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Editors
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Transdisciplinary Theory & Practice

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Editorial

The engineering profession is a small but influential community representing much less than 1% of the world's population, but its work impacts almost every aspect of modern life. Engineers are the practical people. They take the knowledge gained from the sciences and combine it with hard-won practical experience to create innovative products and services. The ultimate creation and operation of engineering designs originate, in large measure, from initial requirements which emanate from the changing needs of society.

These requirements have changed over the years. Before the industrial revolution of the eighteenth century, the primary engineering challenge was functionality—just getting something to work was the main consideration. In the intervening 200 years, new requirements have hit the engineering profession like a series of tidal waves. A few of these include: production volume, cost reduction, production efficiency, improved looks and marketability, quality considerations, pollution controls, safety concerns, automation, computerization, miniaturization, complex systems integration and resource constraints. Engineers have always met the challenges within an evolving and expanding disciplinary structure. While multi-disciplinary and inter-disciplinary approaches have certainly produced some interesting developments, the focus has primarily been the artifact *as* a complex system not the artifact *as part of* a complex adaptive system.

The engineering profession is again being challenged with a new and potent set of requirements which appear imminent: environmental change. It includes global warming, climate change, and any other effects which are the result of significant shifts from the environmental norms under which the artifacts of our civilization were originally designed. In the past, this part of engineering design could be somewhat taken for granted, due to the apparent stability of the environment within a narrow, acceptable, and predictable range of change. However, shifting requirements from environmental changes will not be easily addressed with methods descended from our industrial age. The environment is considered a complex adaptive system, one which is famous for defying prediction. With environmental change, solutions may not be so amenable to the usual disciplinary approaches. The unexpected may soon become unavoidable.

In a period of environmental change, engineering must garner all its resources, across and beyond all disciplines, and face this challenge. Not only will more engineers be required, but they must collaborate and interact in new and more integrated ways to confront the engineering changes that loom ahead. Engineering must now consider the whole, which includes the earth's environment, and directly address complex adaptive systems design. Engineering education must produce a new kind of engineer, one that breaks the barriers of disciplinary thinking. Transdisciplinarity must become an integral part of this venerable profession's future.

The world is constantly growing smaller and smaller. Challenging techni-

cal, medical, social, and cultural issues are no longer just local concerns — issues and problems must more and more be considered from a global perspective. Communication, collaboration, and education on a global scale are the keys to solving the complex problems and issues facing mankind in the 21st century. The successful development of a network of global collaboration would provide a universal sharing of knowledge and benefit everyone by greatly enhancing the ability to solve complex problems facing the peoples of the world. Such problems include living conditions, environmental issues, health and medical issues, energy issues, transportation issues, communication issues, cultural issues, spiritual issues, and educational issues.

This journal volume contains eleven papers. A wide variety of issues related to the transdisciplinarity such as education, complexity, experimentation, theology, epistemological awareness, mechatronic platforms and transdisciplinarity learning have been covered in this volume. We wish to thank the authors for their participation and the reviewers for their assistance in evaluating the manuscripts.

Basarab Nicolescu and Atila Ertas

CHAPTER **1**

Shaping Education and Training to Advance Transdisciplinary Health Research

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Despite at least two decades of effort, the United States has made little progress in addressing the health disparities experienced by its most vulnerable residents. For many diseases, the gaps in health between groups continue to grow. In this chapter, we first build a case for the importance of a transdisciplinary approach to eliminating health disparities, based on the premise that executing successful disparities research depends on the ability to visualize the multiple influences on health and health disparities and understand the complex ways in which they interact with one another to produce worse outcomes for some groups than others. We argue that our failure to prepare investigators to conduct transdisciplinary research has greatly impeded our progress toward eliminating the nation's disparities. Finally, we articulate the challenges to implementing transdisciplinary education and training and recommend elements of a successful transdisciplinary educational program in health.

1.1 Introduction

Why transdisciplinarity is today not only realistic a realistic aim but also a necessary one?

Despite at least two decades of effort, the United States has made little progress in addressing the health disparities experienced by its most vulnerable residents. These health disparities occur in incidence, mortality, and survivorship for a range of serious health conditions, including heart disease, cancer, HIV/AIDS, and diabetes. They occur by race/ethnicity, socioeconomic status, disability status, and geography. Racial/ethnic disparities have received the greatest attention and can be summed as the gap in life expectancy between

urban black males and Asian males (15.4 years) [1].

Despite elegant quantification of health disparities and advances in our understanding of their determinants, we have made little headway in reducing the nation's disparities. For many diseases, the gaps in health between groups continue to grow through time. As an example, although cancer mortality decreased between 1975 and 2004 for the U.S. population as a whole, significant African-American and white gaps persist [2]. The disparity in breast cancer mortality, in fact, has grown since the mid-1980s, with the improvements in mortality experienced by white women not reflected in similar improvements for African-American women.

Although health disparities by race and ethnicity have been acknowledged since at least the 1970s, it was not until the 1990 U.S. Census, when data on race/ethnicity became available for all fifty states, that the full extent of these disparities became apparent. The federal government reacted with a number of programs, such as President Clinton's 1998 Racial and Ethnic Health Disparities Initiative, which set an ambitious goal of eliminating racial and ethnic disparities by 2010. In response to this challenge, the National Institutes of Health (NIH) began rethinking its approach to health research.

