifies two common elements: the idea of synergy and the need for complementary skills. The evolution of mechatronics has undergone, in Grimheden's opinion, six stages. The last stage is the one in which we can speak of an identity of mechatronics, a thematic one according to Grimheden (2006).

The second issue is the *legitimacy* of the subject that is its reason to exist. Legitimacy is the consequence of the relationship between the result of training offered by universities and the requirements that society has in regard to the abilities of the graduates. Legitimacy can be formal or functional, depending on the type of knowledge promoted. Formal knowledge is what can be read, understood and assimilated form books, courses, etc. Functional appearance of legitimacy has to do with practical skills that cannot be learned from books, but can be gradually acquired by laboratory experiments, trial and error type exercises, etc. From this point of view, Grimheden believes that the legitimacy of mechatronics is a functional one (Grimheden, 2006).

Thirdly, the *selection* problem of the most important aspects of the subject X to be studied must be analyzed. There are two extreme types of selection. The first one is "the horizontal", or by representation, which provides a broad and comprehensive perspective on the whole subject. The second is "vertical", step during which, by example, only a limited number of the subjects aspects are deeply studied. According to Grimheden, the thematic identity of mechatronics requires a *vertical* selection, by example, following the formation of practices and practical skills focused on key words (synergy is one of them), which are its fundamental themes (Grimheden, 2006).

Finally, the last aspect is *communication* that is the most efficient way to send subject X to graders and students. There are two forms of communication. The first is the active communication, where the teacher-student relationship is similar to the feed-forward open loop control, the educational act being centered on how the teacher should act to achieve its objectives. The second form is interactive communication, similar to closed loop control, where the feedback that the teacher receives from the student has

the essential role. According to Grimheden, there is a close link between the functional legitimacy of mechatronics and its appropriate form of communication: the practical skills required by the industrial market can be formed only through teamwork, learning based on problem solving and projects, which necessarily involves opting for an *interactive* form of communication of mechatronics (Grimheden, 2006).

7. The Trans-Thematic Identity of Mechatronics

All philosophies of science agree on the meaningfulness of two types of scientific statements: the phenomena ones that refer to empirical matters of fact, and those concerning logic and mathematics, the latter being of analytic nature (Berian, 2009b; Holton, 1988). Holton assigns a system of two orthogonal axes to these two types of sentences *Ox* and *Oy,* respectively that represent the dimensions of the plane of any scientific discourse. In this plane, called the contingent plane, a scientific concept or a scientific proposition has both empirical and analytical relevance. Starting from the notion of contingency (Berian, 2009b), Holton assigns a new meaning to this term, but one that is related to its primary meaning in logics (Holton, 1988).

Carrying on, Holton adds another axis, *Oz*, that is perpendicular to the contingent plane, representing the dimension of *themata*: themata represents fundamental ontological presumptions, generally unconscious, that, although incapable of being scaled down to empirical observations or analytic judgements, are dominant in the thinking of researchers (Holton, 1978, Nicolescu, 2002). As Basarab Nicolescu asserts, themata refers to the most intimate and profound part involved in the genesis of a scientific idea (Nicolescu, 2002): „these themata are hidden even for the one that uses them: they do not appear in the constituted body of science that perceives only phenomena and logical and mathematical sentences."

A *thematic concept* is analogous to a line element in space which has a significant projection on the Oz axis, the thematic dimension (Holton, 1988). Purely thematical concepts are rare. Therefore the thematic concepts usually have considerable values of their projections on the other two axes (as, for example, the case of the concept of energy). While the contingent plane *Oxy* is adequate when we are dealing with a purely scientific discourse, we must use the tridimensional *Oxyz* space every time we plan on doing a complete analysis, including of historical, sociological and epistemological nature of certain concepts, processes or scientific approaches.

Returning to Grimheden's perspective on the identity of mechatronics, we've stated above that he considers (by looking at what is common to several definitions of mechatronics) the idea of synergy as being the conceptual essence, the theme on which the identity of mechatronics is based on. The notion of synergy is integrated, however, together with that of emergence in the theory of complex systems or the complexity theory (Berian, 2008). *Entropy* is a concept that plays an essential role both in non-linear thermodynamics and in information theory (Berian, 2011). On the other hand, the notion of *information,* belonging firstly to information theory, also plays a fundamental role in mechatronics (Mătieş, 2002).

The concept of *self-organization* belongs to non-linear thermodynamics and mechatronics alike. Regarding the role of self-organization in mechatronics, our previous papers presented two types of self-organization of complex mechatronical systems:

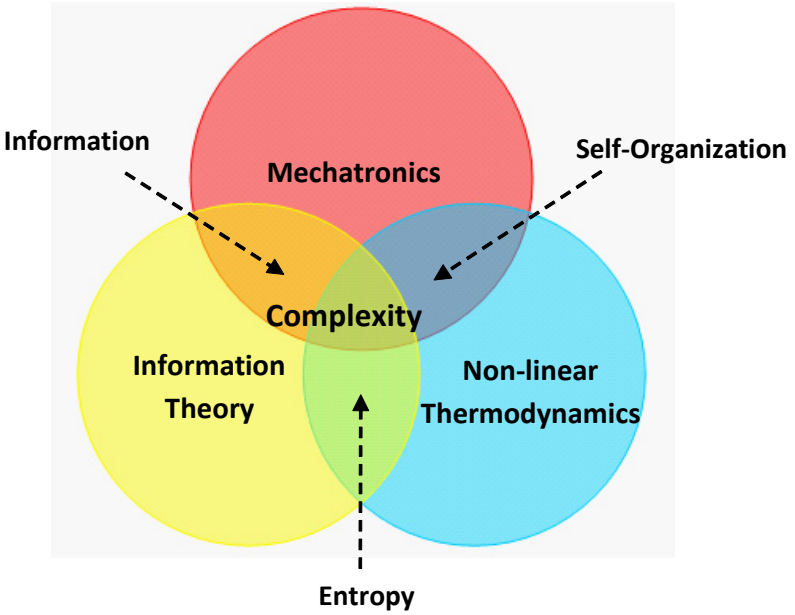

Figure 1. The Integrative Potential of the Thematic Concept of Complexity.

through stigmergy (Berian, 2008), respectively homeokinesis (Berian, 2009b). The integration of all the notions and fields mentioned above is due to the notion of *complexity* (Figure 1).

Coming back to the problem of identity, it can be stated that, in mechatronics, *complexity is a thematic concept,* in the sense defined by Holton, concept that gives the measure of the identity of mechatronics. A first argument favoring this sentence is that of the fact that the term integration is a central one in mechatronics (Măties, 2002), while complex mechatronical systems have an inherent power of integration (due to the emergent properties of synergic character) that grows higher as the degree of complexity grows higher (Berian, 2008).

Themata usually appear in the shape of alternatives (Nicolescu, 2002): continuous-discontinuous, unity-hierarchical structure, holism-reductionism, etc., each new *thema* implying the separation, the opposition of alternatives. Particularly, in the present case, we have the dyad made of the contradictories simplicity-complexity. Therefore, on the one hand, complexity has integratory valences while, on the other hand, it appears to be the source of a separation. In Basarab Nicolescu's opinion, however, the themata must be seen as facets of symbols, while the symbol assumes the unity of the contradictories; for example, Bohr's complementarity represents a symbol that "realizes in itself the unity of the contradictories continuous-discontinuous, waveparticle" (Nicolescu, 2002).

Specifically, complexity appears as a facet of the bootstrap principle, a symbolic principle that "conceives nature as a global entity, fundamentally inseparable" (Nicolescu, 1999). Thus, we consider that *complexity represents the theme at the base of the identity of mechatronics* (Berian, 2011). The idea of complexity is more comprehensive

than that of synergy, as self-organized mechatronical systems distinguish themselves firstly through their complexity, due to the existence of emergent properties with a pronounced synergic character (Berian, 2008).

In Basarab Nicolescu's opinion, a theory founded on a symbolic idea is an open theory, as its feature of permanence is guaranteed precisely by the existence of the symbolic idea. Such a theory can undergo changes of the form level (particularly of mathematical formalism), but its direction remains unchanged (Nicolescu, 2002). Therefore, viewing mechatronics from the perspective of transdisciplinary methodology, its identity is based on a symbolic principle (that plays, in addition, the role of an epistemological principle), which leads to mechatronics being an open field (Berian, 2009b).

In a transdisciplinary approach, mechatronics transcends, therefore, the limits of a simple thematic identity. In conclusion, we claim that *the identity of mechatronics is trans-thematic, founded on the idea of complexity* (Berian, 2010).

8. The Hexagonal Model for Integral Mechatronic Education

As ahown, according to Stéphane Lupasco's epistemology, the two antagonistic dynamism of the system tend, during the transition from current to potential or vice versa, to reach the T state, state where the organization and resistance of the system are maximum. Therefore, "maximum strength" (corresponding to maximum efficiency) of a teaching model which provides a integral education is achieved when the antagonism of opposite forces is maximum. There are three pairs of dynamic antagonistic regarding mechatronics: formal legitimacy / functional legitimacy, horizontal selection / vertical selection and active communication / interactive communication. Updating the formal legitimacy requires functional legitimacy potentialization and vice versa, the same reasoning appling to the other two pairs of dynamism as well (selection and communication). Absolute update of any dynamics is the equivalent of adopting an incomplete education approach, which neglects the benefits of antagonistic dynamism updating, since the latter will be completely potentialized, so sterile.

Consequently, in terms of a model for a integral mechatronics education (Berian, 2011), mechatronics is symbolically located in the area of maximum resistance, which corresponds to a triple T state (each pair of dynamics having its own T state), state in which the contradictory are not contrary because of the reconciliating role of the principle of the included middle (Figure 2).

In other words, the model presented, based on the logic of the included moddle, outlines the nonseparability and the existing unity between the sides of mechatronics that seem to be irreconcilable: formal legitimacy/functional legitimacy, horizontal selection/ vertical selection, active communication/ interactive communication. The detailed analysis of how this reconciliation is achieved of this sides of mechatronics can be followed in our work (Berian, 2009b; 2011).

9. Conclusions

From a transdisciplinary approach, mechatronics is an open field, so its identity transcends the limits of a simple thematical identity. The stating and the argumentation of the idea that the identity of mechatronics – founded on the thematic concept

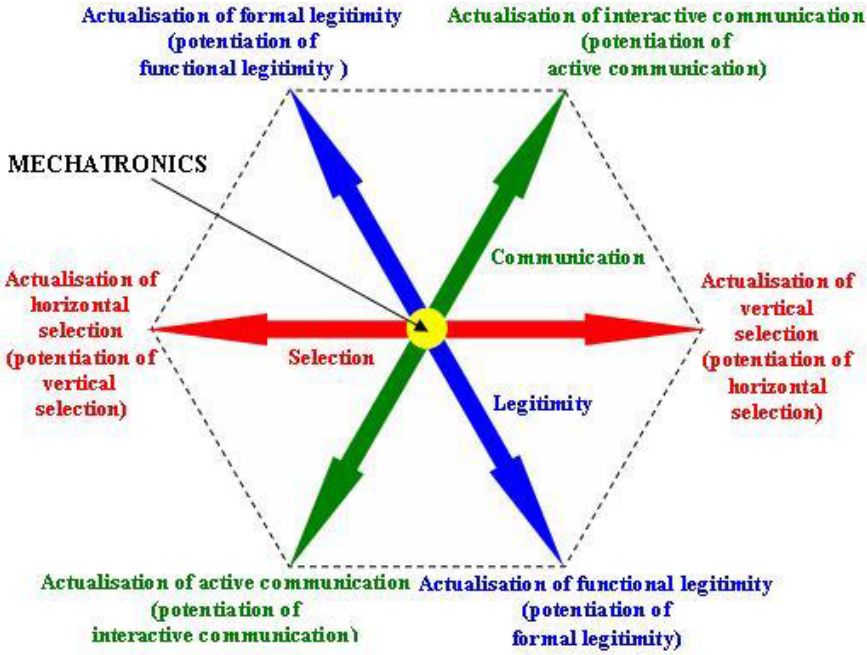

Figure 2. The Hexagonal Model for Integral Mechatronic Education.

of complexity – is trans-thematic, serves as a starting point in the substantiation of a future complex and rigorous transdisciplinary approach to mechatronics. The results of theoretical, didactical, and experimental research of the authors of this paper represent openings to new investigations in the area of technology and mechatronic education. These openings are justified both by the creative potential of transdisciplinary methodology and by the positioning as an open field attributable to mechatronics. Some of these openings are: the developing, at a conceptual level, of the hexagonal model for integral mechatronic education and its validation in organizing project competitions and mechatronic products; research and definition of new openings regarding the expansion of the content of discipline curricula from mathematics and natural sciences, through the integration of certain modern applications of the principles, laws and phenomena of physics, chemistry and biology in mechatronics and biomechatronics; research, development and implementation of educational interactive technologies on mechatronic platforms and the development of the innovative potential of the portable laboratory and of the multifunctional regional laboratory of mechatronics, in the advancement of the dialogue between science and society.

As demonstrated in the contents of the present paper, mechatronics is capable of providing conceptual resources and applicatory instruments, with the purpose of establishing additional studies, starting from the openings previously mentioned.

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4 From a Disciplinary to a Transdisciplinary Vision of the University: A Space of Knowledge, Culture, Art, Spirituality, and Life

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Abstract

How does one understand the University situation today? Is the disciplinary paradigm viable? What are the consequences of this paradigm? In my paper, I give one answer to these questions and review, from my own academic experience in a Mexican University (Veracruzana University), strategies like Complex Thought (Edgar Morin) and Transdisciplinarity (Basarab Nicolescu) to affirm the urgency of moving from a one-disciplinary vision to another—transdisciplinary. I maintain that only with this change will the University, especially in Latin-America, be able to offer an integral education in which both professors and students may solve «real world» problems effectively and affectively. Only in this way will the University contribute to a genuine social transformation.

1. Current State of the University

How does one define today's University? Is there only one kind of University? The first problem is that there is not only one definition for the current University; its essence, or universality, has stopped being operational in a world where transformations come at an increasingly intense speed with social and political problems ever more acute.

There are also large disparities between universities of the north and those of the south and between public and private universities. For example, there are abysmal dif-

ferences between the National Autonomous University of Mexico or the University of Sao Paulo in Brazil and the National University of El Salvador in Central America. It cannot be denied that characteristics of every society determine its own style of education, yet the dominant paradigms are still imposing their educational practices.

The University, a very classic and traditional institution with more than nine centuries of existence, faces dizzying changes marked by globalization, cultural diversity, and information and communication technologies. This situation occurs within the frame of inequality.

In light of this environment, it is necessary to ask if the University is currently satisfying the necessities of society and of promoting creativity by means of the transmission and generation of knowledge. In this sense, the question is: does humanity today live better than before thanks to the University?

It is difficult to know what part of society's achievements are a result of the University's action while at the same time what share of responsibility the University has had in the big failures, but undoubtedly it takes part in both. Certainly, the human potential locked in the University has not been sufficiently tapped into, especially due to its rigid institutional structure and its uncritical response to external demands. So, its crises have its origins both from within and from with out.

The Crises of the University

The Portuguese academic Boaventura de Souza did an analysis of the situation of the public university, in particular in Brazil. The analysis indicates that there are three crises: one of hegemony, due to the contradictions between the traditional functions and those who in the 20th century were attributed to it; another of legitimacy, for the fact that it stopped being an institution consensual, opposite to the contradiction of the hierarchical organization of specialized knowledge's and to the social and political requirements of democratization and equality of opportunities; and an institutional crisis, for the contradiction between recovery of autonomy and the increasing pressure for submitting it to criteria of efficiency and productivity of managerial character or social responsibility (Boaventura, 2010)[12].

The epistemic state of the University and its social function is, today more than ever, antagonistic. Thus, one comes to recognize the need for transformation in Latin America.

The globalizing and neo-liberal perspective that promotes expansion of the educational market sought to impose a managerial paradigm that led the marketing of the University. This stimulated the creation of the "university market".

As a consequence, the problems grew. For instance, we saw the unprecedented acceleration of the fragmentation of knowledge, a rejection of sharing knowledge, a lack of tolerance, and a separation of science and culture (the origin of which goes back at least three centuries ago).

Media culture displaced to a great extent the academic culture. Teachers turned into objects of evaluation. Efficiency has arisen to the detriment of creativity and open thought. In sum, "universities follow the mandates of a lone simplistic, professionalizing and enterprising culture of education" (Guillaumin, 2009, p. 111) [6].

Opposite of this vision, one began to speak from the academic field of changing

mentality and institutional structure and of orientating the University toward the sustainability. It is precisely from this approach that we encounter two questions: how can the University respond to the challenges of the 21st century? What reforms does the University need in order to offer an integral and open formation that links *effectivity* and *affectivity,* which connects the university student with the complexity of the world, which contributes to the genuine social transformation, and which gives a place for culture, art, spirituality, and life in the university?

An extremely reductionist thinking has raised the possibility of "closing the university if it does not answer to its *raison d'être*." If its *raison d'être* is the generation of knowledge, it is practically impossible that this happen. However, if one goes along with the global and neo-liberal vision of turning the university into a "market of credits," then inevitably it will have to disappear to make way for a new organization based on the integral and creative formation, spiritual autonomy, and a connection with society of the student.

We must not forget, as well Edgar Morin and Basarab Nicolescu remind us, that at present the risk is the destruction of our planet and, in consequence, of humanity. For this reason, the University must respond at the same level as the present circumstances.

2. The Disciplinary University

The disciplinary fragmentation and the division of systemic problems maintain a theoretical superficiality, strongly conditioning the social development of countries.

The disciplinary organization has a correlate in the genesis of the modern universities in the 19th century. In this respect, the disciplines have a historic development that is ingrained in the history of society, but in addition it possesses an epistemological and paradigmatic dimension similar to the understanding of the ways of organizing disciplinary knowledge and their processes of closing and opening.

The notion of discipline, in this context, can be defined as an organizing category inside the scientific knowledge, instituting division and specialization. The organization of the knowledge into many disciplines has stimulated separate models, increasingly preventing the methodological and epistemological integration.

University knowledge has been predominantly disciplinary "whose autonomy imposed a process of relatively decontextualized production in relation to the daily needs of society. Following the logic of this process, the researchers determined the scientific problems to resolve, defining its relevancy and establishing the methodologies and the rhythms of inquiry … The University produces knowledge that society can apply or not, an alternative that, as socially relevant as it, may be indifferent or irrelevant for the produced knowledge" (Boaventura, 2010, p. 41) [12].

Alternatives to the Disciplinary Paradigm

For example in Brazil, Ubiratan de Ambosio has raised the urgency of new models or a different way of facing life with a new organization of the University. He proposed a transdisciplinary approach for a real change in the essence of the humanity (1997) [2].

In effect, throughout the 20th century, a new way of seeing and understanding the world was generated that instigated the rupture of former shared convictions, concepts, techniques, and values supported and used by scientific communities. A new epistemol-

ogy emerged with the General Theory of Systems, Cybernetics, Constructivism and Constructionism, Sciences of Cognition and later Complex Thought and Transdisciplinarity that opened the possibility of co-generating a more dynamic conception of the human being and a new way of understanding reality and knowledge itself (Adame, 2010) [1].

This nascent epistemology started by generating a new way of "knowing our knowing" (Morin, 1994) [9]. What in the paradigm of modernity was translated as an anomaly, a contradiction, and a sign of mistaken thought, in this different perspective appears as a crisis, a fork in the road, a possibility of new ways.

For example, the unidirectional reason/effect was confronted with the circularity that proposes a recursive effect. In this way, the knowledge that the University generates must regenerate the knowledge that the University offers. A University that does not recognize the biodegradability of knowledge cannot affirm that it generates knowledge. It is not a question of changing what it is necessary to know, since it is always dynamic, but the way of knowing. The concept of feedback arises as a unit of interaction in a system where the observer is a subjective participant, a co-participator in the process that before was made separate in an effort to be objective.

The situation of a change for the University offers to all its members the possibility of placing themselves within the change itself and invites others to actively involve themselves in this construction of "doing while doing."

Little by little, from this position, the knowledge is traveling between interactions and cognitions that are mutually influenced.

Between a globalization that socially homogenizes and a fragmentation that mutilates education, an intermediate zone emerges, which is only possible to conceive from a complex and transdisciplinary perspective of constructing the University.

3. Transdisciplinary Vision of the University

New looks to address and to transform the role of the University in the contemporary societies have appeared from different areas for many decades. As much from the social, political, cultural, and economic point of view as from the perspective of the increasing complexity of the real world, the function of the knowledge is key in terms of transformation and in terms of citizenship and social responsibility.

The University, as an institution that produces knowledge and forms opinion and trends, has an unquestionable social responsibility. Its priority task today should be regarding thought itself—elucidating the conditions that construct knowledge, that form professionals that conceive the human condition to know and act. From this perspective, the University has an urgent task: determining the why, how and what to know.

The hyper-specialization and compartmentalization of disciplines prevent access to broader and related knowledge. That is the reason why the single disciplinary education is becoming increasingly inadequate and why there must be cooperation between disciplines, among the various center of culture and knowledge, among different knowledges (scientific, artistic, and techniques).

