Transdisciplinary Art, Technology, and Management for Sustainable Enterprise

Paul Shrivastava[1] **and Silvester Ivanaj**[2] , [1] *Concordia University, Montreal, Canada, and IRCASE, ICN Business School, Nancy France, Email: paul.shri@gmail.com,* [2] *ICN Business School and CEREFIGE, Nancy, France, Email: silvester.ivanaj@icn-groupe.fr*

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.

Keywords: aesthetics, art, Artem, enterprise, management, sustainability, sustainable development, technology, transdisciplinary.

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

---

[1] Alliance for Technology, Learning, and Society

[2] The Transdisciplinary Journal of Engineering & 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 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

---

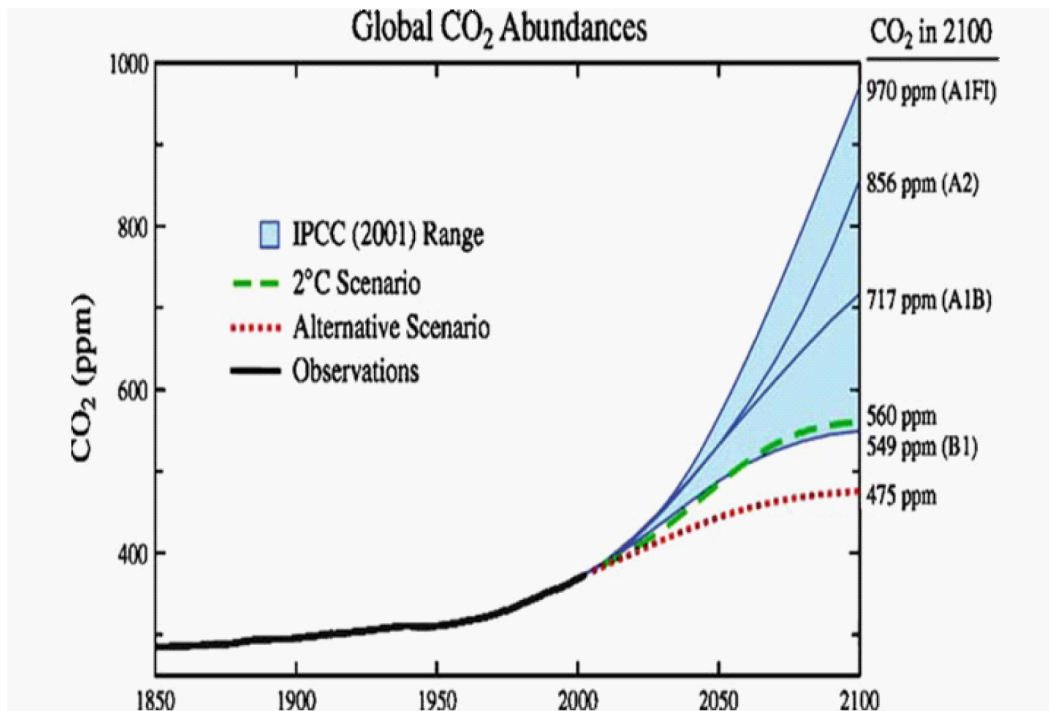[3]3Intergovernmental Panel on Climate Change.

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

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 Cooperation 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,

---

[4]4Joint Academic Coding System

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 identities 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 abstractions 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 Artems 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 advan-

tage 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 P. Shrivastava and S. Ivanaj/Transdisciplinary Art, Technology, and Management for Sustainable Enterprise 98 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.

Acknowledgements

References

[1] Busch, T. and Shrivastava, P., 2011. The emerging carbon crisis, Greenleaf Publishing, London.

[2] Denman, K. L., Brasseur, G., Chidthaisong, A., Ciais, P., Cox, P. M., Dickinson, R. E., Hauglustaine, D., Heinze, C., Holland, E., Jacob, D., Lohmann, U., Ramachandran, S., Da Silva Dias, P. L., Wofsy, S. C., and Zhang, X., 2007. Couplings Between Changes *in the Climate System and Biogeochemistry. In Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[3] Houghton, J. T., Ding, Y., Griggs, D. J., Noguer, M., Van der Linden, P. J., and Xiaosu, D., (Eds.), 2001. Climate Change 2001: the Scientific Basis. Cambridge Univ. Press, p. 892.