The National Cancer Institute (NCI) was the first NIH institute or center to incentivize a transdisciplinary approach to health research. Its Transdisciplinary Tobacco Use Research Center (TTURC) initiative was launched in 1999 and three center initiatives followed in the early 2000s: the Centers of Excellence in Cancer Communication (CECCR) and Centers for Population Health and Health Disparities (CPHHD) in 2003 and Transdisciplinary Research in Energetics and Cancer (TREC) centers in 2004. All aim at eliminating cancer disparities and preparing the next generation of transdisciplinary investigators.

In this chapter, we first build a case for the importance of a transdisciplinary approach to eliminating health disparities. Executing successful disparities research depends on the ability to visualize the multiple influences on health and health disparities and understand the complex ways in which they interact with one another to produce worse outcomes for some groups than others. This can be done neither by a single investigator nor by a single discipline. Yet, despite a growing emphasis on transdisciplinary research in the United States, few research teams can say that they have achieved transdisciplinary functioning. We argue that our failure to prepare investigators to conduct transdisciplinary research has greatly impeded our progress toward eliminating the nation's disparities. Finally, we articulate the challenges to implementing transdisciplinary education and training and recommend elements of a successful transdisciplinary educational program in health. In all, we draw upon the author's experience as director of the CPHHD at the University of Chicago (2003 to 2010) and co-director of the TREC at Washington University in St. Louis (2011 to present) for illustration.

1.2 The Centers for Population Health and Health Disparities

The eight Centers for Population Health and Health Disparities (CPHHD) that were funded in 2003 represented a range of racial and ethnic populations and cancer types. The group of investigators collaborated to define a model that would help frame research and speed understanding across disciplines [3]. The major implication of the model is that multiple levels of influence, from the molecular to the societal, interact in complex ways to produce cancer disparities. The framework for analysis includes three primary levels of determinants, namely distal, intermediate, and proximal. Distal determinants include population-level social conditions such as variation in rates of poverty or racial and ethnic segregation. Their roots are embedded in societal norms about health or social practices and socioeconomic disadvantage. Intermediate determinants include the immediate social and physical contexts and social relationships in which the distal effects are experienced, such as communities and neighborhoods. These social contexts include opportunities for social interaction to temper the effects of distal factors. Also included is the accessibility of local health care resources to residents, availability of transportation, and attributes of built or physical environments. The intermediate determinants are the links through which the environment affects individual demographic factors as well as the biologic responses that compose the proximal determinants. Demographic factors refer to both contexts and individuals and in the model can have independent effects. Proximal determinants include biological and genetic factors. They also include individual-level factors such as demographics and health behavior.

Research has evolved from merely describing disparities to beginning to address them with public health interventions. Multi-level conceptualizations such as the CPHHD shared model, with components that range from the intracellular to the societal, represent a challenge to researchers. The multiple levels of investigation suggested by the CPHHD model [3] map across a range of scientific disciplines, from the biological/genetic to the social, each potentially bringing its own separate approach and unique way of executing and reporting research. Lacking, however, is the capacity to promote and sustain communication across disciplinary boundaries, thus impeding our progress in understanding and eliminating disparities. Capturing the complexity of health disparities requires not only taking into account all levels that impact those disparities but also the interactions that occur between levels, such as the complex interplay of genes and environment that occur in a number of diseases [4,5]. Yet few health researchers are prepared to work on teams that span disciplines, diminishing our capacity to address disparities.

1.3 The Center for Interdisciplinary Health Disparities Research

The Center for Interdisciplinary Health Disparities Research (CIHDR) at the University of Chicago was one of the original eight CPHHDs, with a mission of understanding and addressing the African-American and white disparity in mortality from breast cancer in the United States. The disparity has grown since the mid-1980s, with the improvements in mortality experienced by white women not reflected in similar improvements for African-American women. The four research projects of CIHDR were led by social, behavioral, biological, and clinical researchers organized around a shared research questions, namely how features of the social environments of African-American women contribute to the African-American and white disparity in breast cancer mortality. Despite their disparate backgrounds, this was a question that united the group.

The four CIHDR projects provide an ideal mechanism for investigating the pathways through which the social environment shapes biology and health, for two major reasons. First, the team of CIHDR investigators comes from a variety of disciplinary backgrounds, allowing them to consider social, behavioral, and biological aspect of health in the same shared projects and analyses. Second, in testing it's shared model (see Figure 1.1), CIHDR investigators take a multilevel and multifactorial approach to health that considers influences from within the cell to the level of society [5].

CIHDR's approach is transdisciplinary. According to Rosenfield's definition, transdisciplinarity occurs when the exchange of information and sharing of resources alters discipline-specific approaches, thereby integrating disciplines to achieve a common scientific goal [6]. Each CIHDR project, two of which use animal models and two which work with African-American women living on Chicago's South Side, explores part of the shared model.

This mutually-informative, iterative approach to science allows the CIHDR team to fully explore all components of their shared model, from elements of the social environment, especially features of urban neighborhoods, to psychological responses to those features, to gene and hormone expression within tumors. By giving each project equal weight, the transdisciplinary approach allows investigators to explore all hypothesized determinants of hormone and gene expression changes, as well as those changes themselves, in equal depth, without favoring any one element of the model [7].