Under compartmentalization, teachers and university researchers are interested only in the skills they need to excel in their field. Research and education in science, literature, philosophy, and human sciences generally respond to criteria of technical ef-

ficiency and profitability without offering a critical view of knowledge, a prerequisite for making necessary distance and to give meaning to the task of knowledge.

The University, as a space where knowledge is generated and processed, cannot fail to look at itself critically to detect its own stagnation. It is necessary to recover its ability to regenerate to avoid higher risk: mental and emotional stagnation of new generations.

Isolated academic disciplines are less than adequate to deal with wider personal and social problems. The fragmentation of the disciplines leads to passivity and, at its best, answers only one part of what social life demands: that we were trained by a single discipline.

While knowledge does not provide the all the necessary means to contend with the complexity of reality, it does increase the expression of our human potential.

That complex reality is not only that of work and daily subsistence, nor the world television programs present, nor financial markets, nor that of the corrupt dictatorship or pseudo-democratic governments, nor the savage crimes that occur daily; on the contrary, the complex reality is also that of the tiny acts of courage, solidarity, affectivity, creativity, spirituality, and all that is infinitely small or infinitely large that escape our senses.

How can science and scientific research, arts and its practices, technical and traditional knowledge —all of them products of intelligence and imagination of humankind— be available and beneficial for society?

If the purpose of university culture is the elevation of spirit, achieving this requires linking all the knowledge and recognizing that only from the human dimension will the University serve humankind. For a better understanding of the world, the University must overcome the radical disjunction of knowledge across disciplines and establish a bridge between them. The University in the 21st century should prepare persons that can be placed between, across, and beyond their discipline, their culture, their nation, their politics, and their religion.

4. Complexity and Transdisciplinarity

The paradigm of complexity designed by Edgar Morin and transdisciplinarity methodology proposed by Basarab Nicolescu constitute a relevant pathway for the transformation of the University.

We take of the complex thought–the opposite of the simplified thought–the multidimensional relationship between man, society, life, and the world. The complexity is relevant because it suggests the invention against repetition. This is a new strategy that faces the challenge of real world. Edgar Morin proposed a method that consists of three principles: dialogic, recursive, and holographic (Morin, 2000) [7].

Complex thought questions the validity of teaching knowledge without teaching what it means to know. Perhaps as never before, complex thought requires an ethical and strategic purpose. Morin, on the occasion of a dialogue on the relationship between ethics and development, emphasized that:

"We must also change the structure of the education system, because development brings a conception of expertise of each person, and each person is dedicated in their particular corner and forgets the responsibility of solidarity with the whole. If we change the structure of education, no more specialization, but we raised fundamental and global problems, then we generate a new mentality. We need to help education, but not this

education which ultimately leads to the impossibility of conceiving the most important problems" (Carrizo, 2003) [4].

Transdisciplinarity, in turn, is an epistemological proposal according to the tenets of complexity that sees the advent of a human being capable of contending with all that is between, across, and beyond what has been considered Reality. To understand its broad scope, it is necessary to apply the methodology proposed by Basarab Nicolescu, whose three pillars are: levels of Reality (ontology), the included medium (logic), and complexity (epistemology). In the Manifesto of Transdisciplinarity, Nicolescu makes the contextualization of this approach and explains its broad scope (Nicolescu, 2009) [10]. Levels of perception are added to the levels of Reality. Nicolescu warns of dangers to the approach of recognizing only the levels of Reality but not the unknown the levels of perception, or vice versa.

The transdisciplinary perspective sees the human being as *Homo sui trascedentalis*, a person who is born again and whose potential "is inscribed in our very being" (Nicolescu, 2009, p. 57) [10]. It is a being that is recognized in its irreducibility and its inner and outer double transcendence by which it accesses freedom. Transdisciplinarity does not comprehend the division between science and culture but is trans-cultural. This principle shows that human beings are identical from a spiritual point of view, beyond the vast difference between cultures.

In the building of Transdisciplinarity are the two great revolutions of the twentieth century: quantum physics and informatics. Quantum physics and informatics have paradoxically changed the face of the world. "Today, despite the unprecedented growth of knowledge in human history, we know more about what we do, and less about who we are" (Nicolescu, 2009, p. 13) [10]. So our challenge is to work for self-knowledge, especially with the threat of spiritual destruction of the species by "the relentless logic of utilitarianism" and "efficiency and effectiveness" that fosters distorted phase techno-science.

Transdisciplinarity culture is a prerequisite for a transformation of mentalities. The true spirit of transdisciplinarity goes beyond what is being done now. It not only seeks the unification of knowledge but self-transformation and a new lifestyle.

In the field of education, transdisciplinarity is called to play a central role, first to imagine the revolution of intelligence based on balance between analytic intelligence, feelings, and body. Thus, a new type of education should take into account all dimensions of human beings.

5. Results and Perspectives

This is what has been attempted for more than five years at the Universidad Veracruzana in Mexico with a project named "Eco-dialogue Station" and today has become a Centre for Dialogue of Knowledge and Sustainability. Basarab Nicolescu knew this project in situ, and he certified its viability.

The purpose is to promote the transition from the Universidad Veracruzana to responsible and sustainable forms of knowledge and learning and research processes. Subsequently, the Master of Transdisciplinary Studies for Sustainability set the objective of building and ownership of a transdisciplinary approach to address real world

issues from creativity, affection, wisdom, and dialogue of knowledges, which have generated action-based research projects.

But the examples are multiplied in various parts of the world, from Africa to Romania, from Mexico to Brazil, from Bolivia to Costa Rica and Chile, among others. Therefore experience has taught us that "an important evolution, such as move from a disciplinary to transdisciplinarity logic can not be so sudden and total" (Galvani, 2007, p. 145) [5]. The transdisciplinarity approach should be implemented gradually and pragmatically. It is necessary to start with concrete situations and problems and analyze them from a transdisciplinary perspective.

Universities should encourage each student to develop a real and committed approach using multi-, inter-, and transdisciplinarity skills, enabling him or her to create in his/her professional life strategies to solve complex problems.

The University cannot fail to respond creatively to the demands of the labor market, social needs, and to one's own knowledge and new social relations. To better fulfill its mission, the University has to adapt to the cyber age, as Nicolescu described as a free zone (Nicolescu, 2009, p. 63) [10].

The University must have a permanent training program for teachers aimed at achieving the "Transdisciplinarity attitude," i.e. the cosmic and conscious verticality driving the transdisciplinarity approach. A new transdisciplinarity culture requires a change of reference system, a prerequisite for a transformation of mentalities:

1. Shift from the consideration of a problem as if it depended on a single level of Reality and place in the field simultaneously different levels of Reality;
2. Renounce finding a solution to a problem in terms of "true" and "false" of the binary logic. Also, the solution to a problem cannot be more than temporary reconciliation of opposites, re-likened at another level of Reality where contradictions are manifest;
3. Recognize the inherent complexity of the problem, namely the impossibility of decomposing the problem into simple, fundamental parts. Replacing the notion of "foundation" for consistency, in this multidimensional and multireferencial world.

The experience that I participated in the Veracruzana University confirmed the feasibility of Transdisciplinarity Research Workshops containing researchers from all disciplines. This refers to specific projects gradually introducing researchers and creators outside the University, including musicians, poets, and artists, working in different media and using new technologies with the aim of establishing academic dialogue between different cultural approaches, taking into account the inner experience and culture of the soul. This experience would broaden one's relationship with the world, with nature, and with others (Nicolescu, 1997) [11].

The University should be a space for discussion of the new university ethics. It requires rethinking ethics for universities from Latin America, an ethic that will not put the utilitarian or pragmatic principles ahead of social needs and human sentiments.

How can the University surmount the two large living pressures today, the hyper-privatized by merchandising of knowledge and the hyper-public that demands a much larger public space?

According to Boaventura, it depends on the country project. Neo-liberalism in Mexico devastated the idea of a national project (which does not mean "nationalistic"). The country needs to redo it and remake the University. In a circular process, the nation and University will be reinventing each other at the same time.

How can we establish active, ongoing, systematic, and meaningful relations with all that live, a relationship that allows us to reach the full mental, emotional, physical, and spiritual potential that we have? The poet Michel Camus with his vertical gaze could see that the Transdisciplinarity University will emerge from the Multidisciplinary University, being the basis of this inner experience, which he called the "agriculture de l'âme," which only lives in self-creation and self-transformation oriented toward self-knowledge by both, teachers and students, who also must be unified and not viewed separately. This is not a "science of education, but an art of living, to create, transform and be reborn together in another way" (Camus, 1997) [3].

It will be necessary to work on methods for awakening and recognizing the vertical levels of all kinds: perception, reality, complexity, nature and sense of language, silence, strength, and others. The spirit of inquiry cannot flourish otherwise. The University must re-introduce in all the domains of education dimensions of life and, as far as possible, of love. The University must meet the fundamental desires of the students: to enjoy physical and mental passion for research and pursue self-transformation.

Now that I have been away from the tendency to binary interpretation in a single level of Reality, I can not fail to recognize that establishing a link between thinking, doing, and feeling is necessary to learn simultaneously from different levels of Reality and go beyond that separation.

For this, I assert that for the University to become a multidimensional community requires a profound transformation toward transdisciplinarity, involving the ecologization and contextualization of knowledge.

The University should stand for, not against, what society demands. The University offerings should not be oriented to serve just a group of society, usually a minority, to the harm of a majority; hence the self-ethics and the communitarian ethic should be the basis of University education based in sustainable principles. This will achieve a genuine social transformation.

How can we reform the institution and not reform minds? And how can we reform minds without reforming the institution? There is no logical answer to this contradiction, Morin said, but life, he adds, "is capable of providing solutions to unsolvable problems logically" (Morin, 2011, p. 151) [8].

We must aspire to a University where effectivity and affectivity walk together, enabling human beings to manifest themselves in all their magnificence.

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5 On Models for Transdisciplinarity

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Abstract

In this chapter we discuss about transdisciplinarity, interdisciplinarity, pluridisciplinarity, and unification theories in mathematics. Some related duality extensions are also presented.

1. Introduction

The transdisciplinarity ([1,2]) is a new approach about disciplines and what is between disciplines, above them and beyond them. Its purpose is the understanding of the current world. For example, this chapter, written at a transdisciplinary level, abides somewhere between epistemology and abstract algebra, with implications in physics, topology, etc.

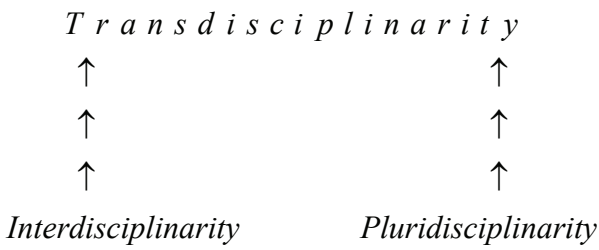
In abstract algebra, two diferent algebraic structures, which are dual concept, were unified at another level by [3]. This was posible by embedding them in the category of the Yang-Baxter structures. (Recasting some objects in another setting, in order solve certain problems is a nonstandard tehnique in mathematics.) The celebrated Yang-Baxter equation traverses statistical mechanics, theoretical physics ([4]), knot theory ([5]), quantum qroups ([6]), etc.

Similarly, one can view the transdisciplinarity as a unification for interdisciplinarity and pluridisciplinarity. Our analogy is based on the observation that interdisciplinarity appears at the border of two different disciplines, while in pluridisciplinarity we deal with several disciplines serving a certain discipline.

Consequently, the current chapter attemps to clarify the transdisciplinary terminology for the interested mathematicians, gives an informal introduction to the coalgebra theory and proposes the use of mathematical models in the development of the transdisciplinary thinking. The organization of the chapter is the following. In section 2 we detail our algebraic model for transdisciplinarity. The third section contains algebraic details about duality extensions and explanations.

2. An algebraic model

Let us consider the following diagram, which shows that the transdisciplinarity includes both the interdisciplinarity and pluridisciplinarity.



Let us detail this picture.

The interdisciplinarity generates new disciplines. For example, the transfer of the mathematical models in physics generated the mathematical physics. (For examples of interactions between mathematics and music, or between mathematics and lingvistics, we refer to [7].)

Let us use the mathematical formalism to describe this situation. For the disciplines

$$D_1 \text{ and } D_2$$

The interdisciplinarity associates a (new) discipline:

$$D_1 \text{ and } D_2$$

In mathematics, this is called an operation. An operation usually has a unity:

$$D \bullet 1 = 1 \bullet D = D \qquad \forall D$$

In our case, a unity is represented by an "empty disciple", a discipline which only contains the notions, symbols and formulas appearing in all disciplines.

The pluridisciplinarity refers to the study of an object from one discipline, using other disciplines. For example, a Giotto's picture can be studied from the perspective of art history, physics, chemistry, history of religions, history of Europe and geometry (cf. [1]).

Let us use the mathematical formalism to describe this situation. We consider one object from a discipline

$$O \in D$$

and take projections of it into other disciplines

$$o_i \in D_i \qquad \forall_i \in I.$$

In mathematics, this is called a co-operation or co-multiplication.

Now, the information processed by these new disciplines will be collected and help to evaluate the initial object. In mathematics, this role is played by the co-unity.

Back to Abstract Algebra, we consider the category of rings or, even better, algebras to represent the interdisciplinarity. (An algebra structure has a multiplication and a unity.) The category of coalgebras, or co-rings, could be used as a model for pluridisciplinarity. (A coalgebra has a comultiplication and a counity.)

Now, the question is if the category of algebra structures and the category of coalgebra structures can be seen as forming just one "bigger" category. This later category would play the role of the transdisciplinarity.

A unification for the categories of algebras and coalgebras was proposed in [8]. Moreover, in a special case, this unification is also an extension for the duality between algebras and coalgebras. This 'bigger' category is related to the celebrated Yang-Baxter equation. The following picture briefly explains this unification.

$$\begin{array}{ccc} Yang-Baxter\ \ structures & & \\ \uparrow & & \uparrow \\ \uparrow & & \uparrow \\ \uparrow & & \uparrow \\ Algebra\ structures & \longleftrightarrow & Coalgebra\ structures \end{array}$$

The final conclusions of this section are related to the interactions between mathematics and physics, which are not only described by the mathematical-physics, but are of a more complex nature: many problemes arising in physics helped the development of mathematics; on the other hand, by solving equations from physics, the mathematicians help the physicists, and sometimes anticipate their observations.

This kind of situations are suggested by the two diagrams of this section.

3. Algebraic details

This section is devoted to Abstact Algebra, and its purposes is to briefly explain to the reader the concepts used before and to give him a short bibliography.

For the algebraic aspects of the Yang-Baxter equation, we recomand the book [9]. Algebras, coalgebras and their duality are studied in [10]. A more compact lecture on these topics could be [8] or, alternatively, [3] and [11].

The Pontryagin duality refers to the duality between the categories of compact Hausdorff Abelian groups and discrete Abelian groups. The Pontryagin-van Kampen duality theorem extends this duality to all locally compact Hausdorff Abelian groups (see [12]) and it also represents a unification for the two kinds of topological groups.

Taking the Pontryagin-van Kampen duality theorem as a model, we posed the following question: «Is it possible to extend the duality between finite dimensional alge-

bras and coalgebras in the same spirit?» We gave a positive answer by constructing the extension described in the previous section.

The constructions related to the extension of the duality between finite dimensional algebras and coalgebras have many applications: in noncommutative descent theory ([13]), in constructing large classes of Yang-Baxter operators([14]) and Yang-Baxter systems ([15]), in Knot Theory ([5]), in finding solutions for the colored Yang-Baxter equation ([16]), etc.

4. Conclusions

Algebras and coalgebras are different algebraic structures, and their axioms are dual to each other. While the algebras have multiplications, the coalgebras have another type of operations, called comultiplications. Therefore, the unification of these structures came as a surprise. This unification was possible by recasting these structures in the category of solutions for the Yang-Baxter equation. Thus, this equation captures the common information encapsulated in the associativity axiom and in the coassociativity axiom.

The interdisciplinarity associates a discipline for other two disciplines, and the pluridisciplinarity refers to the study of an object from one discipline, using other disciplines. The transdisciplinarity is a more general approach about disciplines. It includes the interdisciplinarity and pluridisciplinarity; the transdisciplinary thinking motivates the attempts of unifying theories, structures, disciplines, etc.

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6 A Transdisciplinary Understanding for Economic Risk Management

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Abstract

Starting from the assumption that transdisciplinary is becoming a fourth research method (alongside the empirical, interpretive and critical approaches), we believe it is the favorable context for analysis as well as for sustained attempts to understand sophisticated economy in a new conceptual framework placed at the forefront of knowledge. As a matter of fact, in accordance with the „Charter of Transdisciplinary" (Freitas & Morin & Nicolescu, Convento da Arrábida, 1994), from which we quote Article 12: „The development of a transdisciplinary economy is based on the postulate that the economy must serve the human being and not the reverse", we will focus on several categories specific for the economic risk, such as enterprise risk management, financial risk. In an attempt to systematize this approach, we searched to identify in the academic literature similar concerns and formulate some theoretical pillars on which to establish the transdisciplinary understanding and behavior concerning the existence of risks with economic particularity.

1. Introduction

Risk and uncertainty are pervasive and central determinants of economic progress and well-being. They influence microeconomic decisions, as well as the final analysis and synthesis of macroeconomic performance. Risks even derive from cognitive limits of economic agents and their interaction. Furthermore, modern economies also use markets to price and business risk, so that quantitative analysis of these risks is more

important than ever. A deeper understanding of the nature of the economic risk is therefore essential to improve and manage the economic situation of companies, families and nations. Growing and extending our understanding of economic risk is the central objective of this research, which aims to be a part of the interdisciplinary and transdisciplinary future development for applied economics (through social banking), statistics, mathematics and welfare. Ultimately, the objective of our research is to improve the decision-making capabilities of both public and private institutions by reducing economic risks and better exploiting economic opportunities. Furthermore, the research aim is to expand a theoretical and methodological framework for the enhancement of decision-making in the area of risk management according a transdisciplinary attitude with the perspective of improving the quality of economic life for the individuals of society. From a similar „people first" transdisciplinary perspective, in the future there could be developed some projects in applying the success conditions of squaring problems with people, cross-applying methods and tracing knowledge dynamics.

According to Nicolescu „transdisciplinarity is a relatively young approach: it emerged seven centuries later than disciplinarity, due to the Swiss philosopher and psychologist Jean Piaget (1896-1980). The word itself first appeared in France, in 1970, in the talks of Jean Piaget, Erich Jantsch and André Lichnerowicz, at the international workshop Interdisciplinarity –Teaching and Research Problems in Universities, organized by the Organization for Economic Co-operation and Development (OECD), in collaboration with the French Ministry of National Education and University of Nice" (Nicolescu, 2007). Research and concerns are continuous in the areas of sustainability, risk perception, risk aversion and risk acceptance criteria and in accordance with the „Charter of Transdisciplinary" (Freitas & Morin & Nicolescu, Convento da Arrábida, 1994), from which we quote Article 12: „The development of a transdisciplinary economy is based on the postulate that the economy must serve the human being and not the reverse." Although the project is focusing on the specific of enterprise risk management area, the developed approaches will be generic and transcultural. The conceptual framework of the knowledge universe about enterprise risk management, promoted for this proposal, is based on (1) studying the research activities of renowned scientists for contributions in transdisciplinary (Jantsch, 1972 as cited in Apostel & al.; Lichnerowicz, 1972 as cited in Apostel & al.; Piaget, 1972 as cited in Léo Apostel & al.; Nicolescu, 2008) and (2) on the review of several key documents that were identified in a comprehensive review of the literature. The methods for review can be described as follows. We shall continue and use a study design of descriptive qualitative content analysis based on literature review related to the project mentioned topic areas: financial risk, operational risk, enterprise risk management. Electronic sources searches were performed using also „multidisciplinary", „interdisciplinary", „transdisciplinary" and „definition" as keywords to identify the pertinent online literature. The result may indicate that transdisciplinary attitude maintains theoretical and empirical linkages between studies of risk management and of regulatory processes. Furthermore, by developing interdisciplinary studies at the intersection of management, sociology, organization theory, economics, political science and law, we arrive at a transdisciplinary in risk management. Tiziano Raffaelli (2008) reconsiders the relationship between economics and physics and biology, even if not included and not identified as transdisciplinary (Raffaelli, 2008 as cited

in Shinoya & Nishizawa, 2008) in Marshall's seminal idea of the self-development of mental machine, developed in his earlier studies in psychology and neurophysiology. The core of his vision consists of economic and social evolution as the gradual absorption of novelties in an increasingly complex structure through successive phases of standardization and specialization.

A transdisciplinary approach consists in finding a way to integrate the various disciplines (e.g. physics and biology) into economics to understand the risks to a complex economic world as an integrated system (Barkley, Jr. 2009; Beker, 2011). Economic risk assessment limits without global regulations allow the exacerbation of global systemic risks including transdisciplinary feed on money raised from anywhere in the world. It has represented a failure of the collective imagination of many bright people the way of preventing stability from creating future vulnerability. It will require rethinking a great deal about economics and the way global economic risks operate in an unconventional approach to risk management. The globalization of the economy and the risks that are originated in the development based on the sophistication and the innovation of financial services coming from financial institutions are based on the technology of informatics (which is likely to create irreversible gaps and unforeseeable risks) which also has the ability to understand the economic environment, to act effectively and in line with the biodiversity of financial services. In addition, it made material resources seem limited in relation to the creative imagination applied in the banking environment. These are the most important reasons and the global market is now pressing banks to take more risks far-reaching global seemingly unpredictable and independent, and banking system, facing in the first line with the economic risks, is responding through a regulated, uniform behavior. Systemic transdisciplinarity cooperation will be necessary, in which the pillar 3 of Basel - banks should establish a coherent disclosure and communication strategy around risk management – could be insufficient. It is expected to extend towards the global economic environment outside the banks and completion of the Basel agreements on the adequacy of risk of the social dimension and ethics by which profits to generate streams transdisciplinary.