[4] Nakicenovic, N. and Swart, R., (Eds.), 2000. Emissions Scenarios. Cambridge Univ. Press, p. 612.

[5] World Resources Institute, "Population Living on Less Than $1 Per Day, 1981-2004," World Resources

Institute. http://www.wri.org/chart/population-living-less-than-1-per-day-1981-2004, July 24, 2008, accessed: Nov., 21, 2011.

[6] Intergovernmental Panel on Climate Change, 2001. http://www.ipcc.ch, accessed: Dec., 15, 2011.

[7] Stern, R., 2007. The Stern Review on the Economics of Climate Change. http://mudancasclimaticas. cptec.inpe.br/rmclima/pdfs/destaques/sternreview_report_complete.pdf, accessed: Dec., 22, 2011.

[8] The Economics of Ecosystem and Biodiversity Report, UNEP, 2009. http://www.teebweb.org /Link Click.aspx?fileticket=I4Y2nqqIiCg%3D, accessed: Dec., 15, 2011.

[9] UNDP, 2011. http://hdr.undp.org/en/reports/, accessed: Dec., 15, 2011.

[10] Hunger Report, 2011. http://www.worldhunger.org /index.html, accessed: Dec., 15, 2011.

[11] Rockstrom, J., Steffen, W., Noone, K., Persson, A., Chapin, F. S., Lambin, E. F., Lenton, T. M., Scheffer, M., Folke, C., Schellnhuber, H. J., Nykvist, B., De Wit, C. A., Hughes, T., Van der Leeuw, S., Rodhe, H., Sorlin, S., Snyder, P. K., Costanza, R., Svedin, U., Falkenmark, M., Karlberg, L., Corell, R. W., Fabry, V. J., Hansen, J., Walker, B., Liverman, D., Richardson, K., Crutzen, P., Foley, J. A., 2009. Safe operating space for humanity. Nature, 461(September).

[12] Shrivastava, P., 2010. A Pedagogy of Passion for Sustainability. Academy of Management Learning and Education.

[13] Nicolescu, B., (Ed.), 2008. Transdisciplinarity Theory and Practice. Hampton Press, Cresskill, New Jersey.

[14] Marinova, D. and McGrath, N., 2004. A Transdisciplinary Approach to Teaching and Learning Sustainability: A Pedagogy for Life. Teaching and Learning Forum, Proceedings contents. http://lsn.curtin.edu.au/tlf/tlf2004/marinova.html, accessed: March, 20, 2010.

[15] Costanza, R., 2003. A Vision of the Future of Science: Reintegrating the Study of Humans and the Rest of Nature. Futures, 35, pp. 651-671.

[16] Charter of Transdisciplinarity. http://basarab.nic olescu. perso.sfr.fr/ciret/english/charten.htm, accessed: Dec., 22, 2011.

[17] Hurni, H. and Wiesmann, U., 2004. Towards Transdisciplinarity in Sustainability-Oriented Research for Development. In Hurni H, Wiesmann U, Schertenleib R, editors. 2004. Research for Mitigating Syndromes of Global Change. A Transdisciplinary Appraisal of Selected Regions of the World to Prepare Development-Oriented Research Partnerships. Perspectives of the Swiss National Centre of Competence in Research (NCCR) North-South, University of Berne, Vol. 1. Berne: Geographica Bernensia, pp. 31-42.

[18] Hadorn, H. G., Bradley, D., Pohl, C., Rist, S., and Wiesmann, U., 2006. Implications of Transdisciplinarity for Sustainability Research. Ecological Economics, 60(1), pp. 119-128.

[19] Klein, J. T., 2004. Prospects for Transdisciplinarity. Futures, 36(4), pp.515-526.

[20] Jansen, L. L., 2003. The Challenge of Sustainable Development. Journal of Cleaner Production, 11(3), p. 231.

[21] Stokols, D., 2006. Toward a Science of Transdisciplinary Action Research. American Journal of Community Psychology, 38, pp. 63-77.

[22] Bateson, G., 1972. Steps to an Ecology of Mind. Chicago University Press.

[23] McNeill, D., 2001. Inter-disciplinarity and Sustainable Development Policy: What Have We Learned?, Presentation at the World Bank, 3 December. http://www.sum.uio.no/pdf/publications/working-and-occasional-papers/mcneill.pdf, accessed: March, 20, 2010.