The projects' investigators represented a range of disciplines. A rodent model involving Sprague-Dawley rats was led by a biopsychologist who is an international expert in open-cage experimentation. The second was led by a breast oncologist who is also a molecular biologist. These two projects use rodent models that mimic human breast cancer to identify pathways by which the social environment influences a particularly aggressive form of breast cancer. Working with animal models allows social conditions to be manipulated and biological outcomes assessed throughout the life cycle. McClintock et al.

[4,8] found that normally highly-social rats that were socially-isolated from the time of weaning became hyper-vigilant to novel phenomena in their environments and developed more malignant spontaneous mammary gland tumors at a much earlier age than their non-isolated peers. Even prior to tumor growth, both isolated transgenic mice [9] and inbred rat strains [8] developed heightened stress hormone response to an acute stressor. Perhaps more important for the study of human psychosocial functioning was the discovery that within a group, those rats isolated from reciprocal care and support, particularly in the face of stressors, were more likely to die at an earlier age with mammary tumors [10]. Those with reciprocal support relationships survived the longest with mammary tumors, which may mirror discrimination among humans.

The larger CIHDR study enrolled African-American women living in neighborhood areas on Chicago's predominantly African-American South Side. Women were enrolled at the time of diagnosis with first-episode breast cancer and tumor tissue was collected at the time of biopsy or tumor excision. This project was led by a breast oncologist who is also expert in the genetics of breast cancer among women of West African ancestry. The fourth project, led by the author who is a social scientist, followed a group of African-American women newly diagnosed with their first episode of breast cancer. These women lived on Chicago's South Side, in 15 neighborhood areas with largely African-American residence. Although geographically homogenous, the sample of women varied by socioeconomic status, from women who were homeless and those with median family incomes higher than the Chicago average.

Women were interviewed twice in their homes beginning four to six months after surgery by specially-trained African-American women interviewers. The team measured a variety of social environmental factors, psychosocial responses, and ways of conceptualizing stress, collecting both intrapersonal and biological measures [11]. Additional data were obtained by observations in neighborhoods and publically-available data geo-coded to women's addresses. In order to compare across women in the study, a team was assembled to assess the built environment of the four-block area around each women's home. Scales were developed for measuring vacant lots and building in the four-block areas to assess for features that would either enhance or discourage women's social interactions.

Figure 1.1 Center for Interdisciplinary Health Disparities Research (CIHDR) Shared Model across Disciplines, with the Position of its Four Research Projects Demonstrated.

1.4 Challenges to Transdisciplinary Functioning in Health Disparities Research

Challenges to transdisciplinary functioning were identified at a number of levels. Transdisciplinarity presented a number of challenges to individual CIHDR investigators, as it became clear that the group represented a number of per-

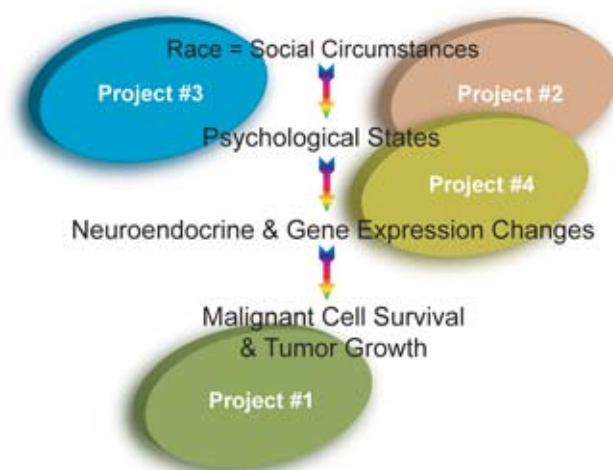


Figure 1.1: Center for interdisciplinary health disparities research (CIHDR) shared model across disciplines, with the position of its four research projects demonstrated.

spectives, modes of communication and operation, and ways of knowing. These differences were most apparent when team members were deciding upon shared conceptual frameworks, research designs, and methods of analysis. Individual investigators often operated outside their comfort zones.

Tensions resolved once sufficient trust had developed for group members to accept that others' "different" ways of knowing or operating represented good science. Over time, the group was able to develop a lexicon shared across projects that allowed members to describe CIHDR's work as a whole and how their own project contributed to that work. They began to pool the best of their disciplinary theories and methods, which often required concerted negotiations.

The task of establishing and maintaining a balance among disciplines generally falls to the leader of a transdisciplinary team, as it did in CIHDR. Without this balance, certain disciplinary ways of knowing and operating might have been privileged over others, obscuring the holistic perspective needed to fully capture the determinants of health disparities and their interactions. The tendency is for investigators to fall back on their old modes of operation, requiring the leader to remind them of their shared questions and goals (i.e., to force the bigger picture). A task of transdisciplinary leadership is to build consensus and foster the cooperation among members that allows for the free exchange of ideas.