2. Transdisciplinary Axiomatic for Risk Management

The question of the risks is more and more extended to the whole of the risks incurred by a population, territory, business concern with a master's or overall management (it is undertaken with a concern of control or integrated risk management). It is the merit of systemic and singularity of risk analysis to have clarified this situation and its complexity. It is also in particular operational limit. A certain level of systemic complexity is not controllable by systems but by the communities concerned. It is there the socio-performance intervenes to build the conditions and their achievements.

We must recognize the nature of the economic literature consistent from one epistemological initial risk. The idea is that risk and uncertainty is concerning the unknown, but that risk is an attempt to control misunderstood by applying knowledge-based world order. Uncertainty, on the other hand, represents the entirely unknown fortuitous and therefore it cannot be controlled or predicted (Althaus, C.E., 2005).

2.1 Fields of Complexity in Risk Management

First of all the multiplicity of the types of risks appears. In all cases this concerns people physically and morally, individual property and collective human communities and their issues. It also comes with temporal moments of different apprehension. There is speculation, an early confrontation with threats and events imaginable risks, which involves the emotions and imagination. There is the moment of crisis with safeguard issues, responsiveness, resources and specific skills. There is the restoring time, resilience, material and human reconstruction. Finally, there is the time of integration with memory and its complex processes, lessons, skills progression, the evolution of means and methods and decision-making. It will be noted that the initial speculation will be nourished from this final capitalization, until changing the course of the things. Everybody is often focused on one of these moments and even one of its phases, multiplied by the various sets of themes, generates a large number of specialties.

Let us add that the crossing between the risks is a dimension to be considered. On the imaginary and emotional level, the memory crosses the fields and a test resounds on all the later speculations. Fear, worry, anxiety are major parameters of the experience, interpretation, anticipation, evaluation, and even behavior, reasoning, postures and arrangements. In the same way, the material effects are linked only by the economic plan. Intellectual models tend to become widespread and thus to transpose the solutions but also the analysis of the problems; finally it is always in the sphere of collective or community human affairs that different risk areas will interbreed in relation to common issues and even every apprehension and individual practices necessarily taken in the collective life cultural context. Let us consider community question of socio-performance for example. How get out established consistency in the scientific and operational approaches while many experiments appear to be legitimate despite patent misunderstandings, which appear each time. The multiplicity of issues, areas, circumstances led to an indefinite fragmentation that finds its consistency into a transdisciplinary unit that includes the diversity of situations and their apprehension. This is probably the condition of the capitalization of knowledge, skills and control situations. But this is the way the risk analysis born a systemic vision with the methodological humanism and there is no question here of a comparative critical analysis which would notably make sure at what stage of the systemic design the risk management arrived, with the experience of its founder on human things. It will just provide an overview of the issue through three analyses: the epistemological analysis of the risk superior judgment and practical action to improve resilience to adversity and improve agility to seize opportunity (Funston & Wagner, 2010); structural analysis of the experience and human situations; proficiency levels and failure situations. Those allow to link risks to more general issues-related aspects in which they fit.

The above definitions of complexity from risk management are important because they give us a way to complete many different strains of modern economy in a single unifying concern - including the meaning of complexity and biodiversity of economic

transdisciplinary risks. Acceptance of the economic profession they have to perform, with the fact that the economy is complex, signals openness to new ideas for economy, and other disciplines will be a complex transdisciplinary field. The work done - falling into this broad approach to complexity – includes: (a) economists, sociologists and anthropologists facing from biological contexts are redefining by the mathematical theory of games the way that institutions are integrated into the analysis; (b) ecological economics is redefining how nature and economy are seen as interrelating in a transdisciplinary formulation; (c) psychological economics is redefining how rationality is treated; (d) econometric work dealing with the limitations of classical statistics is redefining how economists think of empirical proof; (e) the complexity theory is offering a way of redefining how we conceive general equilibrium; (f) agent-based computational economic (ACE) analysis is providing an alternative to analytic modeling; (g) computer simulations are offering a way to redefine models and how they are used; (h) experimental economics is changing the way economists think about empirical work (Holt et al., 2010).

Our discussion is regarding the research that involves more than one discipline. Multidisciplinary is somehow probably the oldest term. It is usually applied to situations where persons representing different disciplines get together and contribute ideas from their separate disciplines in ways that maintain the distinct identities of their disciplines, as in separate chapters within a book. Interdisciplinary as a more recent term was used as involving a greater integration of the ideas of different disciplines. Following the lead of the literature, we favor the term transdisciplinary to describe the new developments in the cutting edge, which implies a more thoroughgoing and profound interaction between the disciplines leading to some kind of new synthesis and transcendence (Colander et al., 2011).

Based on the new complexity, economics also becomes increasingly a transdisciplinary economics; in this area, there could be much to gain from financing research in agent-based models of the macroeconomics with three interrelated goals. Using the insights gained from agent-based models it is possible to develop an analytical model of a decentralized market system, and apply it in a way that includes a sophisticated, highly articulated financial sector. Second, predicting economic fluctuations by using large-scale agent-based models. Third, the ability - defined as risk intelligence - to distinguish effectively between two types of risks: the risks that must be avoided to survive by preventing loss or harm; and the risks that must be taken in order to gain some competitive advantages. Risk intelligence means the ability to transform these insights into superior transdisciplinary reasoning and into practical action, to improve resilience to adversity and to improve ability to seize opportunities.

It will involve collaboration between economists and computer programmers: economists funded in this area should be thoroughly capable of writing such agent-based programs at a professional level and supervising the work of programmers not trained in economic theory (Gintis, 2010). Modern economy including risk management is now much more willing to accept it; it seems that the formal part of the economy has

limited applicability, at least as currently developed and therefore it is difficult to integrate the methods of other disciplines into their methods.

2.2 Epistemological Limits of Risk Between Considered to be Taken or Void

Four directions mark out an epistemological compass as many postures of knowledge with their presupposed and their own logic. The risks are the result of threats existence, the potential violence with which different attitudes are possible: suffer them, dominate them. All occurs as if they were an otherness of the threat, source of deterioration, an opposite enemy to defend from. The risks are the possibility of a malfunction, of the intervention of a hazard into a system. The failure of a control loop can produce chain dysfunctions. There is also a need of strengthening the control systems and anticipating hazards. There is, of course, a possible competition between the complexity of the control system and the controlled system. The ideal is to establish a self-learning loop control system and to avoid the human error, which never captures the complexity with a perfect safety. These two logical approaches share certain fatalism about the risk origin. The risks are those disorders involved in a project. They show a limit in the control of operational procedures and streamlining of intervening factors. Disorders could be avoided if one would enact rules allowing the anticipation of the imponderable ones and that one would improve the means and competences of situation rationalization. The two previous logics easily take actors to factors more than humans. The risks are the translation of the imperfection of the human condition. They invite us to cultivate coping skills related to the issues involved. Collective intelligence and collective responsibility are the result of a confrontation at risk, its hypothesis and experience. The risk assessment is based on the value of the issues themselves reflecting community values and the common good. This is the area of social performance. The two preceding logics make relative the risk with stakes and their level of control. The last and the first personalize the risk and the reactions with respect to its occurrence.

To each epistemological position (Althaus, C.E., 2005) we can associate both modes of knowledge in force in the scientific universe, joining major issues of our time where the report to the world and the realities are in question, including the replacement of what is human in the trial of knowledge such as subject, object and project.

3. A transdisciplinary Perspective in Microeconomic Risk Management

Starting from an analysis of the significances of the risk management and financial field, we will wonder about convergences and specificities of these various disciplines for tending towards an integrated system of control approaches by the conciliatory processes efficiency, effectiveness, safety, solvency, profitability in the organization. After

a short presentation of the issue of risk in the enterprise, we develop how to handle it through an instrument built on four levels: planning, management, simulation, self-monitoring on a daily basis. Finally, we highlight the importance of the actors in the risk management by a change in the specialists approach towards the development of self-control in the business to better understand the risks.

During the last decade, other approaches different from the transdisciplinarity were developed and described by several eminent researchers and teachers. Starting from the meaning that includes a collaborative process of a new way of organized knowledge generation and integration by crossing disciplinary boundaries for designing and improving solutions to unstructured problems, one can easily see that „phrases of collaboration, shared knowledge, unity of knowledge, distributed knowledge, common knowledge, and integration of knowledge, integrated disciplines, beyond discipline, complex problems, and societal fields" are the major convergences (Ertas, 2010). Even if a precise definition of the transdisciplinarity is debatable, the current definitions and expressions can be defined as follows. Transdisciplinary Knowledge is a shared, common set of information from diverse disciplinary knowledge cultures (engineering, natural science, social science and humanities). Transdisciplinary Knowledge Integration is a social process, which only works if the participants are open to share and discuss their different perspectives. From this point of view we intend to explore – now and in the near future - how - from an economic perspective - transdisciplinary knowledge integration can be facilitated in the context of integrated assessments (IAs) and vulnerability risk assessments (RAs) of enterprise management. Even though knowledge from a wide range of social science and economic disciplines must be integrated in some transdisciplinary assessments (TAs), the actual process of integration is rarely addressed explicitly and methodically. Knowledge integration is conceptualized into the two subsequent phases of the elaboration of a shared language and the design of a methodology. Three devices for facilitating knowledge integration are put forward: (a) semantic ascent or the shift from speaking in a language to speaking in a meta-language about the former, (b) formalization or the translation of statements made in ordinary or technical language into a formal language, and (c) knowledge integration methods, which are methods that provide a meta-language for speaking about the knowledge to be integrated and organize the process of integration. Transdisciplinary assessments (TAs) address problems that cannot be solved by a single scientific discipline, or by science alone. People from different disciplines and from outside of science all possess unique knowledge about distinct aspects of the problem and need to collaborate to design and implement effective solutions. Integrated assessment (IA) and risk assessment (RA) are two variants of TA which are prominent in the context of problems associated with financial crisis and a transdisciplinary approach to sovereign debt (Pilkington, 2011) such as how to mitigate financial risk components and how to disconnect mathematical incentives from excessively stimulating leverage as to optimize investment performance. The transdisciplinary way of problem solving in the wider sense is labeled frequently as assessment instead of research. The term 'research' is reserved for the intra-scientific practice of problem solving whereas the term 'assessment' refers to the joint problem solving amongst science and other stakeholders (Hinkel, 2007). The Transdisciplinary Research Process can be understood as collaboration among specialists from various disciplines to develop and use integrated conceptual frameworks, tools, techniques and methodolo-

gies to solve problems without a common structure research. Transdisciplinary research leads to the creation of new patterns and provides pathways to new frontiers.

3.1 Enterprise Risk Management – A Transdisciplinary Framework

The risk can be defined as a damaging situation related to the daily activity of the enterprise whose occurrence is uncertain and with detrimental impact to the company or its stakeholders. The risk is inherent in any action, in any economic involvement. From a discipline to another, there is a specific meaning of the risk. However, similarities also exist for the integration of different control approaches for a more comprehensive risk management. Thus, the management activity covers three sets of actions necessarily integrated: to choose the objectives, for the company or a subset of it; to determine and arrange the means to implement and to achieve these goals; to place the tools for assessing the methods used and actual results. That is to say that the management control must ensure that the actions have been undertaken economically (available resources at least cost), efficient (use of the means available in the most productive manner without waste) or effective (movement towards the goals of the organization).

Earlier managers were seeking to control the operation of their business by imposing centralized systems. Control was mainly focused on results and supplemented by procedures controls. The internal control function was designed to ensure the protection of the heritage of the company, the reliability of the accounting records and annual accounts.

Then, in the seventies, the black box was changed. The multiple causes behind this crisis are well known: the end of the post-war shocks on commodity markets, development of international trade and competition, financial market development. Moving from curative to preventive, organizing the change, standing up to competition, recreating a human environment conducive to performance, restoring public confidence in the operation and the management of the companies: these are the tasks facing those responsible for control in and over the company. In order to provide a common vision to participants for what control means in the company, for its objectives, its multiple dimensions and levels involved, there is a need for designing an organization framework. It is at the elaboration of a referential that (at the end of the ‘80) the American practitioners of management control of corporate finance, internal audit, the external audit were involved together with corporate law and specialist teachers in these areas. When defining internal control we describe any systematic measures (such as reviews, checks and balances, methods and procedures) taken by an organization to enhance adherence to its policies and plans by managing the significant risks, having regard, in particular, to any significant failings or weaknesses that have been reported.

The definition of internal control has evolved over recent years as different internal control models have been developed. In the United States many organizations have adopted the internal control concepts presented in the report of the Committee of Sponsoring Organizations of the Treadway Commission (COSO). The COSO reports describe internal control as consisting of five essential components. These components, which are sub-divided into seventeen factors, include: (1) control environment; (2) risk assessment; (3) control activities; (4) information and communication; (5) monitoring. The COSO model is depicted as a pyramid, with control environment forming the base

for control activities, risk assessment, and monitoring. Information and communication link the different levels of the pyramid (SARBANES-OXLEY SECTION 404, 2008 & COSO, 2011). As the base of the pyramid, the control environment is arguably the most important component because it sets the tone for the organization. The factors of the control environment include employees' integrity, the organization's commitment to competence, management's philosophy and operating style, and the attention and direction of the board of directors and its audit committee. The control environment provides discipline and structure for the other components. Risk assessment refers to the identification, analysis and management of uncertainty the organization is facing with. Risk assessment focuses on the uncertainties in meeting the organization's financial, compliance and operational objectives. Changes in personnel, new product lines or rapid expansion could affect an organization's risks. Control activities include the policies and procedures maintained by an organization to address risk-prone areas. An example of a control activity is a policy requiring approval by the board of directors for all purchases exceeding a predetermined amount. Control activities were once considered to be the most important element of internal control, but COSO suggests that the control environment is more critical since the control environment fosters the best actions, while control activities provide safeguards to prevent wrong actions from occurring. Information and communication encompass the identification, capture and exchange of financial, operational and compliance information in a timely manner. People within an organization with timely, reliable information are more able to conduct, manage and control the organization's operations. Monitoring refers to the assessment of the quality of internal control. Monitoring activities provide information about potential and actual breakdowns in a control system that could make it difficult for an organization to accomplish its goals. Informal monitoring activities might include management's checking with subordinates to see if objectives are being met. A more formal monitoring activity would be an assessment of the internal control system by the organization's internal auditors.

3.1.1 The Financial Risk

The economical characteristic of the transdisciplinary model for risk management – in our point of view - is that it is characterized by a consumer-oriented view. In this view of evaluation is often referred to as a consumer-oriented, consumer-based or needs-based evaluation, even if they differ slightly in their meanings. In the transdisciplinary view, evaluation affords the consumers the primacy in evaluation and therefore the main function of evaluation is the determination of the merit or worth (or value) of a risk management framework or risk assessment framework in terms of how effectively and efficiently they are serving those affected, particularly those receiving, or who should be receiving the services provided and those who pay for consequences. The characteristic of the transdisciplinary model (similar to statistics, ethics and logic) is that evaluation is a discipline that can be characterized by the study and improvement of certain tools (e.g., methods) for application between and within other disciplines (Coryn & Hattie, 2006). The disciplinary characteristic of the transdisciplinary view of evaluation can be separated into three components: disciplines (e.g., social sciences, economy); fields of evaluation (i.e., types of risks, performance, portfolio); and fields of application (e.g., banking, health, audit, enterprises financial activities, services).

Graphically, the conceptual transdisciplinary model based on some disciplinary elements can be represented by spatial planes in three dimensions. In this model, each plane represents the three disciplinary components. The rear plane on the x and y axes represents the disciplines, the vertical plane on the y and z axes represents the fields of evaluation, and the horizontal plane on the x and z axes represents the fields of application. Any particular risk model (for evaluation) can then be located as a point or volume (e.g., a cube) in a three-dimensional space (Coryn & Hattie, 2006). Before a transdisciplinary view on evaluation, economics was represented in a two-dimensional space, where firms are located on a plane at co-ordinates based upon their position with respect to two strategic dimensions, with clustering of firms indicating the strategic groups within the industry. This representation of strategic dimensions is very widely used, as it enables an easy understanding of the strategic positioning of firms and therefore it is particularly successful as a didactic tool. Later research into strategic groups extended the two dimensional model to use multiple strategic variables (Robertson, 2003). Whilst the positioning of firms using two strategic dimensions can be accomplished by representing the positioning on a plane, and whilst the positioning of firms using three strategic dimensions can be accomplished by representing the position of the firms within a cube, problems occur when one tries to represent firms in a space with more than three strategic dimensions. However, higher dimensional space can be represented by using the mathematical notion of a hypercube: the analogue in a space of four or more dimensions of [a cube above] in ordinary three-dimensional space (Robertson, 2003). We can therefore represent n-dimensional risk strategy space by using an n-dimensional hypercube. Thus, the location and movement within the n-dimensional hypercube can represent a firm's risk management strategy.

Financial risk is a key variable to enterprise risk management that not only leads to business failure but also brings about associated enterprise's financial crisis. The exploration of the expansion law of financial risk is an important part for an enterprise to improve its risk management ability. The expansion of financial risk has a cyclical direction, strength and coupling features. The constituent elements of financial risk expansion include the source of financial risk, financial risk motivation, financial risk vehicle, financial risk pathway and financial risk expansion threshold. From inside of an enterprise, financial risk expansion is mainly following the space-time theory with some direction and intensity. Enterprise's three-dimensional financial risks reflect macro, medium and micro levels, with expansion in time and succession in space. Financial environment-adaptation risk (FER), financial resource-allocation risk (FRR) and financial stakeholder-cooperation risk (FSR) constitute the three transdisciplinary dimensions of financial risks of enterprise. We need to build three matrix identification models, which are the FER identification model, FRR identification model and FSR identification model. FER identification model uses „Financial environment adaptation rate" as its horizontal axis and „Value creation rate of investment capital" as its vertical axis. It reflects the two-dimensional relationship between value creation capability and environmental adaptability. FRR identification model uses „Financial resources optimization rate" as its horizontal axis and „Free cash flow rate of investment capital" as its vertical axis. It reflects the two-dimensional relationship between cash support ability and resource allocation capability. FSR identification model uses „Financial interests' synergy rate"

as its horizontal axis and „Cash value added rate of capital investment" as its vertical axis. It reflects the two-dimensional relationship between cash added ability and interest coordination capability (Feng, 2011). To identify three-dimensional financial risks of enterprise an analytical index system must be mapped (See Tab. 1).

Table 1. Analytical Matrix.

Index name	FER variables	FRR variables	FSR variables
Market environment adaptation degree	V_1	-	
Investment environment adaptation degree	V_2	-	
Financing environment adaptation degree	V_3	-	
Value creation rate of investment capital	V_4	-	
Cash cycle dominance degree	-	V_5	
Cash deferred payment dominance degree	-	V_6	
Free cash flow rate of investment capital	-	V_7	
Capital synergy satisfaction degree	-	-	V_8
Customer synergy satisfaction degree	-	-	V_9
Employee synergy satisfaction degree	-	-	V_{10}
Supplier synergy satisfaction degree	-	-	V_{11}
Cash value added rate of capital investment	-	-	V_{12}

Calculation of FER identification matrix adopts the following formula:

$$x_1 = \left(\Pi_{i=1}^{3} v_i\right)^{1/3} - 1$$
$$y_1 = v_4 \tag{1}$$

Calculation of FRR identification matrix adopts the following formula:

$$x_2 = \left(\Pi_{i=5}^{6} v_i\right)^{1/2} - 1$$
$$y_2 = v_7 \tag{2}$$

Calculation of FSR identification matrix adopts the following formula:

$$x_3 = \left(\Pi_{i=8}^{11} v_i\right)^{1/4} - 1$$
$$y_3 = v_{12} \tag{3}$$

Suppose the sample number of enterprise is n in an economic environment, which means the domain is $U = \{u_1, u_2, L, u_n\}$. If the calculated data matrix of X and Y of every matrix are the following

$$\begin{bmatrix} X_{11} & X_{12} & X_{1n} \\ X_{21} & X_{22} & X_{2n} \\ X_{31} & X_{32} & X_{3n} \end{bmatrix} \quad \text{and} \quad \begin{bmatrix} Y_{11} & Y_{12} & Y_{1n} \\ Y_{21} & Y_{22} & Y_{2n} \\ Y_{31} & Y_{32} & Y_{3n} \end{bmatrix}$$

Then we sort the data from small to big according to the row of the data matrix and we get:

$$\begin{bmatrix} X_{11} & X_{12} & X_{1n} \\ X_{21} & X_{22} & X_{2n} \\ X_{31} & X_{32} & X_{3n} \end{bmatrix} \quad \text{and} \quad \begin{bmatrix} Y_{11} & Y_{12} & Y_{1n} \\ Y_{21} & Y_{22} & Y_{2n} \\ Y_{31} & Y_{32} & Y_{3n} \end{bmatrix}$$

Then, the thresholds of X and Y axis in every matrix can be obtained from the following formulas:

$$X_{i-} = \frac{1}{k}\sum_{j=1}^{k} X_{ij} \qquad \text{for} \quad X_{ij} < 0, \tag{4}$$

$$X_{i+} = \frac{1}{n-k}\sum_{j=k+1}^{n} X_{ij} \qquad \text{for} \quad X_{ij} > 0, \tag{5}$$

$$Y_{i-} = \frac{1}{k}\sum_{j=1}^{k} Y_{ij} \qquad \text{for} \quad Y_{ij} < 0, \tag{6}$$

$$Y_{i+} = \frac{1}{n-k}\sum_{j=k+1}^{n} Y_{ij} \qquad \text{for} \quad Y_{ij} > 0, \tag{7}$$

where: X_i+, X_{i-}, Y_{i+} *and* Y_{i-} are thresholds of X and Y axis, k is the number of negative, $n - k$ is the number of positive, i represents risk dimensions, $i = 1, 2, 3$ (Feng, 2011).