[24] Eishof, L., 2003. Technological Education, Inter-disciplinarity, and the Journey toward Sustainable development: Nurturing New Communities of Practice. Canadian Journal of Science, Mathematics and Technology Education, 3(2), pp.165184.

[25] Dovers, S., 2005. Clarifying the Imperative of Integration Research for Sustainable Environmental Management. Journal of Research Practice, 1(2). http://jrp.icaap.org/index.php/jrp/article/view/11/30, accessed: March, 19, 2010.

[26] Polk, M. and Knutsson, P., 2008. Participation, Value Rationality and Mutual Learning in Transdisciplinary Knowledge Production for Sustainable Development. Environmental Education Research, 14(6), pp. 643653.

[27] Edwards, M. G., 2009. Visions of Sustainability: An Integrative Metatheory for Management Education. In Management Education for Global Sustainability, ed. C. Wankel and J. A. F. Stoner. Charlotte, NC: Information Age Publishing, Inc., pp. 5191

[28] Rohwer, G., 2010. How to Encourage Education for Sustainable Development in Geography. http://www.geo.fu131berlin.de/geog/fachrichtungen /schulgeog/medien/download/RohwerHow_to_enco urage.pdf, accessed: March, 20, 2010.

[29] Hadorn, G.H., Hoffmann-Riem, H., Biber-Klemm, S., Grossenbacher-Mansuy, W., Joye, D., Pohl, C.,

Wiesmann, U. and Zemp, E., (Eds.), 2008, Handbook of Transdisciplinary Research. Springer.

[30] Kagan, S., 2011. Art and Sustainability: Connecting Patterns for a Culture of Complexity. Bielefeld: transcript Verlag.

[31] http://artem.inpl-nancy.fr, accessed: Dec., 13, 2011.

[32] Ivanaj, V. and Ivanaj, S., 2010. The Contribution of Interdisciplinary Skills to Sustainability of Business: When Artists, Engineers, and Managers Work Together to Serve Enterprises. In J.A.F. Stoner & C. Wankel (Eds.), Global Sustainability as a Business Imperative, Palgrave Macmillan, pp. 91-109.

[33] Nicolescu, B., 2010. The Transdisciplinary Evolution of the University Condition for Sustainable Devel opment. http://basarab.nicolescu.perso.sfr.fr/ciret /bulletin/b12/b12c8.htm, accessed: Dec., 22, 2010.

[34] Levin, M., Borgen, E., Gjersvik, R., Klev, R., Munkeby, I., Rolfsen, M., and Saebo, H. J., 1997. Creating Transdiciplinary Knowledge– Learning from Working in the Field How Engineers and Social Scientists can Collaborate in Participative Enterprise Development. Concepts and Transformation, 2(2), pp. 165-188.

About the Authors

Dr. Paul Shrivastava is the David O'Brien Distinguished Professor of Sustainable Enterprise and Director of the David O'Brien Centre for Sustainable Enterprise at Concordia University, Montreal. He also leads the International Research Chair in Art and Sustainable Enterprise at ICN Business School, Nancy, France. In these roles he combines scientific and artistic approaches to sustainable development, exemplified in the conference Balance unBalance 2011, and his book Learning from the Financial Crisis (edited with Matt Statler) published by Stanford University Press. He has published 17 books and over 100 articles some of which are listed below under Publications.

Shrivastava held the Howard I. Scott Chair in Management, a distinguished professorship at Bucknell University (Lewisburg, PA), and was Associate Professor of Management at the Stern School of Business, New York University. He was awarded Fulbright Program Senior Scholar award to study Japanese corporate environmental management at Kyoto University, Japan. He has taught at the Helsinki School of Economics, and IIM Shillong. He is the author of Bhopal: Anatomy of a Crisis (1989), a book that launched the field of organizational crisis management. He founded the Organizations and Natural Environment Division of the Academy of Management (the world's largest academic professional association in Management studies).[5] He received a Bachelor's degree in Mechanical Engineering from the Maulana Azad National Institute of Technology, Bhopal, Post Graduate Diploma in Management from IIM Calcutta and Ph.D., University of Pittsburgh.

He co-founded two academic journals - The Industrial Crisis Quarterly published by Elsevier, and Organization and Environment published by Sage Publications, has served on the Editorial Boards of several leading Management studies journals, on the Board of Trustees of DeSales University, Allentown, PA, on the Board of the Finance and Sustainability Initiative, Montreal, and as Senior Advisor to the Indian Institute of Management Shillong.