1.5 The Role of University Administrations in Fostering Transdisciplinary Health Research

Operating transdisciplinarily is not intuitive, but instead requires training and education as well as Institutional supports to yield maximum benefit. A general lack of attention to the transdisciplinary education of students is mirrored in the governance of faculty by institutional administrators. There is a general lack of recognition within the academy of the potential for transdisciplinary science to improve the health outcomes of all members of society. Academic advancement has traditionally been a solo journey, and the tenure clock is not set to incorporate the time that it takes to build and maintain transdisciplinary teams. Likewise, the time lines of federally funded grants, which influence academic timeleins, do not include the time that it takes for transdisciplinary teams to begin functioning smoothly as units. Also, promotion and tenure committees traditionally focus on new advances in understanding and research that “changes the field,” ascribing lower status to the application of scientific advances to improve the health of communities. Appointment and promotion guidelines that emphasize the contribution of transdisciplinary research and the time required for integrating research with practice will help set the standard for these activities to be valued and rewarded. Likewise, a metric that captures the impact on health associated with research, teaching, and service may help to create demand for the investment of time and shed light on the contributions of transdisciplinary research. A recognition of the need to develop promotion and tenure guidelines for transdisciplinarity is beginning to appear in institutions of higher education in the United States, but has yet to reach its full form.

It is important to note that, although transdisciplinary education would move us forward on the path to ameliorating health disparities, we also need to breach the divide between research and practice. It does not matter how well a new drug or treatment works if it cannot be implemented within communities. Yet there is a general lack of communication between researchers who focus on discovery and practitioners who implement evidence-based practices in real-life situations. Integrating transdisciplinary research into practice also requires substantial teamwork and time, in part through forging relationships with the communities who bear a disproportionate burden of health disparities. These activities may be harder to quantify in a way that can be consistently measured as contributions by individual faculty members.¹²⁻¹³ Developing metrics that can be reported for promotion and tenure will again be essential for fostering research with the potential to address health disparities.

1.6 Transdisciplinary Education and Training

Although fostering transdisciplinary functioning among already-funded center investigators and helping university administrators to recognize its importance

are very worthy tasks, we must also find ways to educate the next generation of transdisciplinary researchers. Although such education has been recommended since at least 2000 [14], disciplinary scholars for the most part continue to be trained primarily in the language and methods of their individual fields of training. Although scattered transdisciplinary training programs exist, they operate almost exclusively within professional schools, and have yet to be systematically integrated into formal educational curricula at either the undergraduate or graduate levels. This lack of systematic education in transdisciplinary science reinforces what has been referred to as the “siloed” nature of research, and hinders the transfer of knowledge across disciplines.

The following recommendations for transdisciplinary education have been derived from a review of existing transdisciplinary training programs and from reports by the National Academy of Sciences, National Academy of Engineering, and Institute of Medicine [14,15]. They fall into six categories: structure, socialization, content, pedagogy, evaluation, and resources.

1.6.1 Structure

Support from a university’s central administration can facilitate the diffusion of transdisciplinary culture across its units (i.e., departments and schools). This facilitation has the potential to break down barriers to uptake and implementation, such as different schedules and degree requirements for students and insufficient time to develop and implement seminars and courses that expose students and trainees to a range of perspectives. Clark [16], for example, recommends that directors of transdisciplinary programs report to academic vice presidents or provosts rather than to deans, in order to “embed” the program in the culture and functioning of the university as a whole.

Institutions can help maximize the success of their transdisciplinary programs by recognizing that teaching in such programs is more time-consuming than teaching within a single discipline, especially if instruction involves problem-based learning and group projects. Pellmar and Eisenberg [17] suggest that universities maximize the successes and sustainability of their transdisciplinary educational programs by distributing the costs across departments and sharing facilities. They argue that universities should consider creating and supporting independent transdisciplinary centers and institutes to conduct such training, rather than housing them within existing departments.

University administrations should encourage a broad base of faculty to engage in transdisciplinary education and research, so that programs are not dependent on small cadres of faculty for success. The Outreach and Training Core at the TREC at Washington University requires its trainees to develop a three-member mentoring team that spans disciplines, so that each trainee will be exposed to a range of perspectives on cancer and obesity. Mentors are oriented to the program initially and meet as a group at regular intervals.

A 2005 report of the National Academy of Sciences, National Academy of Engineering, and Institute of Medicine [15], recommends five attributes

to maximize the success and sustainability of transdisciplinary educational programs:

- Flexible departmental and school budgets and cost-sharing policies;
- Financial support to start programs, and bridge funding for programs in between external funding opportunities;
- New faculty recruitment that is shared across departments, schools, and colleges;
- Faculty incentives for transdisciplinary scholarship and training;
- Tenure and promotion policies and procedures that accommodate transdisciplinary work and the unconventional teaching, service, and research demands of such work.

1.6.2 Socialization

In addition to structural supports, successful transdisciplinary team educational programs socialize trainees to be members of transdisciplinary teams. This can be done by introducing the transdisciplinarity as early in the continuum of education as possible, as well as offering more formal training at the undergraduate, graduate, doctoral, and postgraduate levels [15].

Transdisciplinary team functioning is enhanced if students learn basic skills of group process, communication, and negotiation and conflict resolution early in their educations [18]. These skills are not intuitive. These skills can be taught using group exercises such as role playing and rehearsal and orientation to different disciplinary culture and approaches. Faculty should also “immerse themselves in the languages, cultures, and knowledge of their collaborators [15, p. 4].” Transdisciplinary collaboration in research and teaching by faculty members likewise can serve as a model this behavior for students.