3.1.2 Transdisciplinary Knowledge Integration on Enterprise Risk Management

The next step concerns the compliance of the organization - how to reconcile the required efficiency, effectiveness, safety and solvency in a transdisciplinary approach. There should be understood the areas and significant systems of risk and the latter, the

financial information flowing. These flows are taken into account for the initialization of the operations that are an expression in financial terms, to their translation in the accounts. The apprehension and understanding of these flows determine the nature and extent of their controls. This dynamic approach by flows induced an approach to control by activity and activities by the various functions that contribute to their achievement. Such an approach is usually recommended by the states company of the auditors as regards control. The analysis process, that is to say the sequence of tasks, activities or operations performed by different entities (services, departments) with resources (human, equipment, materials, procedures, information) in dealing with business objects (information, contracts, records, orders, invoices, inventories, regulations) to outputs (services or products) allows for a comprehensive approach to risk in both angles of management, legal and financial. So what are the similarities – it is specific to say - to the convergence characteristics or elements that the disciplines of management, financial or legal, share (universal character) that can identify overlaps and synergies (resulting from an inherent transdisciplinary view) for specific characteristics or elements of each discipline and that bring a wealth complementarity in their group? Why the efforts of these various disciplines are in most cases implemented in isolation without real coordination? Can it be integrated into an overall system of control? It means to differentiate multidisciplinary by transdisciplinary. The simplest form of collaboration between disciplines has been called multidisciplinary where an issue is regarded from the perspectives of various disciplines, but each discipline produces its own results. Multidisciplinary research is essentially additive not integrative. A more sophisticated form of collaboration is the interdisciplinary research, in which a common problem is solved jointly by different disciplines; knowledge from several disciplines is not simply added up but integrated. Interdisciplinary research produces one common result, rather than segregated disciplinary perspectives. Above all, the collaboration that at the same time (not only integrates disciplinary knowledge) aims at transcending disciplinary boundaries, has been called transdisciplinary research (Hinkel, 2007).

3.1.3 Transdisciplinary Assessments on Risk Control System

We can identify three convergence criteria for the four control functions: independence, lack of decision-making, contingency generic. For other criteria, the summary is as follows. The functional field is covered by all the activities of the company (operational and functional) for management control, internal control and quality, different from the financial analysis for the perimeter, which is more restrictive (high resource-consuming activities including financial ...). The functions of financial analysis, internal control and quality are subjected to external audit (inspection, self-control device, statutory audit, certification ...); it is rarely the case for management control. If the financial analysis and internal control can be considered as functions regulated nature (technical professional standards, ethics, responsibility ..), the character is relaxed to prescribed quality standards (professional technical, safety, ..) and more to management

control (mainly technical professional standards, ...). As for cutting short-term / long-term analysis, we find that the functions for financial analysis and management control and time control assessment follow a continuous process for the functions of quality and internal control. The financial analysis and internal controls are involved from time to time, upon request, intermittently while the control and quality management functions are more rooted in the company with periodic and recurrent interventions. Management control and quality of feed management accounting information as the internal control and financial analysis derive their raw material from financial accounting. The nature of information is mainly quality and quantitative for the quality, quantitative and financial for the management check, financial for the financial analysis and the three at once for the internal check. Users or recipients of the control functions are external for financial analysis (shareholders, bankers, tax), internal (players in the organization) for the management audit function; for the quality and internal control they are both internal (players in the organization) and external (third party or client). As for the preferred values of each control function: productivity, efficiency in management audit, reliability, compliance, integrity, sincerity, security for the internal control solvency, liquidity, profitability, profitability for financial analysis, compliance, satisfaction, expectations and certification for the quality, they unite around the three key variables of control: cost, performance and risk. It is then the approach control under the angle of measurement or the evaluation in order to apprehend these key-variables of costs, performances and risks. For each key-variable, one must define the criteria to deduce their characteristics or properties. One must also measure or evaluate some of their impacts, i.e. the effects discounted on the activity. Finally, one must follow their evolution in time using indicators. The risk and performance, measurement or costing conveyed by the functions of management audit, financial analysis, internal control and quality lead to an integrated system of approaches of control.

4. Conclusion

Risk management, even when it applies, as explained, has been the constant object of change and revision, which is not unusual in a matter of such dynamic and permanent evolution. This explains how an eminently single-hazard vision has seen the convenience of migrating toward a multiple-hazard approach. This greater complexity is compensated by the integral nature that it takes on when dealing with different conditions of risk within a single political, economic and social reality, thereby allowing for the identification of generalities and particularities, common and divergent areas, and interest groups with differing needs and expectations. In few words, integral risk management includes a systemic vision, coherency in policies and decisions and rationality in the use of resources. Considering everything expressed until now, it seems redundant to affirm the need to approach this complex matter of risk management from the multidisciplinary, interdisciplinary and ideally, transdisciplinary point of view. A multidisciplinary focus comprises a way of approaching a process concentrated on the treatment

of one or several issues from the perspective or view of one discipline, yet including the contents or contributions of the others. According to Piaget, this constitutes the lowest level of integration. An interdisciplinary focus means that two or more disciplines or forms of knowledge are combined or coordinated at conceptual level to see their interrelationships and/or to explain an object or problem. A transdisciplinary focus deals not with a single discipline, but rather with a field of knowledge. This focus allows for the interaction of different disciplines to develop a common perspective, while conserving the riches and power of their respective areas of knowledge. The complexity and interdependence of topics that fall under the so-called risk management heading require an equally complex approach. Some of the most relevant include development, economic development, culture, poverty, vulnerability, environment, risk, resilience, marginalization, governance, and democracy, to mention only a few of them. Although it is undeniable that leadership in economic and banking risk management matters requires disciplines such as economy designing methodologies in its multiple anticipative facets, financial synergies, financial engineering, economy and public health, the contribution of the sciences, such as transdisciplinary jurionomics, mathematics, econometrics, computational statistics, cybernetics, anticipative systems, econophysics and computer science, are of undeniable value. Still other disciplines such as sociology, anthropology, health and political sciences and many others make a potentially enormous contribution around this interdisciplinary approach. When mentioning interdisciplinary and transdisciplinary approaches, we cannot fail to consider two, in particular, which mark clear tendencies in the changing world situation: the sectorial and organizational aspects. Sectorial factors are understood to be the interaction of institutional groups, recognized for their representation in areas of economic and social development, education, governance and similar considerations. Organizational considerations refer to the administrative structures, from the centralized level, through the organizations on the operational base, including the intermediate structures of different denominations, such as profit centers, branches or departments, or units indistinctly referred to as local network or mobile units. Sectorial and territorial aspects interact and illustrate how a matrix of multiple inputs is able to generate multiple results. Risk management integrates this matrix as a transversal element, present in practically all situations, adding a related factor of complexity to the mix, but distributing the load among the components of the process.

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7 An Essay in the Philosophy of Transdisciplinarity (the "Bioethics" as a Casus)

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Abstract

The current situation in philosophy is characterized, practically unanimously, as a crisis of scientific rationalism. This crisis frightened and continues to frighten some researchers with its possible negative consequences for modern culture as a whole. Others are enchanted and interested. For our part we believe that the unfolding historical situation is where the formation of new opportunities for philosophy and science takes place. Moreover, these new opportunities are discerned most easily when there occurs a meeting of philosophy, on the one hand, and other types of scientific reason (as represented in natural sciences and the humanities), while, on the other, that of philosophy and the extra-scientific forms of rational experience (religious, esoteric, everyday, etc.).

The peculiarity of the current meeting between philosophy and the other forms of rational assimilation of reality consists in that it takes place in the context of transdisciplinarity. Lying at its base are impulses directed at finding solutions to the ecological, energy, information and demographic problems, as well as the problem of health, and so on. This results in the formation of a new type of investigative activities. In the philosophy of science this new type of investigative activities is represented as "postneoclassical science" (Vyacheslav Stepin); in the sociology of science, as "type 2 science" (Michael Gibbons, Helga Nowotny, Peter Scott), postacademic science (John Ziman), "other modern" science (Ulrich Beck), etc. The production of scientific knowledge at

the modern stage is a hybrid of fundamental research oriented to the cognizing of truth and investigations that are pragmatically oriented to a useful effect.

In the classical knowledge production method, the value orientations are as it were implicit (like Merton's science ethos) and controlled by a system of intrascientific mechanisms. In the new one (expressed to the greatest extent in biology and medicine), there arises a reflection to these value orientations, which is realized via transdisciplinary (institutionalized both inside and outside of science) mechanisms for normative presentation of scientific practices. Active in these transdisciplinary interactions are (aside from natural scientists) representatives of the humanities and the public. Let me emphasize this: transdisciplinarity proves one of the vectors of a multidimensional transformation of science, which exceeds the boundaries of its classical self-identification. It is in this respect that transdisciplinarity is for us an object of philosophical discussion. While studying the phenomenon of transdisciplinarity, we will regularly turn to the "bioethics" as a casus.

1. Bioethics as a casus

Historically bioethics took shape as a search for answers to the most difficult moral and anthropological problems (sometimes balancing literally on the brink of life and death) generated by advances in biomedical technologies. Cloning, organ transplantation, euthanasia, gene therapy and eugenics, as well as many other occurrences in the recent history of the biomedical science make philosophers, doctors, biologists, lawyers, theologians and other experts look for solutions to crucial ethical and anthropological problems.

Rationalization and responsible decision-making in critical situations, first, cannot be based solely on expert findings coming from natural scientists (primarily doctors and biologists). Their cooperation with representatives of the humanities and the public is a vital necessity. Second, there is not a single philosophical, moral or religious doctrine which is able to suggest a system of universally recognized values or anthropological ideas to deal with the fast-growing number of conflicts and difficulties. Third, the public forum tends to become the sphere for decision-making, with bioethics itself proving a factor in the formation of a public space. Finally, fourth, the existential significance of upcoming problems predetermines valid decision-making in the "here and now" mode.

Thus, philosophers and other experts, while not renouncing their traditional posture as "side observers," actively co-participate in the acceptance of existentially important decisions. For example, we must decide, here and now, whether the embryo is human and thus protected by the precept, "Thou shalt not kill", or if the embryo is a conglomerate of cells which it is lawful to manipulate for scientific and medical purposes, such as isolation of stem cells to treat sick people. It is precisely in this existential situation that the eternal philosophical problem of the "human-being" requires a concrete solution. And the solution is possible only as a result of complex interactions between scientists representing different disciplines, politicians, theologians and members of the

public (who do not possess specialized disciplinary knowledge, and are, in a sense, "untrained").

The specificity of the situational rationalization and "here and now" decision-making finds its expression in "casuses" of bioethics, or single occurrences (like the discovery of the cloning technology or legitimization of the euthanasia)[1].

In the context of our reasoning, casus can be defined as an occurrence of a special type or real-life event, which provokes a variety of disciplinary and extradisciplinary responses, and simultaneously involves them in a certain joint action, literally acting as a common cause. The casus "plots" a certain concrete space of opportunities for those responses, though these are not something to be grasped by the mind and are precisely ones that really operate in person's lifeworld. Moreover, the concrete circumstances of an event and its position (place) in the sociocultural context are also included in the sphere of opportunities.

To be sure, not each event in biomedicine can rank as a casus. It is necessary that a life-event contain an impulse, provoking a need for rationalization and for movement beyond the generally accepted and established view, both scientific and among the public. An occurrence must be paradoxical. It must hold within itself a quality of tragic "aporia" or "amechania," contain an imperative demand for scientific, philosophical, theological and other disciplinary rationalization aspiring to the status of universal. But the complexity of existential problems in bioethics is such that not a single disciplinary rationale can not pretend to sufficiency. Verity clashes with verity, good with good, truth with truth, the clash causing an aporia of reason that generates a paradoxical transgressing impulse to look for base and basing, but already in the communications sphere of the life-world, the sphere of the generally significant.

Thus, bioethics as a casus provokes the formulation of fundamental philosophical problems. How is it possible to conceive, not only a unity of diverse definitions of reality but also a variety of possible unities? How is a rational intercourse between reasons of a different type possible without them being generalized within a concrete disciplinary perspective (for example, within the framework of some specific philosophical doctrine)?How the paradoxical experience of transdisciplinarity is possible?

2. Transdisciplinarity: community in attunement

We will start by describing a specific existential attunement which paradoxically defines a fundamental community, "community in attunement." It is this community that can retain philosophical and disciplinary approaches which differ in their interpretation of reality, as well as individual and parochial preferences within the conventional framework of a unified investigative perspective. The community in attunement creates an opportunity (prerequisite) for intercourse without a preliminary theoretically (disciplinarily) selected basis.

The life dynamics of human communities is defined by the play of the dominant existential attunement that determines the orientation between the poles of threat and

rescue, one specific for each culture. The culture of the classical epoch and science are characterized by a linear orientation to the fight against danger embodied in outer nature. The salvation in this context is seen as a scientifically valid technical control over the natural factors. Modern culture preserves the existential vector of the classical epoch, but it is supplemented with a vector pointing the opposite way. At this stage, the threat to human existence is diagnosed as lurking not only in nature but also in the technological expansion and domination of the objective scientific type of rationality. In this case, salvation is believed to consist in the preservation or revival of humankind's original natural environment. Paradoxically, science emerges as a savior and as a source of existential threat at the same time.

Lying at the base of transdisciplinarity is a continuous repetition in the interplay of the moods of hope and fear, their paradoxical merger in a single human feeling that causes an existential aporia. People hope for a scientifically-based technological solution to their problems and yet fear technology, in which is seen both a savior and an ultimate threat. The boundary between what is one's own and someone else's, a stable one in the classical consciousness, is called into question. And it is the paradox of existential attunement that cements life into a specific integrity. "Such being attuned, in which we 'are' one way or another and which determines us through and through, lets us find ourselves among beings as a whole. The founding mode of attunement [die Befriedlichkeit der Stimmung] not only reveals beings as a whole in various ways, but this revealing—far from being merely incidental—is also the basic occurrence of our Dasein.[5]"

3. The main themes of transdisciplinarity

Let me say that the word theme is not accidental in this context. Our understanding of the genesis of knowledge in the life-world sphere are based on the ideas of Gerald Holton as presented in his book Thematic Origins of Scientific Thought: Kepler to Einstein. Holton's approach is of importance to us precisely in that he looks for the origins of science in the same place where the transdisciplinary experiment unfolds, to wit, in life-world structures. It is not accidental that he works, not only with scientific and philosophical texts but also with diaries, correspondence, interviews, laboratory logs, and general education curricula. Holton notes that the thematic structure of scientific activities can be regarded as mostly independent from the empirical and analytical content of investigations. It is displayed in the process of studying those opportunities for choice, which are basically open to a scientist [6]. Holton's thematization idea is labile enough to be able, on the one hand, to keep the inner complexity of the scientific experience and its formation, while, on the other, to express certain thematic repetitions in the development of both scientific and philosophical thought.

The modern type of paradoxical existential interplay, imposes on philosophy and science a repetition of a whole series of traditional themes (which we view as paradoxes)—power and vulnerability of the human mind, freedom and determination, part and whole, reductionism and holism, preformism and epigenesis, creationism and gradual-

ism, individual and social, natural and artificial, etc. Notice that these themes (paradoxes) open the way for the multiplying bioethical collisions. In the net of paradoxes that is being constantly woven we will single out three knots which are of most importance for the understanding of the transdisciplinary philosophy: the paradoxical relationship of one and many, philosophy and sophistry, as well as the transposition of philosophy.

4. One and Many

Heraclitus' polemos governs the polyphony of scientific and philosophical perspectives that come into being and are locked in a debate in bioethics. This kind of "polemical" interaction of diverse forces that are drawn into joint action may have an uncountable number of variations, ranging from an ideological feud to synergy motivated by the attainment of a mutually beneficial consensus. But in either case the "polemicists" feel the need for each other in order to become realized as their own selves. In a clash, they are "communicated" to each other, and they are in it together.

But if neither in teology, nor in reason, nor still in nature we assume a certain "eternal law" or a unity principle that is the same for everyone, the question arises as to what one may hope for as one comes face to face with the most difficult existential problems? How is association possible without generalizations? How can one conceive not only the unity of the diverse (this is something that dialectics is good at) but also the diversity of possible unities? The "bioethics" casus is of interest in that it contains a useful tip, a spontaneously found vital practical solution. To deal with the most difficult life-aporias generated by advances in biomedical technologies, committees on ethics were formed in the 1960s, which are turning, by the start of the current century, into an institutionalized form of bioethics which is present in the structure of modern science. The answer is being formed in the context of a joint communicative transdisciplinary dispute or discussion, where a doctor doesn't cease being a doctor, nor does a philosopher stop being a philosopher.

Their expert positions (definitions in categories of the universal) arise as a reaction to the existential aporias that rend the naive general significance of everyday views on life, death, and humankind as such. They are vitally needed for a reasonable solution to the identified problems, but they are insufficient. What makes them sufficient is a joint transdisciplinary effort to achieve, via public discussions, an agreed generally significant evaluation of unfolding events. Once achieved, the agreed general significance (universality, as it were)—such as when death is defined as the "death of the brain"—on the one hand, imparts legitimacy to certain biomedical practices (in our case, transplantological), while securing the congruity of wrangling disciplinary perspectives as a peculiar social contract, on the other.

Yet, no matter how convenient, this kind of "social contract" does not relieve philosophy of the responsibility for making a properly philosophical rationalization of its co-participation in transdisciplinary bioethical communications. We believe that Juer-

gen Habermas' idea of "unassuming philosophy", which he formulated in the context of a debate on liberal eugenics projects [4], is an important step forward in this kind of rationalization. The philosophical search for universal foundations is, in this case, correlated with the communicative strategies used to identify the general significance in a variety of disciplinary unities.

According to Habermas, the naive identification of one's own private speculative perspective with a certain self-evident position of the universal has proved its irrelevance in present-day philosophy. The assumption that there is a universal, one-for-all perspective of truth or idea of good life, which until recently used to inspire the philosophical community, is not just called into question. It is itself perceived as a threat of an inadmissible interference with each person's right to "develop an ethical self-awareness in order to implement in reality, in accordance with one's own capacities and good intentions, a personal concept of 'good life.'[4,12]".

But then the question arises as to whether the reason's unassumingness is a manifestation of its impotence? What can a philosopher hope for while unassumingly putting forward judgements on, in particular, ethical acceptability, or, for example, liberal eugenics? What can mankind hope for in the face of existential threats? In modern democratic secular society, references to God are relevant only within a community of fellow believers. In this situation, Habermas suggests his "reduced proceduralist" variant of reading "the other" as a language or communicative practice. According to Habermas, not only can a correct moral judgement determining relations between subjects be obtained, but also a correct ethical self-awareness "can be obtained either in revelation or 'be given' in some other way. It can only be won by joint efforts[4,21]".

Participants in communication get a chance to advance towards an understanding of what the common good is via: challenging the presupposition of "the other;" consistent advancement, criticism and rejection of poor judgements; and selection of successful premises for the possibility of being one's own self in the face of each other. The basis of this understanding is the fact itself of an agreement being reached. It is not accidental that the principles and rules of bioethics are, in effect, the rules of competition between different value orientations in the space of the public dialogue rather than general "solutions" to problems.

The attainment of "the generally significant by agreement" is guaranteed by the resolve of the participants in communication to be true to the commitments they assumed in the face of each other, not by a certain universal logic. The joint effort to move to a transposition along with the other in response to his reciprocal wish to become himself precisely together logically justifies the position of philosophizing in transdisciplinary investigations, and provides the most general answer to the Kantian question, What can I hope for? It is the "greater thing" that is revealed in the dialogue bound by a community in attunement in the face of urgent existential problems.