Bronstein argues that transdisciplinary training programs are most successful when students are trained to be dependent on one another in shared projects, with each providing a piece of the puzzle [19]. This can be accomplished through formal and informal interactions and by creating program goals that emphasize collective ownership of products among investigators. Other joint social interactions across disciplines might include shared on-site cafeterias, lounges, and other more public spaces that are designed to attract students, trainees, staff, and investigators from a variety of disciplines.

1.6.3 Content

The most successful transdisciplinary training programs include courses taught or co-taught by faculty from a variety of schools, departments, and colleges and include a wide range of topics such as:

- Transdisciplinary theory

- Transdisciplinary team roles
- Transdisciplinary training and research process
- Communication skills
- Collaboration skills
- Conflict resolution
- Multi-level determinants of health and health care delivery
- Research methods
- Practice and research ethics
- Medical terminology

Oandasan and Reeves suggest the following competencies to foster the goals of transdisciplinary education, namely the ability to: (1) describe one's roles and responsibilities clearly to other professionals and community stakeholders; (2) recognize and observe the constraints of one's role, responsibilities, and competencies, yet perceive needs in a wider framework; the ability to recognize and respect the roles, responsibilities, and competencies of other professionals; and, (3) work with other professionals to effect change and resolve conflict in the provision [20, p. 31]. Nash also suggests that faculty encourage the development of the common values and cooperative behaviors that are necessary for successful transdisciplinary team functioning [21].

1.6.4 Pedagogy

Transdisciplinary coursework and experiences should be distributed throughout curricula, rather than being restricted to elective courses. This integration has only been achieved in a few universities in the United States, such as the University of California, Berkeley, Claremont Graduate University, and Washington University (see Table 1.1). Transdisciplinary education is perhaps best accomplished through didactic and experiential teaching methods. Technology can be a valuable tool for expanding the program capacity through the use of case scenarios, vignettes, or experiential simulation laboratories to create real-world examples of patient problems.

A common pedagogical tool used to supplement problem-based learning in successful transdisciplinary training programs is experiential and service learning facilitated by community stakeholders in real-world settings. The University of California, San Diego, for example, provides transdisciplinary student training in three community clinics for vulnerable patients [22]. These community experiences afford trainees the opportunity to practice their classroom learning in real-world healthcare settings. As part of their training program, trainees participate in a daily "learning circle" in which everyone reflects on what they learned in the clinic that day.

Table 1.1: Transdisciplinary problem-solving course offered by the master's in public health (MPH) program of Washington University in St. Louis.

Course	Focus
Chronic Disease, Policy and Prevention in Public Health	The prevention and control of obesity considered from social, behavioral, and biological perspectives
Strategies for Eliminating Health Disparities	The integration of public health and social services to eliminate health disparities
Tobacco Control in Public Health	The examination of tobacco control from a wide variety of disciplinary perspectives
Child Maltreatment	The prevention of child maltreatment seen through a variety of disciplinary perspectives
Livable Lives	The creation of the conditions so that low and moderate income families can lead lives with a reasonable degree of stability, support, and resources to take care of their basic needs, find children successfully

1.6.5 Evaluation

Scholars agree that the success of transdisciplinary educational programs depends on comprehensive evaluation of program processes and outcomes. This is essential for achieving sustainability and ensuring ongoing support from administrations and funders. This evaluation should include longitudinal follow-up of program graduates to assess their career trajectories and the impact of the educational program on their career trajectories. These assessments benefit from the use of qualitative and quantitative measures of program outcomes. Trainees' progress can be measured through time using a more traditional bibliometric approach in which transdisciplinarily-prepared manuscripts, presentations, and funding proposals are tracked over time and compared with those of investigators working independently. Metrics have as yet not been developed, however, to measure improvement in the quality of research through working transdisciplinary teams.

1.6.6 Resources

The Study Group on Interprofessional Education of the World Health Organization has undertaken the task of preparing an evidence-based recommendations for the education and training of transdisciplinary health care team members [23]. In 1998, the U. S. Congress created the Advisory Committee on Interdisciplinary, Community-Based Linkages (ACICBL) to help guide the Secretary of the Department of Health and Human Services on policy and program development around cross-disciplinary training involving community research which through time has become transdisciplinary in nature and scope. Authorized by the Public Health Service Act, the ACICBL includes representation from Area Health Education Centers, geriatrics, chiropractic, podiatry, social work, psychology, and rural health. Since their first report, this organization has made recommendations that all training and grants funded by the U.S. Health Resources and Services Administration (HRSA) must include a transdisciplinary approach to patient care and research.

1.7 Conclusions

Although they are challenging to implement and maintain, transdisciplinary research teams confer a distinct advantage over other disciplinary collaborations in their ability to understand and ameliorate health disparities. At the most fundamental level, these teams of biological, social, behavioral, and other scientists bring specialized knowledge from a variety of disciplines that reflect the multiple levels at which health disparities occur. Yet merely having knowledge of the biological, behavioral, and social contributors to group differences in health is not sufficient to capture the complex interactions among determinants that characterize health disparities.

It is the unique mode of functioning of transdisciplinary teams that confers their advantage. Rather than operating in silos representing the separate levels of influence on disparities, as is customary with multidisciplinary and interdisciplinary approaches, transdisciplinary teams operate as a mutually informative unit above and beyond individual disciplines. The new intellectual space created allows them to visualize the range of influences on a particular disparity. Practical gains occur in addition to scientific gains. Being part of a research group that represents a number of disciplines exposes teams such as CIHDR and TREC to a wider range of subsequent funding possibilities and venues for disseminating their work.

Successful transdisciplinary research occurs when disciplinary scholars are able to visualize all of the determinants of complex social problems such as health disparities. The same processes must be created to prepare the next generation of transdisciplinary scientists in health. Trainees must be able to take a holistic view of health and health disparities and learn the skills needed to operate in the spaces between disciplines. Transdisciplinary education that combines exposure to a range of disciplinary knowledge and methods with effective instruction in processes for working on teams to transform knowledge and methods into solutions for complex social problems is the gold standard. We have suggested a number of successful methods to guide institutions and organizations to achieve these ends.

At the present time, true transdisciplinary team functioning remains an ideal. If we truly want to end disparities and, in the words of President Clinton in 1998, “to make sure all Americans, no matter what their background, have a better opportunity to lead healthier lives,” it behooves us all to work together to address the barriers to transdisciplinary health research.

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CHAPTER **2**

The Need for Transdisciplinarity in Higher Education in a Globalized World

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A viable education can only be an integral education of the human being. Transdisciplinary education is founded on the inexhaustible richness of the scientific spirit which is based on questioning, and of the refusal of all a priori answers and all certitude contradictory to the facts. At the same time, it revalues the role of the deeply rooted intuition, of the imaginary, of sensitivity, and of the body in the transmission of knowledge. It is only in this way that the society of the twenty-first century can reconcile effectivity and respect for the potentiality of every human being. The transdisciplinary approach will be an indispensable complement to the disciplinary approach, because it will mean the emergence of continually connected beings, who are able to adapt themselves to the changing exigencies of professional life, and who are endowed with a permanent flexibility which is always oriented towards the actualization of their interior potentialities. If the University intends to be a valid actor in sustainable development it has first to recognize the emergence of a new type of knowledge: transdisciplinary knowledge. The new production of knowledge implies a necessary multidimensional opening of the process of learning: towards civil society; towards cyber-space-time; towards the aim of universality; towards a redefinition of the values governing its own existence.

2.1 Introduction

Why transdisciplinarity is today not only realistic a realistic aim but also a necessary one?

The first argument is the big-bang of the number of disciplines who increased from 7 (when first universities were founded in the 13th century), to more than 8000 en 2012. A great expert in a given discipline is totally ignorant

in more than 7999 disciplines. The decisions which are taken in our troubled world are based on ignorance and this fact provokes inevitable crisis which will be deeper and deeper in the future.

Second argument: the rapid changes in our contemporary world induce more and more unemployment and therefore human beings have to change their jobs several times during their active life. But passing from one job to another is practically impossible in the context of an accelerated super-specialization.

Third argument: recent discoveries in neurophysiology illustrated, for example, by the works of Antonio Damasio [1], underline the unexpected fact that the analytic intelligence is too slow compared with the intelligence of feelings. Therefore, we have to find equilibrium in our educative system between the analytic intelligence and the interior being.

Fourth argument: globalization induces an enormous migratory flux of people belonging to countries of a given culture, religion and spirituality towards countries of another culture, religion and spirituality. The new education has to establish the dialogue between cultures, religions and spiritualities.

Fifth argument: the rapid advance of means of communication implies an increased complexity in an interconnected world. The new education has to invent new methods of teaching, founded on new logics. The old classical binary logic, that of “yes” and “no”, i. e. the logic of the excluded middle, is no more valid in the context of complexity.

The last argument I would like to formulate is the following: solving problems in the real world forces university to interact with society, industry, banks and ecology. These problems clearly belong to the field of “trans”: their resolution asks us to go beyond academic disciplines. Transdisciplinarity is therefore realistic and necessary for the survival of universities.

2.2 Disciplinary Education and Transdisciplinary Education

The transdisciplinary knowledge corresponds to an *in vivo* knowledge, concerned with the correspondence between the external world of the Object and the internal world of the Subject. By definition, the transdisciplinary knowledge includes a system of values, the humanistic values. It leads to a new type of education—the transdisciplinary education (TE), distinct from but complementary to our present disciplinary education (DE) (see Table 2.1).

It is important to realize that the disciplinary knowledge and the transdisciplinary knowledge are not antagonist but complementary. Both their methodologies are founded on scientific attitude. Building the transdisciplinary mind at the University is our main challenge today.

In order to explore the new, transdisciplinary education, we have to apply the transdisciplinary methodology [2].

The methodology of transdisciplinarity is founded on three postulates:

Table 2.1: Comparison between disciplinary education (DE) and transdisciplinary education (TE).

Disciplinary education (DE)	Transdisciplinary education (TE)
<i>IN VITRO</i>	<i>IN VIVO</i>
One level of Reality	Several levels of Realities
External world - Object	Correspondence between external world (Object) and internal world (Subject)
Accumulation of knowledge	Understanding
Analytic intelligence	New type of intelligence - harmony between mind, feelings and body
Binary logic (absolute truth / absolute falseness)	Included middle logic (relative truth)
Oriented towards power and possession	Oriented towards astonishment and sharing
Exclusion of values	Inclusion of values

1. The ontological postulate: *There are, in Nature and in our knowledge of Nature, different levels of Reality of the Object and different levels of Reality of the Subject.*
2. The logical postulate: *The passage from one level of Reality to another is insured by the logic of the included middle.*
3. The epistemological postulate: *The structure of the totality of levels of Reality is a complex structure: every level is what it is because all the levels exist at the same time.*

The first two postulates received, in the 20th century, experimental evidence from quantum physics [3], while the last one has its source not only in quantum physics but also in a variety of other exact and human sciences.