5. Philosophy or sophistry?

The transdisciplinary theme can also be considered as a repetition of the collision between philosophy and sophistry, a repetition that creates resources for its own new rationalization. To quote Natalya Avtonomova's expressive writing, "Once in Greece, in the times of the Second Sophistry, philosophy took the upper hand over rhetorics, proving over persuading, and the object thought over the attainment of some outside goal. In the current situation, rhetorics in world culture had its revenge on philosophy, subordinating its objective aspirations to functional justification. Today, possibly, it would make sense to put rhetorics at the service of philosophy again [2]". We agree with the idea of this formulation of the theme; yet, we believe that speaking in terms of victories and defeats is unproductive. The comeback of sophistry and its rehabilitation does not mean that "object nature" and "objectivity" are renounced; rather, it is a case of one wishing to find the means to rationalize their transforming(disappearing and reappearing) character. The public forum is where the projects "object nature" and "objectivity" are approved. Simultaneously it is where the methods and skills enabling one to form one's own opinion are practiced. And it is not a consequence of disrespect for truth but an attempt to reveal the quality of the "human-dimension". "Truth" reveals its "human dimension" in crisis situations where the existing rules and unwritten laws fail, and things foreign are put in a presence via resistance. Rhetorics uses its "intercourse aids"—argumentation, proofs, demonstration of probabilities, and other techniques—in order to generate definite emotions and sensations capable, in turn, of forming new or modified stereotypes, perceptions, and behaviors.

Standing behind objectivism is reason's desire to assume the point of view of God. In following this philosophical tradition, Bertrand Russell wrote this: "The free intellect will see as God might see, without here and now, without hopes and fears… calmly, dispassionately, in the soul and exclusive desire of knowledge—knowledge as impersonal, as purely contemplative, as it is possible for man to attain[9]". It's important to note, however, that philosophy is a variety of philosophies, which grows increasingly complicated, and each of those philosophies offers its unique view of the world as a whole. Culture has in its possession powerful resources enabling it to retain, the human and the divine, without letting them blend though they are inseparably, that is, what is of human dimension and what is objective, the sophistical and the philosophical. It suffices to point to Peter Abelard's conceptualism as interpreted by Svetlana Neretina, from whom we will borrow (albeit in a somewhat modified form) the ideas of equivocation (double rationalization) and concept [8]. With regard to concept we will also take into account the approach suggested by Gilles Deleuze and Felix Guattari [3].

In our interpretation, the idea of equivocation or double rationalization implies an immanent two-stroke nature of thought, as well as an active role of not only reflection that determines the specificity of the theoretical thought process but also the intellectual procedure which we will allow ourselves to call "transflection." Transflection is, in our view, a specific validating method in "unassuming philosophizing," which differs from

the classical method of philosophical reflection in that it takes into account the nonlinear nature of intercourse occurrences.

The meaning of classical reflection is the recognition of the identical in itself (self-identity) and in the other. Therefore it is immanently retrospective. Transflection is attuned by amazement and oriented to a "fundamental meeting" (Deleuze) with otherness in itself and the other, rather than to recognition. In this sense, it is prospective and open to an unknown and perilous future. The otherness is rhythmically structured by the governing existential attunement. It retains the plane of integrity as a fundamental riddle (problem) whose solution is the target of scientists' and philosophers' transdisciplinary communicative activities. As a validating procedure, transflection is due to retain the zone of openness to one another and need for one another (tolerance towards itself and the other), and to defend against reflective "removals." Reflection and transflection do not abolish each other. They are in contact and thus define (impose the limits) and redefine the Kantian question, "What am I able to know?"

The important thing is to retain in the word able, not only the cognitive plane but also the communicative one: I am able to know what I am able to communicate to the other (implying intersubjective universality by agreement or general significance), as well as something greater, something that can come into being and do so precisely in the zone where intersubjectivity is called into question. While notion is the expressive means of reflection, transflection, as a method of the unassuming philosophy, works with concepts. These are the forms of thought that operate as conditions of a direct dialogue intercourse between the one who speaks and the one who listens, or the one who writes and the one who reads.

The existential energy of aporias of life-occurrences (casuses) and the paradoxical experience of their rationalization is concentrated in the variety of paradoxical problem knots, concepts as embryos of thought. For example, the development of heart transplantation techniques revealed the concepts of "life" and "death" as a problem knot (subject of interdisciplinary dispute). The meaning of paradoxical situations cropping up in connection with the progress in new reproductive technologies (abortion, test-tube fertilization and embryo transplantation, cloning) is concentrated in the specific bioethical concept of "human." The paradoxes of the new models of doctor-patient relations are embodied in the concept of "personality."

As distinct from the definiteness of notion, concept (in view of its primordial paradoxicalness) is originally underdefined. For classical thinking, the indeterminacy of cognition and mutual understanding was of "subjective" nature related to the insufficiency of reason. In modern science and philosophy it becomes "objective," pointing to "coming-into-being" as an imminent property of reality itself. A concept "lives" in a conversation, reproducing in itself the subjective and objective aspects of the interlocutors' utterances as well as the "something greater" transflection retains. It is for this reason that it is an indispensable "intermediary" in dialogue or "generalization-free intercourse," localizing itself in the border zone between everyday speech (the word)

and disciplinary discourses (the notion).

At this point we come to the next important distinction between the notion and the concept. An extended form of the notion is a scientific, logically coherent theory (or a theoretical model). The concept unfolds into a conception, while retaining the paradoxicalness of conceptual grasping (a possibility of alternative theories). Inside philosophy (its specific areas such as ethics or anthropology), theology, biology and medicine, psychology, and other disciplines a concept-powered conceptions of man, personality, death, life, etc. take shape.

As they pass to the sphere of transdisciplinary communications, concepts take on the form of conceptual narrations. Unlike ordinary narrations that structure relations in the life-world, the plots of conceptual narrations and structures of their peripeteia include the above-mentioned existential aporias, of which the concepts are the paradoxical clots of meaning.

Mediated by the translation of disciplinary knowledge into the language of narrations, the transdisciplinary communication models concrete forms of joint living of individuals in a bid to solve existential paradoxes packed in concepts. It is a specific kind of "preemptive living-out" of the situations that may yet arise. For example, a biologist, who has invented a new technology, must translate his results into the language of the life-world in order that the meaning of his discovery be comprehensible to non-specialists. Thus, he is forced as it were to expand the framework of his experimental dialogue with nature by converting the dialogue itself into an experiment designed to coordinate his position with the moral positions of other subjects. It is with those primary narrative representations (knots, of which concepts are plots) that philosophers, lawyers or psychologists start working. Proceeding from a narration as the initial empiria, they (each in his own way) study it professionally and thus translate it into the specific languages of definite disciplinary areas. This research may result in interpretations of the meaning and moral value of the scientist's discovery. But the intelligibility of the professional judgement of the philosopher, psychologist or any other expert for others (non-experts) can again be achieved only as a result of retranslating the results of the philosophical, legal or psychological analyses into the language of life-world narrations. The meanings they reveal and evaluations they produce must be retold as open or closed variety of life-stories that are possible as a result of realization or non-realization of some biomedical technology (for example, permitting or banning to clone human beings).

In this context, the mutual under-translatability of the languages of partners in transdisciplinary communications (the insolubility of the fundamental paradoxes) is of substantial positive importance as a meaning-generating zone. As Yury Lotman stressed, "The value of the dialogue proves linked, not with that intersecting part [the intersection of the language space of the one who speaks and the one who listens.—L.K.], but with the transmission of information between non-intersecting parts. This puts us face to face with an unsolvable contradiction: we are interested in an intercourse precisely in the situation which complicates the intercourse and ultimately makes it impossible.

Moreover, the more difficult and less adequate the translating of one non-intersecting part of the space into the language of another is, the more valuable the fact of this paradoxical intercourse becomes in informational and social respects. One can say that translating the untranslatable proves a high-value information vehicle [7]". The thinking act performed in the context of this kind of translation is a type of transflection. It is thanks to the retention of the meaning-generating zone of the paradoxical "translation of the untranslatable" that the transdisciplinary communicative effort contains within itself the possibility of a meeting with "something greater," which is unattainable in principle from within the individual expert perspective.

In the inter-speech situation of transdisciplinary communications we considered above, the voices of the philosopher (in the classical sense) and the sophist are only situationally distinguished self-identifications of the internal and external speech of a real individual whose specific position (trans-position) we will now consider.

6. Trans-position of philosophy. We will single out three thematically possible positions of philosophy relative to the experience of transdisciplinarity, with account taken of how they unfold within the "bioethics" casus. First to note is the position of Side Observer, which was historically secured in the new European philosophy. Philosophy speculates about transdisciplinarity as a subject existing within the context of a new type of science. Characteristic of this form of a thinker's reflectively imposed self-identification is a paradoxical positioning of being outside of the world (and thus being able to comprehend it as a whole) and being in contact with it on its border. The peculiarity of the thematization in this case consists in that the human effort is eliminated from the result, to wit, the integral idea of the world. In this respect, speculating about transdisciplinarity changes nothing in the subject of thought itself. Any speculation about genes, clones, organs, moral principles or rules naturally reproduces this trans-position of a philosopher's or scientist's self-identity in the situation of transdisciplinarity. Lying at its base is the idea (it's of no importance whether it is conscious or not) about the uniqueness of the universal (truth), which aspires to both integrity and universality.

The second form of philosophy's trans-position is congruous with the position of the cognizing reason in neoclassical science, for which the effort of a cognizing individual, as objectivized in language and instrument, itself becomes observable. The subject nature of science acquires traits of human presence, with human dimension as its object of investigation. We denote this position as that of the Participant. Not only does a philosopher speculate about bioethics, he himself becomes an active participant in transdisciplinary communications. His thinking—his effort as a real individual—proves an occurrence that changes the state of a subject of speculation.

In transdisciplinary experience, the subject nature of disciplinary areas is pinpointed at the moment of its coming into being, and, in effect, it experiences a reincarnation of its own element, for which reason it necessarily appears as unstable (arising and disappearing again). Accordingly, Participant's self-identity is likewise unstable; one can say that it comes into being along with the subject nature of the transdisciplinary experience.

But it is in this transitional, unstable transdisciplinary state that scientific disciplines become open to meeting with other forms of disciplinary scientific knowledge, religious experience, and "auxiliary knowledge" (Martin Heidegger) of everyday life.

The third trans-position of philosophy, which we denote by the word Witness, is, as we see it, the embodiment of the philosophy of transdisciplinarity as such. While keeping the connection with the life practical casus, pushing itself into the interdisciplinary experience under the imperative pressure brought to bear by concepts, and deploying its reply in the conceptual universality of Observer and the contextual general significance of Participant, Observer constitutes itself as the one who retains the distinction (polemos) of the above two conceptual personages and secures the experience of their connected realization. He retains the primary paradoxicalness (the determined chaos) of transdisciplinary experience, which secures as causa sue its constant repetition in multiple existential situations generated by the biotechnological (in our consideration) progress. As he retains the orientation to truth as the basis, and is conscious of the relativity and multiplicity of the truths, Witness introduces his own act of witnessing into his decision to act this way and not the other.

Witness's universum of judgements unfolds within a paradox of two simultaneously present ultimate assumptions of "the universal" and "the generally significant." In the strict sense, Witness is he who, as a unique human individual, testifies the veracity of "the divine," the general significance of the universal. And the power of this testimony depends not only on the truth that is open to him, but also on the luck of Witness receiving two gifts of the real existence—attention and recognition of the others. These others are the communicative community which in respect of the testimony plays the part of Judge whose trial is realized precisely in the communicative effort together.

In a situation where mankind once again is losing its unity and internal stability, where it reveals in itself a menacing and hypnotizing abyss of chaos, a wave of new barbarianism that makes its cultural foundations crumble, the experience of transdisciplinarity, as we attempted to show it, throws light on the positive sense of the existential situation we are living through, where culture turns to its own flesh and matter of recreation.

6. References

1. We borrow the term "casus" from the civil law tradition (where the US is the most characteristic case in point), in which precedents (casuses or cases)—court decisions on particular legal collisions that are accepted as standard for purposes of evaluation and decision-making in other situations—play the normative role. Thus the single becomes the standard for the general. "Casus," in this sense, differs in principle from "example" which denotes application of some general rule to a particular case.Playing a special role in Russian moral self-consciousness are "casuses" enshrined in belles-lettres (the writings of Pushkin, Tolstoy, Dostoyevsky).

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8 Aesthetics of Sustainability: A Transdisciplinary Sensibility for Transformative Practices

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Abstract

Contemporary western societies are marked by symptoms of a culture of unsustainability, rooted in problematic modes of knowing reality, across social systems, whether in the sciences, arts or other fields. Transdisciplinary researchers across the world are already aware of these issues and working on resolving them. To contribute to these efforts and focus on a perspective which potential may have been receiving too little attention so far, this article is introducing how a sensibility to transdisciplinarity and complexity can inform aesthetics of sustainability, and why this matters for a global (environ)mental transformation process. The relevance of this approach is discussed with the field of ecological art and the practice of walking.

1. Introduction

How can a sensibility to transdisciplinarity and complexity, inform aesthetics of sustainability? Why does this matter, for a global (environ)mental transformation process towards more sustainable societies?

Systems thinking and a transdisciplinary understanding of complexity may contribute to heal the fragmentation of our modern modus cognoscendi, and engage us into cultures of sustainability. But this also requires specific aesthetic experiences. The sought-after experiencing of reality implies a more-than-conscious mode of knowing. Knowing

should become a way of connecting ourselves with the complex world around us. This connecting asks for the involvement of body and soul, and of all the human senses in an integrated way. Specific artistic practices, such as ecological art, and everyday-based practices,such as walking, illustrate the relevance of aesthetics of sustainability.

2. From a Culture of Unsustainability to Culture(s) of Sustainability

The notion of "unsustainability" characterizes the multi-dimensional dimensions of the contemporary global crisis of civilization. Most authors writing on this crisis are highlighting its environmental, social and economic dimensions. Fewer authors discuss its cultural dimensions. Among the latter, one major dimension of the contemporary culture(s) of unsustainability which is being discussed, is the problematic character of modernity's dominant modes of knowing reality (besides other, related dimensions such as consumer culture).

Problematic aspects of modernity's modi cognoscendi include:

- traditional, non-contradictory logic operating at single levels of reality (as opposed to a dia-logic informed by several levels of perceptions addressing several levels of reality as well as multiple jumps in logical types within single levels of reality) (Nicolescu 2002);
- the fragmentation of human understanding across disciplines, and across social sectors/systems, with strongly autopoïetic (i.e. self-referential and self-(re)producing) tendencies of modern social systems (Morin 1977, Luhmann 1984, 1986);
- excesses of disembodied, abstracted knowledge, short-circuited knowledge reduced to what is deemed instrumentally efficient by purposive consciousness (Bateson 1973, Lakoff and Johnson 1999);
- and an overall simplification of knowing, whether in the form of "disjunctive thought" (i.e. knowing through the parts) or whether in the form of a holistic simplification (i.e. knowing through the whole).[1]

Edgar Morin denounced three basic modes of simplifying thought: "to idealize (to believe that reality can be reabsorbed in the idea, that the intelligible alone is real); to rationalize (to want to enclose reality in the order and the coherence of a system, to forbid it all overflow outside the system [...]); to normalize (that is to say to elimi-

[1] *I am here only very superficially touching at these issues and notions, assuming them to have become common knowledge for transdisciplinary researchers reading this journal. For a more detailed discussion, following insights from Gregory Bateson, Jacques Ellul, Edgar Morin, Niklas Luhmann, Basarab Nicolescu, and David Abram, among others, see Kagan 2011 (pp. 24-66).*

nate the strange, the irreducible, the mysterious)" (Morin 1992, p. 16). Gregory Bateson warned us of the limited and harmful rationality of purposive consciousness, which installs shortcuts in thought and offers an appealing "bag of tricks" for techno-scientific developments , but leads us to forget that ecosystems are also part of our mental systems (Bateson 1973, 1979).

Sustainability, understood as a search process, should address all dimensions of unsustainability, including its cultural dimension. Sustainability has become a widely used keyword, since the Brundtand Commission introduced "sustainable development" in policy discourse (i.e. development that "meets the needs of the present without compromising the ability of future generations to meet their own needs"). The word has several contradicting definitions, depending especially on whether one wants to stress "limits to [economic and industrial] growth" or one believes in technology's miraculous power to infinitely "substitute" non-renewable natural resources. From a cultural perspective, sustainability can be understood as the search for alternative sets of values and knowledge of the world, reforming the modi cognoscendi and founding an understanding of patterns that connect" the economic, social, political, cultural & ecological dimensions of reality. The cultural dimension has thus a foundational value for the whole search process of sustainability.

Sustainability, which is not a fixed 'utopia' but as a search process for dynamic balance, unfolds itself differently according to the specific contexts, allowing the emergence of resilient cultural-natural hypercomplex systems.

These two key notions, resilience and emergence, require some explanation:

Resilience refers to a system's capacity to endure, withstand, overcome, or adapt to changes from the "outside" or from the "inside" environments. In other words, resilience points at the ability to survive on the long term by transforming oneself in relationship with one's environments (dynamically overcoming, rather than statically resisting change). Resilience necessitates the preservation of diversity (i.e. both biodiversity and cultural diversity) and is related to learning from the unexpected. Such learning requires what I called an "autoecopoïetic" openness and flexibility (Kagan 2010a, 2011), implying a great degree of that form of sagacity that the English language named serendipity.

An autoecopoïetic system is creatively open, and sensible, to environmental disturbances, whereas a merely autopoïetic system (à-la Luhmann) can only be disturbed by already recognized environmental irritations. Autoecopoïesis allows 'emergence', or in other words, the unexpected. When a system is autoecopoïetic instead of just autopoïetic, it is co-constructed by itself and by its environment, i.e. by other systems, thanks to its evolutionary plasticity (instead of setting and designing autistically its development paths).

The concept of emergence points at the creation of a new logic at the level of a system, whereby no analysis of the interactions between the different constituents of the system, can suffice to account for the arising of coherent and novel structures at the level of the whole system. Emergence is the engine of complex, unpredictable evolutions in nature and in societies. The logic of emergence is chaotic, bottom-up and rhizomatic (a rhizome is a polycentric/acentric network: e.g. roots of bamboo), as opposed to the

constrained, top-down and hierarchic logic of human design and of modernistic development.

However, emergence does not only bring new qualities to the whole system and to its parts. Saying only that "the whole is more than the sum of its parts", would be holistic simplification. Emergence also suppresses certain qualities of the parts, or 'virtualizes' them, under the new constraints imposed by the emerging structures ; and emergence does not preclude the existence of rich and complex tensions between different parts, and between the parts and the whole system (Morin 1992, pp. 108-111, Koefoed 2008).

This is leading us to the importance of genuinely understanding and dealing with complexity, in order to address the problematic aspects in our modes of knowing reality. Required is an ecological literacy of nature's dynamic webs of life (Capra 1996, 2002), which is rooted in a literacy of complexity.

Edgar Morin's approach to complexity, away from both the simplification of reductionism and the simplification of systemic holism, introduces the possibility to think unity and diversity alongside each other, and to think about any pair of terms, with a *combination of unity, complementarity, competition and antagonism,* altogether forming a complex relationship and calling forward a dia-logical thinking process.

As introduced after Nicolescu, dia-logics is what allows genuine transdisciplinarity: complementing and overtaking the limits of disciplinary thinking (based on linear logic and the „principle of the excluded third"), with the bridging of different „levels of reality" whereby a „principle of the included third" is operating. Only then can the paradigm of simplicity be overcome, and macro-concepts be constructed, such as Morin's eco-auto-organization (which explores the complex organizational relationships between individual life forms and the ecosystems in which they co-evolve and eco-evolve), and autoecopoïesis (which points at systems operating in ways creatively sensible to chaos - i.e. having a certain productive openness to disturbances).

Such complexity is embedded in everyday life. It is much more present in life forms than in the most elaborate cybernetic system, in daily language than in formal language, in informal social networks than in formal, top-down organizations.

But what does this all have to do with art and with aesthetics?

3. Aesthetics of Sustainability

Since the summer 2010, the ecological artist David Haley keeps repeating to his audiences this one sentence: "We must learn, not to be afraid of complexity!" This has become one of his, and also of my favorite sentences. To achieve this, we need aesthetics of sustainability, which have to be based on an autoecopoïetic sensibility to the environment's complex and dynamic webs of life and to the social, political and economic complexities of contemporary societies. My argument has several roots, which I am summarizing below, but are described at more length elsewhere (Kagan 2011, pp. 217-268):

According to David Abram (1996) historical societies based on phonetic alphabets, and especially modern (industrial and post-industrial) societies, have numbed and suffocated a whole dimension of the human sensibility, which was and is still vibrant among some indigenous peoples: the sensibility to the intelligence of the non-human - and the capacity to bridge perceptions with the non-human - the environment's complex and

dynamic webs of life. We need to re-discover this numbed reflexive sensibility, which the arts and culture may play a fundamental role in re-awakening.

When using the term 'aesthetics, 'I am taking as a basis, John Dewey's understanding of aesthetics as experience, pointing at personal affectivity in everyday life and at a human being's overall interrelationship with his/her environment. "Experience is the result, the sign and the reward of that interaction of organism and environment which, when it is carried to the full, is a transformation of interaction into participation and communication" (Dewey 1934, p. 22 in 2005 Perigee ed.).

Another root of my approach is the movement of ecological art, which developed the notion of "ecological aesthetics" as aesthetics that pays attention and respect to the own complex dynamics of natural phenomena in their relationships to human interventions, and that wants to highlight these aspects in the artistic working process. In other words, the "ecological aesthetics" aims to highlight the form and meaningfulness of natural processes (i.e. complex processes of eco-auto-organization, as theorized in Morin 1977, 1980). Ecological aesthetics is "inseparably linked with the idea that ultimately everything, nature and culture as well, and thus man and his habitat, are connected in an infinite, diverse systems of relationships" (Strelow in eds. Strelow, Prigann and David 2004, p. 11). This idea emerged together with the ecological movement of the late 20th century, and allowed to move beyond a Romantic dichotomy between a pristine nature and an extra-natural human culture, and the Modern opposition between primitive nature and civilized culture. "In the course of the growing ecological understanding that did not start until the late sixties, man came to perceive himself as an integral part of a set of connected, natural and cultural eco-systems, and thus also part of the nature surrounding him" (ibid.). Strelow locates the emergence of this idea in art in the movement from "Land Art" to "Art in Nature": indeed the latter, unlike the former, "do not just seek stimulus from nature, but build her as a partner, as their fellow creator". Ecological aesthetics points at "the traces of this interpenetration of nature and culture" (ibid., p. 12). Because culture is part of nature, "within art, an 'ecological aesthetic' would be a reflexive, socially and environmentally shaping activity", argued Herman Prigann (in eds. Strelow, Prigann and David 2004, p. 111).

These authors further discuss the notions of diversity, inter- & transdisciplinarity, and social transformation (as developed in Joseph Beuys' concept of "social sculpture"), as dimensions of ecological aesthetics. They also point at openness to uncertainties outside the art world. This is a very important element: The understanding of complexity, in nature and in human society, requires such an openness to uncertainties and to the agitations of disorders outside the organized fields of art worlds.

The sociologist and philosopher Jacques Leenhardt is explicitly pointing at the "ecological idea" for its introduction of "complexity and the interaction of causalities [into] the circle of artistic disciplines, whose unduly confined framework it opens up". In other words, he argues that the ecological idea, as in "ecological aesthetics", offers to the art worlds the opportunity to leave the orbit of a culture of unsustainability. But this opportunity does not come without challenges: Leenhardt, in his discussion of the insights of the "ecological idea" to art, warns about the consequences of such insights for artistic practices and the kind of aesthetic experiences that are to be expected: These

can no longer be limited to merely local objects and relations, but must relate them to wider contexts: "the new interest in complex causalities leads to increased attention to global connections rather than spatially limited situations that cannot carry the real driving forces of the phenomena within them. [...] Objects of ecological aesthetics are not permitted small frames of reference" (Leenhardt in eds. Strelow, Prigann and David 2004, p. 112).

Aesthetics of sustainability should not merely based on a holistic sensibility, over-emphasizing the unity and integration of the biosphere or universe (as e.g. Ervin Laszlo and the "integral futures" approach tend to do – see e.g. Laszlo 1996), replacing the disjunctive paradigm of modernity with a simplistic 'New Age' paradigm, but rather should be attentive to complexity, i.e. combining and contrasting unity, complementarity, competition, and antagonism. Or in Edgar Morin's words: "The systems sensibility will be like that of the musical ear which perceives the competitions, symbioses, interferences, overlaps of themes in one same symphonic stream, where the brutal mind will only recognize one single theme surrounded by noise" (Morin 1977, pp. 140-141). Such a sensibility to complexity, and experience of complexity, is what I'm exploring as constituting the very core of aesthetics of sustainability, together with Gregory Bateson's understanding of aesthetics:

For Bateson, the aesthetic is that which is "responsive to *the pattern which connects*" (Bateson 1979, p. 8 in 2002 edition). He defined the "aesthetic preference" of a mind, as being "able to recognize characteristics similar to their own in other systems they might encounter" (ibid., p. 118). A typically aesthetic question, would be "*How are you related to this creature? What pattern connects you to it*?"

Bateson gave the illustration of a group of art students to whom he once asked to explain why a dead crab being displayed, used to be a living thing, (the students were asked to find answers by just looking at the dead crab, and to do as if they had never seen a crab before). The students moved from the observation that the crab showed some symmetry between its parts (left/right), to the observation that the symmetry was not absolute (e.g. one claw bigger than the other), to the conclusion that there existed a similar relation between parts, in the case of one crab ("both claws are made of the same parts") as well as in the crab/lobster comparison and (crab-lobster)/human comparison. They "discarded an asymmetry in size in favor of a deeper symmetry in formal relations" (ibid., p. 8).

Bateson called these patterns within the crab, *first order connections*. The pattern connections between crab and lobster, he called *second-order connections*, or what biologists call "phylogenetic homology". Finally, he pointed at the pattern which connects the patterns connecting, on the one hand, the crab and lobster, and on the other hand, the human being and horse. This comparison of comparisons is labeled as *third order connections*. These three levels of connections, and of perception-conceptualization of connections, are pointing at three different "logical types" (to use Bateson's terminology, after Bertrand Russell ; or different "levels of organization" to rephrase into Nicolescu's terms), i.e. different levels of functioning of systems within systems.

This movement illustrated by the arts students' progression in the example, of pattern recognitions across different levels, is what Bateson proposed as the way to think

about "the pattern which connects": "The pattern which connects is a metapattern. It is a pattern of pattern" (ibid., p. 10).

For Bateson, a strong aesthetic sense is a heightened responsiveness to this metapattern uniting the living world, rather than an arrested perception, stumbling upon the first-order or second-order differences between elements of the living world. To prevent a misreading of Bateson here: The differences are indeed what allows the mind to emerge, so that it can perceive the differences, so of course Bateson's argument here is not against the perception of difference, but against a perception that satisfies itself with the fact of superficial difference and hinders the pursuit of the mind's aesthetic probing of the world around itself, i.e. a probing for connections across differences.

For Bateson, the aesthetics of the pattern which connects is that which can provide a sense of aesthetic unity (and, I would add, an ecological ethics in the same process) that modern societies are critically lacking. This aesthetic lack is an epistemological lack: "our loss of the sense of aesthetic unity was, quite simply, an epistemological mistake" (ibid., p. 17).

I am however departing from Bateson insofar as he defines aesthetics, in general terms, as that which is "responsive to the pattern which connects". But aesthetics may not always be "connective" to the fullest extent described by Bateson. Indeed, an aesthetic experience can exist, which does not reach the level of "third-order connections" and the generality of the unity of all life forms described by Bateson, and which satisfies itself with a unity of meanings and values (in Dewey's sense) with a narrower scope / at a more limited range. In a Luhmannian sense (Luhmann 2000), the existence of more exclusively autopoïetic aesthetic experiences should be acknowledged, as a challenge. The aesthetics described by Bateson should then be qualified as characteristic of aesthetics of sustainability, rather than of aesthetics in general. Aesthetics of sustainability is to be understood as a subset of aesthetics as understood by Dewey, i.e. a form of relation and process-centered aesthetics, which bases itself on a sensibility to patterns that connect at multiple levels.

Coming back to Morin: The insights from complexity theories point not at a holistic sensitivity which would only perceive complementarities and symbiosis, but:

- a complex sensitivity that perceives as much antagonisms and competitions as complementarities and symbiosis, and that transcends the contradictions so as to reveal the complementary tension of antagonism and complementarity ;
- a sensitivity to wholeness and order that also perceives and values disorder, disharmony, as well as uncertainty, and that respects genesic chaos.

Such a sensibility to complexity is more relevant to Dewey's understanding of aesthetics than a solely holistic sensibility fixed on harmony. Indeed, Dewey's characterization of the aesthetic experience as an experience of unity should not be misunderstood as a search for permanent contemplation. Rather, as Richard Shusterman explains, "for Dewey, the permanence of experienced unity is not only impossible, it is aesthetically undesirable; for art requires the challenge of tension and disruptive novelty and the rhythmic struggle of achievement and breakdown of order" (Shusterman 1992, p. 32). Tensions and conflicts are recognized as harboring potentialities for new levels of unity.

Dewey's position echoes, at an aesthetic level, with Stéphane Lupasco's logic of contradiction as applied by Nicolescu across levels of perception and levels of reality.

Understood in this way, aesthetics of sustainability highlight the beauty of the complementarity of antagonisms (which is also crucial to democracies – cf. Kagan 2011, pp. 429-460). This sensibility was already present in several fragments of Heraclitus on aesthetics, such as the following:

> "That which is in opposition is in concert,
> and from things that differ comes the most beautiful harmony."
> Heraclitus (Aristotle, Eth. Nic. 1155b 4 ; frg. B 8 Diels)[2]

> "[People] do not understand how that which differs with itself is in agreement:
> harmony consists of opposing tension, like that of the bow and the lyre."
> Heraclitus (Hippolytus, Refut. IX g; B 51 Diels)

One shall also be open to chaos (i.e. the chaos of chaos theories, not the chaos of Lyotard's postmodernism) as a genesic source for generativity. Life's "creative evolution" emerges not from computational capacities alone, but from the ability to deal with disorder and ambiguity as genesic forces (Morin 1980). Also, an aesthetics of sustainability, which is open to the generativity of chaos, implies a sensibility to emergence (as showed e.g. by the practices of ecological artists who do not try to control fully the natural and social processes with which they work).

4. Transformative Practices Informed by Aesthetics of Sustainability

I will now come back to a focus on ecological art, which is one of the most interesting art movements from the perspective of aesthetics of sustainability. Ecological art emerged from the late 60's in North-America and West Europe. It gradually constituted itself into a movement, and developed the notion of "ecological aesthetics" which I already mentioned above. Ecological art finds its roots and inspirations in the works of pioneers and precursors such as Helen Mayer Harrison and Newton Harrison, Hans Haacke, Joseph Beuys, and Mierle Ladermann Ukeles. Its current practitioners include Patricia Johanson, Shelley Sacks, David Haley, Aviva Rahmani, Insa Winkler, Lynne Hull and Betsy Damon, among others (see Kagan 2011, pp. 269-343, for an overview).

According to a common statement written by the 'ecoartnetwork' (an international network of eco-art practitioners), ecological art "embraces an ecological ethic in both its content and form/materials. Artists considered to be working within the genre' subscribe generally to one or more of the following principles:

- Attention on the web of interrelationships in our environment—to the physical, biological, cultural, political, and historical aspects of ecological systems.
- Create works that employ natural materials, or engage with environmental forces

[2]Quotes from Heraclitus taken from Tatarkiewicz et al. (2006), pp. 88-89.

such as wind, water, or sunlight.

- Reclaim, restore, and remediate damaged environments.
- Inform the public about ecological dynamics and the environmental problems we face.
- Re-envision ecological relationships, creatively proposing new possibilities for co-existence, sustainability, and healing."[3]

For example, Helen and Newton Harrisons' *Lagoon Cycle* (1972-1984), which was one of the founding works for ecological art, brought together an artistic inquiry and a thorough scientific work on the complexity of ecosystemic conditions necessary for sustaining the breeding cycle of a specific species of crab (a work for which they also received a science grant). The LC (*Lagoon Cycle*) is an exemplary work of ecological art because it weaves together patterns of ecosystemic, socio-economic and technological complexity, and of inter-personal learning, in a strikingly insightful way.

The LC unfolds a contradictory narrative, with an exchange between a "Lagoon-Maker" proposing technological solutions for ecosystemic restoration, and a "Witness" critically assessing and questioning these proposals. These 2 main characters are looking into the conditions necessary for sustaining the breeding cycle of a specific species of crab from Sri Lanka, under technologically modified, human-controlled conditions in California. Along their quest for understanding and control, they encounter several difficulties, as well as very peculiar third characters, who constitute ideal-types characterizing the Sri Lankan society and culture, as well as US American / 'Western' society and the working of our market economy.

The Lagoon-Maker and the Witness' learning process is experienced in a dialogue that spans over 7 parts (7 'lagoons'), unfolding reflexively as well as epically with a number of realized and imagined experiments with the crabs. Starting with a visit to Sri Lanka (in the first part), and ending with a poetic vision of the "graceful withdrawal" of humanity faced with global climate change, the work achieves a transversality that connects the local with the global, the short-term with the long-term, the culture-in-nature of Sri Lanka and culture-partly-apart-from-nature of the contemporary US.

As remarked by Marga Bijvoet (Bijvoet 1994), the LC "create[s] a 'world' that reaches out into many different 'regions' (territories, disciplines, space and time, etc.) both real and imaginative [... which] can be perceived in relationship to one another, including the artists themselves. These relationships, however, are subject to processes, and to change [... and] relative positions come forth in the dialogues/discourses between the two protagonists in their views of structure and content vs. process and context".

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[3] *Source: internal communication on the 'ecoart' network mailing-list, in preparation for eventual wikipedia entries (November 2011). See www.ecoartnetwork.org for more information about this network.*

Furthermore, the LC works towards a way of thinking that is less atomistic, and more relational, and the attention to these relations is what characterizes the art of the Harrisons, as Michel de Certeau argued in the catalog of the 1985 exhibition of the LC (De Certeau 1985).

Beyond the single example of the LC, about the evolution of the work of the Harrisons over the past 4 decades, Marga Bijvoet observed: "The small-scale portable farming pieces extended into planning whole ecosystems. What were at first personal explorations in search of a new art form, developed into large-scale research projects into global survival plans, with proposals and plans, collaborative actions and political and social discourse" (Bijvoet 1994, p. 125).

In 2004, the Harrisons themselves characterized their work as "address[ing] the co-evolution of biodiversity and cultural diversity most often, though not always, at watershed scale. [...] We believe that in a well-functioning system, cultural diversity and biodiversity exist in a state of mutual interaction – the former self-conscious and able to intend and transform, and the latter the pattern of self-organization from which we all spring and to which we all return, and which ultimately determines the possible" (Mayer Harrison and Harrison 2004).

The ecological artist and researcher Tim Collins further described the methods of eco-artists as:[4]

- "framed in terms of critical thinking ; as investigate-ers" and story-tellers of "alter-tales", "seek[ing] to identify conflicting and conflicted belief systems" ;
- based on "systems knowledge": "we ask nature first, we seek networks, we try to understand the questions of scale, and the relationships between pattern and connection" ;
- introducing into projects an "unorthodox approach" which, while it can be an "instrumental method", also allows "to open doors and minds" (Collins 2004).

Aesthetics of sustainability are, however, not only relevant to the practice of ecological art. They also relate to very basic and transversal practices of everyday life,such as walking.

Why is the practice of walking especially interesting, from the perspectives of a transdisciplinary sensibility, founding aesthetics of sustainability? In short, because walking (Solnit 2001, Kagan 2010b, 2010c, Haley 2010, Ridsdale 2010):

- stimulates embodied experiencing & learning, embodied action ;

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[4] *In total, Collins listed 53 methods items, categorized in three ensembles: primary, critical and applied (Collins 2004).*

- allows contextual perceptions, locally (ecologically – embedded in a real geography & not conveniently virtual), and transversally (moving, exchanging, comparing), at a slow pace, enhancing attention and fostering serendipity (because walking can be potentially iterative, i.e. open to unexpected disturbances) ;
- bears potentially social and political value, dealing with shared spaces and public space ;
- may combine exchange & introspection (because of encounters with others, and of time given for inner change especially when practicing long-distance walking) ;
- offers an ordinary experience, accessible to all who take the time for walking: walking is low-tech rather than high-tech, and it is open to non elite-wisdoms from all human groups.

In consumer culture, walking is limited to shopping spaces, amusement parks and dedicated half-a-day footpaths for the holidays. However, if one takes the time and effort that some more walking requires, and does it with care and attention (and with the help of walking-based methodologies), one will be learning, while walking (and observing, smelling, touching, attentively, one's surroundings), eventually managing to interpret the most subtle and nearly unnoticeable signs on the road sides, readily discovering what one was not looking for.

Walking can become a genuinely transversal method for knowing, sensing and changing the realities of local communities (and combining artistic and scientific approaches).

Transformation may then also occur, as the reshaping of the form of reality.

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9 Sustainability and Spirituality: A Transdisciplinary Perspective

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Abstract

This paper addresses some issues that describe the experience of a transdisciplinary process and the place of spirituality within the aim of sustainability at the Universidad Veracruzana in Mexico. Spirituality as a dimension of human beings and natural systems, sustainability through the consciousness of a general ecology and transdisciplinary as a transformative experience that allows the inclusion of spiritual dimension in our aim for creating sustainable futures. Our dialogue with the popular traditions and cosmology of ancient Mesoamerican Philosophy is a core in the relationship between spirituality and transdisciplinary.

1. Transdisciplinarity, Sustainability and Spirituality

This paper addresses some issues in our transdisciplinary educational experience for sustainability at the University of Veracruz, Mexico, where we include the spiritual dimension within the aim for sustainability futures. Spirituality is understood as *participating consciousness* that involves the identification of human beings within their environment, where all natural elements and things seem to be alive (Berman, 1987). As a dimension of life, spirituality is understood as an experience that connects all life and human beings with wholeness, which means giving a sense of deep connection with creation and life. Likewise sustainability is understood through the consciousness of a general ecology that implies the recognition that we participate within a larger whole.

These proposals involve a whole epistemological dimension in which the transdisciplinary perspective holds a central place.

Our aim is sustainability—to imagine, create and reinforce our commitment with the subtle weave of interdependence within our planet and our bioregional places— in our ways of living, in our societies. This means the necessary evolution of a spiritual dimension within us and within our communities that reinforces our commitment to life and its preservation and to health, harmony, balance, wholeness, and diversity. This commitment rests on a deep sense of the sacredness of life expressed as love, nurture, creativity, wonder, faith, hope and justice (Orr, 1992).

"Tomorrow may be too late," Basarab Nicolescu said when referring to the triple dimension of the potential self-destruction of our species—material, biological and spiritual—as a product of a blind but triumphant technoscience, obedient only to the implacable logic of utilitarianism. "In the Age of Reason, the irrational is more active than ever," and in this moment of the history, "humanity has the possibility of complete self-destruction" (2002:6-8). Of course, if we do not create new relationships with life and within ourselves, if we do not imagine another way of being in our planet, in our *Mother Earth*—as our ancient people in Mexico referred to it—we will not be able to exist for long as human beings in this planet. The evidences of the planetary/environment crises are plenty (Lazlo, 1990; Morin, 1993).

In this context, as an educational institution, our purpose is to integrate alternative ways to create knowledge that go beyond rationalism and modern science. Our challenge is to learn how to ask new questions and how to improve our thought, research and educational praxis. If we want to create relevant knowledge and co-create new realities in our lives, we have to question the relation between the knowing subject and that which is observed. We need new referents in our way of conceiving *Reality* and our relationship with it. We have to transcend rationalism, dualism and fragmentation of modern science. We need to conceive knowledge as part of a multidimensional and systemic world and situate the ethic and political dimension of the act of knowledge and its social and planetary commitment. "We need to ecologize knowledge based in a self-eco-organized conception that considers the vital link of every life system—human or social—with its surrounding environment" (Morin, 1993: 82).

Transdisciplinarity and systemic thinking provide us with the epistemological tools to challenge the complexity of reality. From a transdisciplinary point of view, complexity is a modern form of the very ancient principle of universal interdependence. This principle entails the maximum simplicity that is possible and that the human mind could imagine, the simplicity of the interaction of all the levels of Reality. This simplicity can only be captured by symbolic language (Nicolescu 2008:19).

In particular, transdisciplinarity offers a conceptual frame to conceive Reality in a non-reductionist way. This methodological perspective provides us with (1) A notion of the multiple levels of *Reality* and Perception; (2) the logic of the *included middle* that allows us to state at the same time the existence of one thing and its opposed; (3) the recognition of the spiritual level of Reality in the core of the knowledge process; and (4) the inclusion of the sacred or the so call *hidden third*, which is in the space of non-resistance, situated in the place where object and subject interact within the knowledge process. (Nicolescu, 2002, 2009).

Transdisciplinarity implies a permanent epistemological awareness, which means that the subject/object relationship is in the core of the act of knowledge. In this sense, the epistemological awareness allows us to incorporate the sacred and spiritual dimension in the main process of knowledge and praxis and to break the static disciplinary meanings and the multiple dichotomies of subject/object, reason/intuition and mind/body. This process allows us to transcend the rationalistic attitude that leads us to take shelter in the certainties that prevent us to go further in our questions and actions. "Transdisciplinarity is a way of self-transformation, oriented towards the knowledge of the self, the unity of knowledge, and the creation of a new art of living" (Nicolescu, 1997).

In this sense we conceive transdisciplinarity as a transformative experience, as a healing and self-transformation process, where the person opens to the permanent questions and the reflexive dialogues within different levels of Reality to approach the paradox of the complexity of the human condition.

At the same time, the dialogue with the cosmology and rituality of Ancient Mexican Philosophy, alive in many of the cultural practices today in our country, has been a very important axis in this relationship between the spirituality and transdisciplinary re-learning experience for sustainability.

2. Embodying Knowledge and Understanding: Our Being-Body in the Process of Knowledge

Man does not have a different body than his soul.