The key concept of the transdisciplinary approach to Nature and knowledge is the concept of *levels of Reality* [4].

2.3 Emergence of a Transdisciplinary Culture

The emergence of a transdisciplinary culture capable of contributing to the elimination of the tensions menacing life on our planet will be impossible without a new type of education which takes into account all the dimensions of the human being.

All the various tensions—economic, cultural, spiritual—are inevitably perpetuated and deepened by a system of education founded on the values of another century, and by a rapidly accelerating imbalance between contemporary social structures and the changes which are currently taking place in the contemporary world. More or less embryonic wars between economies, cultures, and civilizations never stop leading, here and there, to actual wars. In fact, our entire individual and social life is structured by education. Education is at the center of our becoming. The future is shaped by the education which is delivered in the present, here and now.

In spite of the enormous diversity of the systems of education that can be found in various countries, the globalization of the challenges of our era involves the globalization of the problems of education. The different upheavals continually confronting education in one or another country are only symptoms of one and the same flaw: the disharmony which exists between the values and the realities of a planetary life in the process of change. Most certainly, while there is no miraculous recipe, there is nevertheless a common center of questioning which it would behoove us not to avoid if we truly want to live in a more harmonious world.

2.4 The Delors Report

Growing awareness of a system of education that does not keep pace with the modern world is demonstrated by numerous recent conferences, reports,

and studies. The latest and most exhaustive report was developed by the International Commission on Education for the Twenty-First Century chaired by Jacques Delors, in cooperation with UNESCO [5]. The Delors Report strongly emphasized four pillars of a new kind of education: learning to know, learning to do, learning to live together, and learning to be. In this context, the transdisciplinary approach can make an important contribution to the advent of this new type of education.

2.5 Learning to Know

Learning to know means first of all training in the methods which help us distinguish what is real from what is illusory, and in the techniques which enable intelligent access to the fabulous knowledge of our age. In this context the scientific spirit, one of the highest goals ever attained in the human adventure, is indispensable. Precocious initiation into science is beneficial because it provides access, from the very beginning of human life, to the inexhaustible richness of the scientific spirit which is based on questioning, and on the refusal of all a priori answers and all certitude contradictory to the facts. However, “the scientific spirit” does not at all mean the thoughtless increase of teaching scientific matters or retreating to an interior world based on abstraction and formalization. Although such excess is, unfortunately, still current, it can lead only to the exact opposite of the scientific spirit: previous ready-made answers are replaced by other new ready-made answers (this time, having a kind of “scientific” brilliance); thus, in the final analysis, one dogmatism is replaced by another. Nor is it the assimilation of an enormous quantity of scientific knowledge which gives access to the scientific spirit, but the quality of that what is taught. And here “quality” means to lead the child, the adolescent, or the adult into the very heart of the scientific approach, which is the permanent questioning related to the resistance of facts, images, representations, and formalizations.

Learning to know also means being capable of establishing bridges—between the different disciplines, and between these disciplines and meanings and our interior capacities. This transdisciplinary approach will be an indispensable complement to the disciplinary approach, because it will mean the emergence of continually connected beings who are able to adapt themselves to the changing exigencies of professional life, and who are endowed with a permanent flexibility which is always oriented toward the actualization of their interior abilities.

2.6 Learning to Do

Learning to do certainly means acquiring a profession or a craft and theoretical and practical knowledge which is associated with it. The acquisition of a profession or craft necessarily passes through a phase of specialization. One

cannot do open-heart surgery if one has not learned surgery; one cannot solve a third-degree equation if one has not learned mathematics; one cannot be a producer without knowing theatrical techniques.

However, in our tumultuous world, in which the tremendous changes induced by the information revolution are but the portent of other still more tremendous changes to come, any life which is frozen into one and the same occupation can be dangerous, because it risks leading to unemployment, to exclusion, to a debilitating alienation. Excessive, precocious specialization should be outlawed in a world which is in rapid change. If one truly wants to reconcile the exigency of competition with the imperative of equal opportunity for all human beings, in the future every profession and every craft should be an authentically woven occupation, an occupation which would bind together in the interior of human beings threads joining them to other occupations. Of course, it is not simply a question of acquiring several competencies at the same time but of creating a flexible, interior core which could quickly provide access to another occupation, should that become necessary or desirable.

Here also, the transdisciplinary approach can be invaluable. In the last analysis, “learning to do” is an apprenticeship in creativity. “To make” also signifies discovering novelty, creating, bringing to light our creative potentialities. It is this aspect of “making” which is contrary to the boredom and sometimes even despair which is experienced by so many human beings who are obliged to exercise an occupation which does not conform to their interior predispositions simply in order to underwrite their basic needs. “Equal opportunity” also means the opportunity for the actualization of the creative potentialities which vary from one person to the next. Competition could also mean the harmony of creative activities within a single community. Boredom and despair, the source of violence, conflict, and of moral and social resignation can be replaced by the joy of personal realization, no matter what the place where this realization is effected, because a place can only be unique for each person at a given moment.