William Blake

Rationalism postulates that objective knowledge can be reached by the cognitive process of the rational and objective thought and that rationality is separate of emotions and separate from the body. For rationalistic thought, we must think in an objective way if we want to do science; that is, we have to think without the intromission of feelings and subjectivity. This is the only way to arrive to the knowledge of truth, to an objective, univocal and mechanical reality. In this sense, reality is separate of us, "out there," and knowledge is not alive. If reality is "out there" and is an object, we, the subjects of knowledge, are objects too; nothing is alive and we live in a fragmented world where everything is separated. We are lost in a disjointed world and we have lost our participative consciousness. *Participative consciousness* is the sense of being part of the cosmos, where we actively participate, because we are not separated (alienated) observers; our destiny is linked with all the cosmos and our lives have a sense in relationship with it (Berman 1987:16).

Our sense of being separated—conceiving our being, nature and our world in a materialistic way, where everything is separated and life is conceived as an object—is one of the most important tragedies of the modern world and of rationalistic thought. Nature is an inert and chaotic object that has to be controlled. In this world, we live as isolated individuals thinking of ourselves, in a permanent competition among others, seeking how to survive and how to get power, money, and comfort. We have lost our sense of community with life and within us.

> "Why is there this contempt for Nature, which we assume, without any real evidence, to be silent and impotent in regard to the pattern of meaning of our life?" (Nicolescu 2002: 1

In traditional forms of knowledge—in Mesoamerica, in South and North America, in Orient ancient cultures, in the so-called perennial philosophies—we find the presence of complex systems of knowledge that include a holistic notion of reality and a sacred view of life[1] . The empathic relationship with nature that indigenous people have is full of care, affectivity and sensibility. The elements of nature (the water, the fire, the earth, the wind) are alive, like persons; therefore the relationship with these elements has profound implications in the way people understand natural and biological processes and how they assume the act of knowledge. In this act, indigenous people communicate with nature in a sensitive experience. So cognitive experience is embodied in their daily and ritual lives. They dialogue, and in this act of conversation they interact and they create their appropriation process of natural source, a process full of care and love (Grimaldo, 1998). Mythology, rituality and the sacred are always present in these traditional systems of knowledge. When Gregory Bateson (1982, 1989) writes about the sacred in life, about the connecting pattern that is always there, he says, "we can hear the music of evolution and dance with it." That is what traditional cultures have always done in a sacred connection with Nature and Life.

Following these traditions and in a permanent dialogue with them, particularly with the Mesoamerican tradition that is still alive in many aspects of our way of living in Mexico, we find that the process of knowledge is linked with the *somatic experience* (Keleman 1987). Our being-body is in the core of the cognitive experience, the body-emotions/mind-spirit, as a whole, are at once integrated in what we are and in what we are learning and experiencing as subjects/objects of knowledge[2]. (Vargas-Madrazo, et.al. 2004). Cognitive experience needs to be in the Body to be able to break the rationalism, dualism and fragmentation of *Reality*, to be able to confront a complex and multidimensional Reality and a systemic organization (interrelationship). If we want to reach the multiple levels of Reality, we have to open ourselves to the possibilities of multiple levels of perception (emotion, poetics, intuition, love) because our levels of perception create our possibilities to create new knowledge. The corpse, emotions, mind and spiritual dimensions have to be joined in an *ecology of knowledge*, in an integrated and living process where experience is always present. Knowledge without experience is only information without meaning and without sense. Relevant knowledge is neces-

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[1] *Is important to notice that the 90% of the planet biodiversity is concentrated in indigenous territories where people have profound knowledge of natural and biological process of life (Toledo y Boege, 2007).*

[2] *The somatic experience means our biological process conceived like a mental/spiritual process; that is to say that a complex communication process is happening in our whole body (Bateson, 1982, 1989). Each molecule and cell has a complex and systemic interrelation, and in this communication process resides the corporal somatic intelligence.*

sarily linked with experience by a profound perception of our senses, of our multiple levels of perception.

Our body is the scene of the articulation of knowledge in our being. The somatic experience brings our biological life into being. We are not used to our **body life** and to conceiving ourselves as a **living process.** But when we are in contact with our soma through a deep sense of perception with our body through our sensitive awareness or empathy, we can understand and be connected with the organic/emotional level and with the vital energy or impulse that sustains it (the so call *élan vital –Bergson-*) (Keleman 1987). We can view our body as a living system in relation with the environment. The relationship that we establish with our body-mind-spirit influences our sense of relationship with the biosphere of our planet. (Bateson, M.C. 1989:192)

The experience of knowledge through our whole *body-being*—that is our biological life, our emotions and our mind/spirit process—gives us the possibility to improve our cognitive skills that help to open our levels of perception. Self-knowledge is the core to not only knowing ourselves but essentially as a model to understanding "others" in the relationship. As a part of whole life, we cannot be out of the relationship. The Mexican poet Octavio Paz gives us a beautiful image of this:

So that I can be, I must be Other
Get out of me and search me between Others
The Other that are not if I do not exist
The Other that give me my whole existence
Octavio Paz

If we want to integrate knowledge as a living experience, we have to let it grow within our being through the experience of connection, of unity with the "other," through empathy.

Our transdisciplinary approach revolves around the epistemological awareness that springs from the consciousness of our *being-body*. This awareness implies a healing process, something like "sensitive awareness."

> *Awareness is consciousness allied to knowledge. It includes being attentive to what goes on both inside yourself and in the external world. For the external world, the surrounding environment of space and society is as intrinsic a part of us as the nervous system and its body envelope. Awareness cannot be taught verbally. It has to be experience. And in order that it may be experienced, a particular learning situation has to be created. (Verin, 1977)*

Empathy is a discipline. It is a strategy to comprehend ourselves and the world in which we live. Of course there are limits; there are always profound mistakes in trying empathic understanding (Bateson, M.C, 1989). Can I, for example, change my under-

standing of anything by dancing with it? When we are involved in the rhythm, when we try a deep communication with that what we want to understand. In addition, Reality and its levels are infinite, and *knowledge is forever open* (Nicolescu 2008). Nevertheless, there can be truth comprehension when knowledge is alive within us not as information but as experience.

When concepts are living within us, when knowledge is incorporated in our *being-body*, we have the possibility of the unification of what Basarab Nicolescu calls the *multiple Subject*—results of the existence within the Subject of multiple levels of perception[3]. *Unification of the Subject is performed by the action of the Hidden Third, which transforms knowledge into understanding*. Understanding means the fusion of knowledge and being (Nicolescu 2008:22). In this sense, empathy and awareness involve the inclusion of the sacred, of the *hidden third*, where the interaction of Subject and Object takes place (Nicolescu 2002, 2008). In other words, the inclusion of the sacred is the emerging of *a way of being that connects*. (Bateson, M.C, 1989:193-194).

The sacred does not imply belief in God, in gods, or spirits. It is the experience of reality and the source of consciousness of existing in the world. (Eliade, 1978 in Nicolescu, 2008: 16)

The sacred is first of all an experience; it is transmitted by a feeling—the religious feeling—of that which links beings and things and, in consequence, induces in the very depth of the human being an absolute respect for the others, to whom he is linked by their all sharing a common life on one and the same Earth. (Nicolescu, 2008: 16).

3. Poetics of knowledge: The experience of sacred

In our dialogue with Mesoamerican traditions in Mexico, we have found that knowledge is intrinsically linked with the presence and the experience of the sacred. Everything is connected. The elements of nature are alive, and they have multiple connections with the person's life. Through the ritual life, as a way of knowledge, the indigenous tradition incorporates somatic experience and the sacred in their daily lives. Knowledge is linked with sacred experience, and rituality is present in many of the moments of community.

Through the experience of the sacred, the Mesoamerican way of knowledge understands natural processes and integrates this comprehension in daily life in a consciousness of a general ecology and basic respect for life. It recognizes our affinity with the living world and deals with it ethically and responsibly.

The essence of the sacred is relationship is the *connecting pattern* present everywhere. In life process (conceived by Gregory Bateson as a mental/spirit process), the

[3] *"Inspired by Edmund Husserl's phenomenology(Husserl [1966]), we assert that the different levels of Reality of the Object are accessible to our knowledge thanks to the different levels of perception potentially present in our being. These levels of perception allow for an increasingly general, unifying, encompassing vision of Reality, without ever entirely exhausting it. In a rigorous way, these levels of perception are, in fact, levels of Reality of the Subject." (Nicolescu 2009:19)*

elements of totality are connected as stories through metaphor communication; is the way that connectivity works, through relevance. We all share this way of thinking, by meaning, connection and relevance; in forests as well as in us (human beings), we think in terms stories (Bateson, 1989: 23-24)[4]. In all stories, the meaning emerges in the context of relationship, the meaning of words in human beings and of actions in every alive being. When we recognize the relationship, the *connecting pattern*, we discover what is not trivial. We recognize that we are part of the living world and we rescue the sense of the biosphere and of the humanity unity—we rediscover an ecology. In this way we recognize our *participative consciousness* (Berman 1999:16) and we rise to live the poetics of life (Morin 2003: 157). We recognize beauty and we can enter to the depth of living knowledge. When we enter to the sacred scope, we can recognize the beauty of creation; beauty as the substance of all that is alive. Ancient philosophers recognize clearly that *global wholeness is primordially beautiful.* We have lost the sense of biosphere and humanity unity, a poetic sense that can link us with beauty and reverence for life (Bateson 1982:28).

Rituals and symbolic practices are the main actions that allow us to connect with the sacred scope. We know that every sentient being—plants and animals—practice symbolic actions throughout the communication and organization that takes place. Nature has designed rituals as the way we organize our life and our social systems. It is not possible to live without doing rituals[5]. As symbolic practices, rituals allow us to experience life and all kind of social actions and connections through metaphor and paradigms (Turner, 1974); ritual it is a poetic language that allows us to experience the sacred. Through metaphor we experience the sense of unity because metaphor unifies things that are apparently separate. Through experience, ritual and metaphor we come into living knowledge, that is, we incorporate knowledge into our being-body.

In our *Re-learning Transdisciplinary Process,* we use the somatic experience and the permaculture metaphor: *everything gardens*. Through this idea, the somatic experience is linked with the communitarian process. Community is in the core of the *participative consciousness*. The idea of co-intelligence comes from the permaculture metaphor: "everything gardens and everything has an impact on its environment." Co-intelligence is the dance of mutual gardening, of co-influence, of co-creativity. So the notion of co-intelligence refers to the ways people influence each other individually and collectively through social systems. Intelligence is the capacity of life to create and modify patterns

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[4]*The alive world is a symbolic world -Creature- where everything is impossible to understand without the evocation of difference and distinctions. In this world the communication exists through metaphor and everything gets its significance through the relationship. Organism are not things they are relations and the biological world is organized through communication process, that is to say, through metaphor, aesthetic or poetics. (Bateson, 1979).*

[5]*The cells and the molecules realise their own rituals for communication and auto-organization process. In fact, many studies have indicated the existence of complex social behaviour in cells and molecules.*

in its search for what works and what satisfies it. Co-intelligence adds the idea that such patterning is mutual, multidimensional, holistic and evolving. Co-intelligence involves bringing a diversity of perspectives into synergistic interaction through true dialogue to increase the validity, comprehensiveness and fruitfulness of the collective insights that emerge (Atlee, 2003).

In our *Re-learning Transdisciplinary Process*, we are interested in those rituals that focus on depth of human beings to make sense of ourselves and of our relationship with other humans, with nature and with wholeness. Through ritual experience, we explore how the sacred is present in everyday life of the traditional culture in our country, and we learn how these practices attune people with the rhythms of nature; that is, the natural patterns that are outside and inside human beings. We explore how ritual practices of the traditional culture allow us to resituate our connection within ourselves, with the environment, and to create a community rhythm. So we embrace the Mesoamerica ancient philosophy that is still alive in Mexico as a time/space where community emerges and where the opportunity of dialogue, of coherence and co-organization is open. We conceive dialogue and community as a way to create sustainable futures.

4. Conclusions

Our transdisciplinary educational experience for sustainability includes the spiritual dimension as a core for creating relevant knowledge within our societies, at local and global levels. As a main tool for including the spiritual dimension in our research and educational processes, we set the body/being in a central place of the so- called *Re-learning Transdisciplinary Process*. Through this process we use the potentialities of the transdisciplinary perspective to go beyond rationalism, dualism and fragmentation of knowledge. In this way transdisciplinary provides us with the essential tools to improve our thought within the great challenge of creating sustainable futures. At the same time we make an important dialogue with ancient philosophies and traditions in Mesoamerica that improves our way of understanding the spiritual dimension and its place in sustainability.

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10 Transdisciplinary Art, Technology, and Management for Sustainable Enterprise

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Abstract

This paper presents a transdisciplinary approach integrating arts, technology and management to develop sustainable enterprise. We are living in a crisis society in which most major economic, ecological, social, political and cultural systems have broken down. Sustainability and sustainable development have been proposed as solutions to bring us out of crisis. However, sustainability requires transdisciplinary knowledge and solutions. We report on our effort to use transdisciplinary understanding of arts, technology and management in the service of sustainability. The International Research Chair in Sustainable Enterprise and the ARTEM project are discussed as examples on transdisciplinary research and transdisciplinary institutional development. Some lessons from these experiences for research and collaboration are discussed.

1. Introduction

This paper focuses on achieving enterprise sustainability with transdisciplinary arts, technology and management. We were motivated to write this paper by a simple statement from a participant at an international transdisciplinary conference (Balance-Unbalance 2011, Montreal). Participants were asked what they hoped to gain from this conference which focused on art and science reflections on the environmental crisis. One participant said that the conference …"will be helpful to me, a person trying to find my place as an artist, change-maker and just plain old regular girl."

It is in this possibility of making us into plain old regular persons that transdisciplinarity holds its major promise. It can help us become fully human by integrating arts, science, technology and management into a holistic and sustainable way of living. Artists, scientists, engineers and managers are also plain old "regular people", trying to find responses to the environmental crisis. Transdisciplinarity offers a novel reflection of dialogue across disciplines, across professions, and across practices. There are already many dialogues across disciplines in the sciences and engineering. These are exemplified in the work of ATLAS[1] and the past issues of TJES[2]. In this paper we add to these approaches, by adding discourses from the arts and management to science and technology.

Using art as a catalyst, we explore intersections between nature, art, science technology, society and management as we move into an era of both unprecedented ecological threats and transdisciplinary possibilities. We highlight these threats as they manifest in our current global environmental and socio-economic crises, and explore solutions in the form of transdisciplinary understanding and institutional arrangements that favor sustainability. The paper begins by describing the various crises we are now facing using the concept of the "crisis society". The next section proposes "sustainability" as a solution to these multiple crises. The following section suggests transdisciplinary knowledge as the means for understanding and acting on sustainability imperatives. We then describe two examples of transdisciplinary research and institutional arrangement. We end the paper by discussing some lessons for transdisciplinary research and action.

2. The Crisis Society

What we are facing today is not just an "environmental crisis" or "carbon crisis" [1]. We are living in a "crisis society". In other words, the current environmental crisis is not separate from us nor is it taking place outside of our lives; instead it passes through us and we are immersed in it. Both society and environment are complementary and are brutally affected by each other. We wish to centre the notion that the environment or broadly nature, includes culture as part of it. We humans and all our arts, science, economy, technology, culture and society are a miniscule part of an evolving environment. Therefore, a crisis of nature is also a crisis of our social, economic, political, cultural and identity systems.

We live in a crisis society in which all major systems have broken down, they are not delivering sustainable performance for a very large percentage of the world population; a restructuring is long overdue. Let us exemplify these crises with some ecological, economic, social, and political evidence.

Ecological evidence comes in the form of accumulating carbon in earth's atmosphere, declining biodiversity, and collapse of ecosystems by overuse and pollution. For example, the atmospheric concentration of carbon dioxide is an overall good metric. Prior to 1800, atmospheric CO2 had remained at a steady state for millions of years at

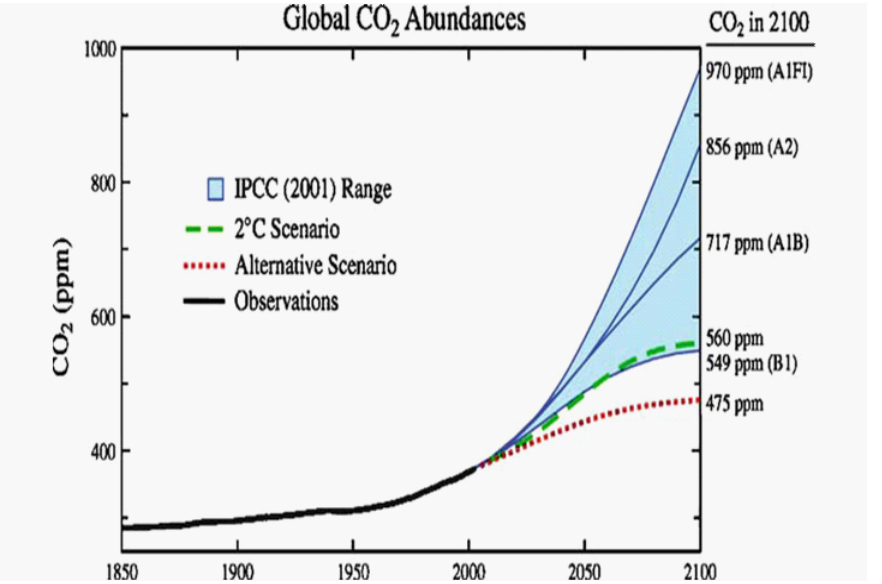

Figure 1. CO2 Scenarios According to IPCC (2001).

a concentration between 180 to 270 ppm [2]. With the onset of industrialization, mass energy production and consumption, atmospheric carbon began increasing rapidly. Current levels have reached 390 ppm, more than twice as much as the pre-industrial era. This accumulation of carbon is associated with disturbances in climate patterns, global warming, declining biodiversity and eroding life support systems. All the alternative scenarios modeled by IPCC[3] scientists (see Figure 1), indicate that even the best-case scenario (the dotted red line reaching 475 by 2100) already places us way beyond safe carbon limits, which was agreed as 350 ppm [3],[4].

Evidence of economic crisis is apparent in the current global financial crisis that started in the U.S in 2008 and has spread across the world. Unfortunately, that is only the latest in a series of colossal and devastating economic collapses – Asian financial markets in the 1990s, Argentina collapse in 2000, Iceland's bankruptcy in 2010, and the current crisis in the Eurozone with Portugal, Ireland, Greece, Spain, all being propped up by artificial "market stabilization" measures that temporarily delay the eventual collapse of individual economies.

Evidence of social crisis is manifested in global poverty and inequity. Two thirds of the world lives in poverty, and an estimated 986 million people in deep poverty in 2004 – receiving only a $1 per day [5].

The poorest 10 percent consumes 2.5 percent while the richest 10 percent consume 30 percent of global GDP. This inequity is unsustainable, and unconscionable.

Finally, evidence of political crises can be blatantly seen on all major forms of daily

media the Arab Spring revolutions in the Middle East and North Africa, the global war on terror now raging in over forty countries, armed conflicts among nations, with large numbers of deaths and injuries around the world is fueling political crises.

There is scientific consensus on these crises, summarized in the following:

- IPCC – Synthesis Reports on global climate change [6],
- The Stern Review: The Economics of Climate Change [7],
- The Economics of Ecosystem Services and Biodiversity (TEEB) 2009 by the Convention on Biological Diversity [8],
- World Development Reports [9], World Hunger Reports [10].

3. Sustainability as a Solution

Human civilization is clearly out of balance with nature. One approach to bringing balance back into our nature and culture relationships is through the concept of sustainability. First proposed by the Brundtland Commission, but now articulated in a myriad of ways by many disciplines, including biology, ecological economics, geography, climate sciences, sociology, political science, and management studies. It has also been implemented in numerous international treaties:

- Stockholm Earth Summit - 1972 formation of UN Environment Program
- Montreal Protocol on Substances that Deplete the Ozone Layer - 1987
- Rio Summit or UN Conference on Environment and Development - 1992
- Kyoto Protocol to the United Nations Framework Convention on Climate Change - 1997

Despite all the intellectual and practical development of sustainability concepts, over the past 25 years, and despite all our good intentions, have we actually become more sustainable? Our short answer is an unequivocal NO. We are living more unsustainable life styles than we did in 1992 when the Rio Treaty was signed and promised to reduce world carbon accumulations in the atmosphere 5% below 1990 levels to 350 ppm. In 2010 it climbed to 390 ppm, and continues to increase toward 430 ppm, growing at 2.3 ppm per year. And on most other indicators of planetary health we have already crossed or near crossing safe thresholds [11]. This leads us to believe that there are deep and debilitating gaps in our intellectual understanding of and commitment to sustainability.

Let us illustrate the epistemic challenge of living sustainably by examining the personal carbon footprint of one of the authors (Shrivastava). In 1975, when he had not even heard the term “sustainability” his carbon footprint was 2 tons per year. Over the next 30 years he became an expert in sustainability publishing numerous books and

dozens of papers on this topic. His carbon footprint went to 22 tons per year in 2005. His scientific cognitive understanding of sustainability did little to make his lifestyle more sustainable. In other words, scientific understanding alone is not sufficient for changing behaviors towards sustainability. Sustainable behaviors require emotional engagement with nature - in our hearts, in our bodies, and with passion [12]. As creatures of habit we live very differently from the way we think.

4. Knowledge for Sustainable Human-Nature Balance

The ways of knowing that we use to understand nature-human balance is a big part of the problem. Much of our knowledge about nature and crises (especially what informs government policies and corporate strategies) is scientific, discipline-based and highly fragmented. We are over-dependent on one type of knowledge, which is rational, cognitive, scientific, and we ignore emotional, embodied and intuitive forms of knowing.

Obviously, disciplinary knowledge has been very productive in understanding many aspects of the crises we are living with. However, disciplines themselves have become progressively fragmented and bureaucratized. The number of scientific disciplines has exploded [13]. In the year 1250 there were only 7 distinct disciplines (In 1251 the University of Paris had 4 Departments). By 1950 there were 54 disciplines. In 1975 the JACS[4] - Higher Education Statistics Agency of UK recorded 1845 disciplines. In 2010 National Register of Scientific and Technical Personnel, National Science Foundation (NSF) archives, USA) listed 8000 scientific disciplines.

Coupled with fragmentation of disciplines is the increasing bureaucratization of scientific research. Much of science and engineering research today happens within big bureaucracies of universities, funded by large governments, international agencies, and corporations.

Our disciplinary understanding is highly fragmented, and organizationally filtered by political and social interests. We know more and more about less and less, and in a partial disconnected way. Disciplines do not offer a way of connecting the dots, and understanding the intricate relationships within nature and between nature and culture.

In the context of a globalized world driven by new technologies and rapid actions that businesses have to undertake, work is becoming increasingly complex and diversity plays a major role. As mentioned by Marinova and McGrath [14: 2] this complexity and diversity in the world requires commensurate knowledge and skills by citizens, professionals, and leaders that cross the boundaries of disciplines and institutions, cultures and social realities. The approach able to cross these boundaries is transdisciplinarity.

5. Transdisciplinarity

These knowledge challenges can be addressed by transdisciplinarity, which seeks to produce holistic understanding and collaborative actions needed to resolve real problems. A transdisciplinary reconciliation of arts, sciences and practice can help overcome

crises in a holistic, integrated, and embodied way. It can re-imagine a future that is unbounded by disciplinary prejudices and conflicts of the past [13].

The concept of Transdisciplinarity has been developed by a Swiss philosopher and psychologist Jean Piaget in 1970. This was nearly seven centuries after disciplinarity had evolved. The word "transdisciplinarity" itself first appeared in the talks of Jean Piaget, Erich Jantsch, and André Lichnerowicz at the international workshop "Interdisciplinarity– Teaching and Research Problems in Universities," organized by the Organization for Economic Co-operation and Development (OECD), the French Ministry of National Education, and University of Nice [13].

Transdisciplinary knowledge can help individuals and organizations to move towards sustainability. It can help understand the complex challenges, personal responsibilities and action possibilities for sustainable living. As pointed by Costanza [15], transdisciplinarity dissolves the frontiers between traditional disciplines and "will allow us to build a world that is both sustainable and desirable and that recognizes our fundamental partnership with the rest of nature". Let us first examine what transdisciplinarity means in terms of its basic assumptions, and in terms of research processes.

As the Charter of Transdisciplinarity [16] states, this approach to knowledge makes specific ontological, epistemic, methodological and ethical assumptions:

- It is open, non-reductionist, inquiry into the human condition and human-nature relations. Ontologically it accepts that reality is manifested at multiple levels - physical, social, emotional, and spiritual, each governed by different types of logic.
- Epistemologically it assumes that many forms of knowledge are not only possible, but necessary. It opens all disciplines to that which is beyond themselves. It aims for semantic and practical unification of meanings to achieve pragmatic solutions to real problems.
- Methodologically, transdisciplinarity favors rigor, openness, and tolerance. Evidence based rigor in argument is the best defense against possible distortions. Openness involves acceptance of the unknown, the unexpected, the unforeseeable, even the unknowable. Tolerance implies acknowledging the right to ideas and truths opposed to our own.
- Ethically, transdisciplinarity is about dialogue and engagement across ideological, scientific, religious, economic, political and philosophical lines. It seeks shared understanding based on absolute respect for collective and individual otherness united by our common humanity.

Doing Transdisciplinary action-research:

- Requires a starting point, focused on problems - research is phenomenon and problem focused, not theory or model driven. (problem/demand-driven research).

- Is Collaborative - Complexity requires collaboration – complex problems cannot be fully resolved within a single discipline or perspective, or by a single stakeholder.
- Is Iterative or co-evolutionary between stakeholders, academics, practitioners, and the public. There is no strict separation between knowledge production and knowledge transfer, they occur in parallel and intertwined ways.

Sustainability and transdisciplinarity are closely related. The necessity to apply a transdisciplinary approach in dealing with sustainability issues, is linked to their very complex and dynamic nature. Sustainability requires the simultaneous understanding and integration of three main different and complex dimensions: economic, ecological, and social, which interact with each other in intricate ways. Hurni and Wiesmann [17] suggest that transdisciplinarity "is necessary to identify and reflect on sustainability-oriented research for development and to facilitate various stages of implementation of this form of research".

Hirsch Hadorn, et al. [18] argue that the close relation between sustainability and transdisciplinarity is because sustainability is directly concerned with complexity and dynamic issues. According to them, the most important questions to be addressed by sustainability research deal with the way processes constitute a problem field, multifaceted sustainability practices, and intricacies involved in transforming existing practices. Talking about the relations between transdisciplinarity and sustainability, Klein [19] also stresses that transdisciplinarity raises the question of not only problem solution but problem choice. Jansen [20] thinks that the renewal of systems as one of the most important dimensions of sustainability, "… implies a strategic approach and breakthroughs in which transdisciplinarity is a key factor…".

Developing the need of collaboration as a requirement for establishing transdisciplinary action research, Stokols [21] identified three types of collaboration: among scholars representing different disciplines; among researchers from multiple fields and community practitioners representing diverse professional and lay perspectives; and among community organizations across local, state, national, and international levels.

Transdisciplinary Arts and Sciences can restore our balance with nature and foster sustainability. Gregory Bateson, one of the most original transdisciplinary thinkers of the late twentieth century, in his "Step to an Ecology of Mind" wrote, "When we find meaning in art, our thinking is most in sync with nature" [22]. This deliberately open vision of transdisciplinarity sees the natural sciences in dialogue and reconciliation with the humanities, the social sciences, as well as with art, literature, poetry and spiritual experience to build human potential and well-being.

Transdisciplinarity treats human identity as an evolutionary, planetary and cosmic phenomenon. Humans have co-evolved on and with the earth and its environment is one of the stages in the history of the Universe. Human physical evolution of the past is now conjoined with evolving intelligences both natural and artificial. Human identi-

ties based on nation, place, religion, clan, and culture are secondary to our identities as earth citizens.

Authentic transdisciplinary sustainable knowledge melds cognitive, sensory, and emotional ways of knowing into contextual, concrete, local and global solutions. It valorizes intuition, imagination, sensibility and the body, in the transmission of knowledge.

Transdisciplinary arts and science can help our crises ridden society by:

- empowering individual action, instead of waiting for leaders,
- enabling local and regional solutions, to protect bio regions,
- enabling immediate action - overcoming political gridlock,
- providing holistic integrated solutions.

The need to adopt transdisciplinary approaches for sustainability was already stressed by several researchers [14], [23]-[28]. Experiences involving transdisciplinary research approaches are becoming more frequent in many fields. Hirsch Hadorn et al. [29], for example, provide an overview of the manifold experiences gained in many fields.

6. Our Experiments in Transdisciplinary Research and Institution Building

To illustrate our transdisciplinary approach to sustainability we describe two projects. First a transdisciplinary research project on art and sustainable enterprise, and the other an educational institutional arrangement, ARTEM that combines art, technology and management to create transdisciplinary education.

a) Art and Sustainable Enterprise (www.ircase.org)

Art influences the enterprise sustainability through architecture, aesthetics of workspaces, design of products and services, graphic art in advertising, and arts-based training methods. Sustainable organizations need arts to attract creative workers, improve worker satisfaction, design eco-friendly and innovative products and services, and enhance employee creativity, innovation, and personal growth. Aesthetic inquiry allows us to study and to develop some ignored aspects of organizational sustainability, such as sensory and emotional experiences. Aesthetic practices offer pedagogical techniques (from music, dance, painting, photography, etc.) for teaching and training on sustainability issues.

According to Shrivastava [12], the arts, as the repository of human passion, are a fruitful avenue for infusing passion into our pursuit of sustainability and building enduring commitment to it. Art, with its unique ability to symbolize complex abstrac-

tions in concrete ways can raise awareness, and bring about a shift in mindset necessary for sustainability. Artistic knowledge is embodied, sensory, emotive, experiential, and holistic. It embraces cognitive conflicts/contradictions and offers emotional resolutions to them. Art is a fundamental type of human experience that has served both social and instinctual functions throughout history. It has the potential for providing emotionally compelling solutions and bringing about real changes in individuals and organizations.

Enterprise managers and employees need to find deeper meaning in work. They need art as an expressive media to become whole and authentic, and to contribute creatively to innovation-starved organizations. Art can spur innovation in design of product/services, in social and work practices, and in the architecture of physical and emotional spaces. Enterprises can learn many things from the arts, including innovation, systemic and contextual thinking, creativity improvisation, resilience and conflict resolution. This project has two objectives:

1. Develop a conceptual framework to establish the intellectual connection between art and sustainable development of organizations, and undertake research projects in this area.
2. Develop an instrumental practical project allowing the design of tools in service of managerial practice of sustainable organizations.

To achieve these goals the project works on several dimensions: research and conceptual work, instrumental or practical projects, and international network building.

Our conceptual framework is built around the following streams of literature, all of which address connections between arts, sustainability and enterprise.

1. Organizational implications of "Design Thinking" - How can design thinking advance sustainable design of products, packaging, work spaces, work flows, habitats, transportation, and organizations.
2. Use of "Arts-based methods" for understanding management concepts and learning management skills.
3. "Sustainable Art" and environmental art– What are the connections between art and sustainability, where is the discourse, and what key intellectual challenges is sustainable art addressing? [30].
4. "Aesthetics theories" and epistemological needs of sustainability. Scientific epistemologies and political praxis seem inadequate for addressing sustainability challenges. Do aesthetic theories offer a better way forward?
5. Psychology of aesthetic perception.

As a second dimension of this project we develop practical programs that help the Lorraine region, companies, communities, and students to engage with sustainability. This involves studying how organizations practice sustainability using art and aesthetics. For example, RSM Richter, a consulting firm based in Montreal, is using installation

art to raise awareness of sustainability and diversity, and attract employees. Ben and Jerry's Ice-cream HQ uses art to express values and culture. Disney Parks use architecture to manage people flow, crowd control, and waiting times. Event managers have used the arts to provide more holistic experiences – by integrating music, theatre, and multimedia shows. Web designers use arts to shape web experiences.

This dimension also seeks to the design of aesthetic practices and tools that can be used to aestheticize organizational experiences, products and services. An outcome is the design of art-based training approaches for sustainable development. These develop aesthetic sensitivity of learning, and create sensory and emotional engagement of learners to the service of sustainable development.

This program involves students and businesses learning sustainability through collaboration with artists and communities. It pursues collective social and environmental goals, encouraging participants to make connection between art and sustainable enterprise.

b) ARTEM

ARTEM stands for ARt, TEchnology and Management. It is an alliance between the Ecole des Mines de Nancy (Graduate School of Mines/Engineering), the Ecole Nationale Superieure d'Art de Nancy (National School of Art) and ICN Business School. It is an alliance of people, artists, engineers, and business people that encompasses the disciplines of art, science, technology, and management. ARTEM enables these schools to enrich their teaching resources and to expand student's educational horizons by brewing together art, technology, and management. Increasingly, the success of a project depends on a triangle of skills: "art, technology, and management". In other words ARTEM is a multidimensional educational project encompassing:

- a political dimension - the political local authorities - with help from the government ARTEM is setting up a new teaching and research structure in Nancy which is characterized by a transdisciplinary approach based on an entrepreneurial view that continues the tradition of "Ecole de Nancy" into the 21st century,
- an open educational process – its pedagogical and research topics are not fixed ex ante, so the process is open, in order to permit creativity and innovation,
- mixed pedagogical methods ARTEM is experimenting with mixed groups of students coming from the three different Schools to manage the "shock of disciplines" and to find common values and practices; this pedagogical process is linked to problem solving activities, but cannot be reduced to a problem-solving concept. The three schools function interactively and offer several curriculum bridges called Artem workshops. These disciplines provide the know-how to conceive, produce, and negotiate, in order to form a new generation of leaders.

- integrated learning space - new state of the art campus shared by the three schools with common facilities.

Since 2000, ARTEM has benefited by the support of about 40 businesses and other local, regional and national economic actors as an association known as ARTEM-Entreprise [31]. This association supports the ARTEM dynamics and provides the forum for dialogue between students, teachers, researchers, and professionals with different backgrounds. ARTEM-Entreprises offer facilities for developing transdisciplinary skills in "cross-cutting workshops" [32]. Each company brings concrete examples and field experiences to students from different backgrounds. Since 2007, many companies have offered projects to students and teachers from the three schools to increase sharing of experiences.

Artem is also developing a common research platform bridging the school's research labs. The three main research themes of the Artem research platform are: division of labor, risks and uncertainties, as well as creativity. The division of labor theme examines how labor processes are questioned, enhanced, or undermined, by current practices in electronic media and mobile technologies. It also explores the increasing complexity of relationships between different types of practitioners (artists, designers, engineers, developers, etc.), as well as the increasing complexity of the notions such as authorship of collective works, sharing authorship with scientists or engineers, processes like "open source" that provide a new place for amateurs. This concept is transdisciplinary, and addresses the issue of hidden relations between art, technology and management.

Artem's second research theme is the ever-increasing concern of companies in relation to risk identification, assessment & management, both technological and natural. Coping with these concerns requires multiple skills, multi-disciplinary knowledge, and an ability to understand and analyze increasingly complex global systems. These risks go beyond the field of science, technology and management, to include personal fears, rumors, imagination and passion. The goal is to work along interfaces between science and art, to render risks and uncertainties more transparent and tangible, yielding practical solutions.

The third research theme includes artist and entrepreneur identities, creativity, and performance. The personal identity of artists and entrepreneurs is a subject of intense discussion and conflict. This sub-theme deals with examining what constitutes their identities, how identities influence engagement with sustainability issues, and how these differences often lead to misunderstandings and conflict. Creativity is an essential element of enterprise sustainability. Many types of creativities (scientific, organizational, social, artistic, strategic, etc.) need to be combined for sustainable development. This theme will develop an understanding of creativity as a mental process, identifying factors that influence the stimulation of creativity particularly in organizations.

The last sub-theme deals with organizational performance. Performance itself is obtained by including creativity, hence the need for a "productive" relationship through constructive dialogues between different actors (finance, H.R, production, marketing, engineers, and artists). In that sense the Artem project can be seen as an experiment, or a performance, which we can learn from. At this point, the emphasis is on design of constructive dialogue, the search for mutual understanding and the question of organizational scope (definition of relevant stakeholders invited to the dialogue).

The new Artem campus is being built, in the heart of Nancy, France. It symbolizes the Artem's transdisciplinary spirit in its innovative energy savings, host island gardens, and creation of convivial spaces. Artem will become the research centre for all three schools. Created by famous French architects, the ten hectare campus will be the catalyst of synergies between schools. The building architecture emphasizes shared spaces, eco-citizenship and openness to the city through a radiating hub for transdisciplinary collaboration. The campus spatially reflects a desire of transversal engagement, openness and creativity, oriented towards the discovery of other disciplines and teaching of foreign languages. Student housing, *Café ARTEM*, a media center incorporating digital access to information resources, and the ARTEM Gallery, create a holistic space of convergence for academia.

7. In Lieu of a Conclusion

Transdisciplinarity discourse in engineering and the sciences has come a long way in integrating across scientific disciplines. There are also some efforts to bridge the great epistemological chasm of the arts and humanities (such as Leonardo). In that journey we present here integrative transdisciplinary projects that links arts, technology, and management towards the goal of enterprise sustainability. Enterprises are the most important vehicles for production and consumption. Making them sustainable is a key challenge for achieving global sustainability as a solution to our many ecological, economic and social crises.

This paper is just a first step in articulating the assumptions and processes of transdisciplinary research and institution building that will be needed in the coming years to build transdisciplinary capabilities. We cannot offer firm conclusions, instead with an attitude of humility and openness, we suggest some fruitful directions for research and collaboration.

1. Transdisciplinary Collaborations – engaging different and diverse disciplines in knowledge based action.

   Knowledge based actions can be built on pluridisciplinarity (or multidisciplinarity), interdisciplinarity, and transdisciplinarity. These concepts are quite distinct but are often misunderstood and used interchangeably. Nicolescu [33] shows pluridisciplinarity concerns studying a research topic in several disciplines at the same time. Interdisciplinarity deals with the transfer of methods from one discipline to another. While both these approaches provide a better understanding of complexity, both remain within the framework of disciplinary research. According to Nicolescu [33] transdisciplinarity is the only approach able to simultaneously address issues between disciplines, across the different disciplines, and beyond all disciplines. Applying transdisciplinarity in research, means creating collaborations – engaging different and diverse disciplines in knowledge-based action. From the practical point of view, the main challenges

are to get collaborators to change their reference frame, and to introduce new ways of understanding the dialectic between simplicity and complexity. The Artem experiment taught us valuable lessons about establishing harmony between attitudes and knowledge.

Choice of collaborators: openness of collaborators is an important feature to take into account for two main reasons. First, transdisciplinary approaches are quite new and few people are aware of their advantages. The more collaborators are open to dealing with novelty and uncertainty more they will be willing to work in novel ways. Second, is the ability of open minded collaborators to adopt and accept motivations, attitudes and knowledge of others.

Establishing a positive dialogue between collaborators: This means that in spite of differences between collaborators there should be a positive collaboration climate. This could be facilitated by explaining clearly the project goals, respecting all parties, use of different work spaces (artists, for example, are less inclined to work within the confines of a meeting room). Working with artist collaborators requires a very good prior understanding of their identity, values and motivations. Words such as compromise, freedom, value, morality, utility, standards, truth, market, business, performance, principles, and outcomes, are perceived quite differently and should be carefully used and explained. Some of the art students see managers as “devils” or “capitalists” devoid of values and principles for whom money is the most important virtue. Successful transdisciplinary collaboration depends on coping with a paradox: asking artists to be useful whereas art is not supposed to have utility as an end. Thus in transdisciplinary collaboration differences and obstacles should be considered more as opportunities than as obstacles. In this context, we should consider transdisciplinary knowledge not as disciplinary knowledge owned by a given silo but as “boundary knowledge”. This “boundary knowledge” contributes to establishing better constructive dialogue between collaborators.

Transdisciplinary action research: One of the main issues encountered when doing research including people with different scientific backgrounds is to establish a common understanding of the outcomes and, above all, how to achieve them. One possible way to overcome these difficulties would be to apply transdisciplinary action research i.e. the knowledge generated through solving real life problems, which in most of cases are holistic, complex and contextual. Levin et al. [34] argued that the cooperation within the research team and a participative approach to enterprise development, shape the type of knowledge that is produced. This idea was adopted by ARTEM - putting students and teachers from art, technology, and management to work together on real-life complex business issues.

2. Aesthetic Experimentation – grounding in practice, unthethering knowledge from displinary theory.

The use of aesthetic practices offers different ways of thinking and reasoning, which ultimately leads to sustainable work practices. This may result in new methodologies for addressing highly dynamic and complex work situations. Aesthetic practices also have the advantage of being pleasant, creating positive climates among participates, and permit people to innovate using their own preferred ways. This goes against the standard methods of inquiry, which lack personal engagement, passion and creative thinking. The results obtained during aesthetic practice experiments are very often surprising even for participants themselves. For example, participants of one aesthetic workshop conducted by IRCASE project, used painting for creating open work spaces, and found the experience "*enjoyable but disturbing", "...was a great experience as I didn't expect at all that it would be a pleasant exercise...", "... we lost our comfortable habits of being skilled in our field of expertise to discover the pleasure and the associated risks to create without knowing...", "... deeply learned a lot about myself and people in the group, about my own vision of the world,"*. Aesthetic experimentation has the potential to induce emotions and provoke a deeper awareness of feeling, something that is difficult with traditional methods of learning.

3. Creative Entrepreneurism - Opening access, reducing risks, empowering.

The Artem experience has shown that transdisciplinarity approaches foster the main factors of entrepreneurial success: innovation, connecting stakeholders and identifying business opportunities. Transdisciplinarity has promoted entrepreneurship with the creation of new businesses based on the Artem project workshops. These projects have become more creative in two ways: 1) the interactions between diverse students and teachers of three schools, and 2) with the serious commitment of business partners. Even when an Artem project has not resulted in creation of a specific new business, it still leaves behind a culture of entrepreneurship. This is because each Artem project is required to present a status called "pre-marketable prototype". Prototyping bringing together artists, engineers and managers into high quality dialogue across cultures and expertise, and makes knowledge the true driver of competitiveness and innovation.

Support of three schools and local enterprises also works towards reducing the risk of venturing and entrepreneurship. The transdisciplinary approach provides open access to different worlds and disciplines, including management, engineering, creativity, and design. It identifies potential sources of failure provides early warning signals, that allow participants to avoid mistakes and improve chances of success. This results in an empowering environment for students.

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