Creating the conditions for the emergence of authentic persons also means insuring the conditions for the maximal actualization of their creative potentialities. The social hierarchy, so frequently arbitrary and artificial, could thus be replaced by the cooperation of levels structured in order to serve personal creativity. Rather than being levels imposed by a competition which does not take the interior being into account at all, these levels would in fact be levels of being. The transdisciplinarity approach is based on the equilibrium between the exterior person and the interior person. Without this equilibrium, “to make” means nothing other than “to submit.”

2.7 Learning to Live Together

Of course, learning to live together first of all signifies respect for the norms which govern relationships between the beings comprising a collective. However, these norms must be truly understood and willingly internalized by each

being, rather than obeyed out of submission to exterior constraints. “To live together” does not mean simply tolerating others’ differences of opinion, skin color, and beliefs; submission to the exigencies of power; negotiating between the in’s and out’s of innumerable conflicts; definitively separating interior from exterior life; and merely appearing to hear the other while remaining convinced of the absolute rightness of our own position. If this is what it means, “living together” is inevitably transformed into its opposite: fighting each other. The transcultural, transreligious, transpolitical, and transnational attitude can be learned. To some extent, in each being there is a sacred, intangible core that is innate. Yet, if this innate attitude remains merely a potential, it can forever stay non-actualized, absent in life and in action. In order for the norms of a collective to be respected, they must be validated by the interior experience of each being.

There is one fundamental characteristic of the transdisciplinary evolution of education: to recognize oneself in the face of the Other. This is a question of permanent apprenticeship, which must begin in early childhood and continue throughout life. The transcultural, transreligious, transpolitical, and transnational attitude permits us to better understand our own culture, to better defend our national interests, to better respect our own religious or political convictions. Just as in all other areas of Nature and knowledge, open unity and complex plurality are not antagonists.

2.8 Learning to Be

Learning to be appears at first like an insoluble enigma. We know how to exist, but how can we learn to be? We can begin by learning what the word “exist” means, for us: discovering our conditioning, discovering the harmony or disharmony between our individual and social lives, testing the foundations of our convictions in order to discover that which is found underneath. In a building, the stage of excavation precedes that of foundation. In order to make a foundation for being, one must first of all proceed with the excavation of our certitudes, our beliefs, and our conditioning. To question, to question always; here also, the scientific spirit is a precious gift for us. This must be learned by the teachers as well as the taught. “Learning to be” is also a permanent apprenticeship, in which teachers inform students as students inform teachers. The shaping of a person inevitably passes through a transpersonal dimension. The disrespect for this necessary process helps explain one of the fundamental tensions of our era, that between the material and the spiritual. The survival of our species largely depends on the elimination of this tension by means of reconciliation between these two apparently antagonistic contradictions which takes place on another level of experience than that of everyday life. “Learning to be” also means learning to know and to respect that which joins the Subject and Object. The other remains an object for me if I do not make this apprenticeship, which teaches me that together we, the Other and me, create the Subject joined with the Object.

2.9 The Integral Education of the Human Being

There is one very obvious interrelationship between the four pillars of the new system of education: how to learn to make while learning to know, and how to learn to be while learning to live together?

In the transdisciplinary vision, there is also a transrelation which connects the four pillars of the new system of education and which has its source in our own constitution as human beings. This transrelation is like the roof which rests on four pillars of a building. If any one of the pillars of the building collapses, the entire building collapses, the roof with it. And, if there is no roof, the building falls into ruin.

A viable education can only be an integral education of the human being, according to the apt formulation of the poet René Daumal [6]: an education which is addressed to the open totality of the human being, not to just one of the components.

At present, education privileges the intellect over the emotions or the body. This was certainly necessary in the previous era, in order to permit the explosion of knowledge. But this privileging, if it continues, sweeps us away in the mad logic of efficacy for efficacy's sake, which can only lead to our self-destruction.

Of course it is not a question of limiting or increasing the number of hours provided for artistic or athletic activities. This would be like trying to obtain a living tree by juxtaposing roots, trunk, branches, and leaves. This juxtaposition would only lead to a semblance of a living tree. Contemporary education concerns itself with only the leaves. But leaves do not make a whole tree.

2.10 The Experiments of Leon Lederman

Experiments made by the Nobel Prize-winning physicist Leon Lederman with children from disadvantaged neighborhoods of Chicago demonstrates what we have been saying [7]. Lederman convinced some secondary school teachers to initiate new methods for teaching physics based on the touching of different objects and the discussion of contributions of different sense organs—sight, touch, smell - in the process. All this was play: it took place in an environment far removed from the usual formal apprenticeship in mathematics and physics. And the miracle happened. Even children who came from very poor families, where violence, lack of culture, and disinterest in the typical activities of children reigned supreme, discovered the abstract laws of physics through play. One year earlier, these same children had been declared incapable of ever understanding any abstraction. It is interesting, moreover, to point out that the greatest difficulties of the operation and - it goes without saying - the major part of its cost, were due to the resistance of the teachers: they had a great deal of trouble abandoning their old methods. The teaching of teachers proved longer and more difficult than the work with children.

The Chicago experiment shows well that the intelligence assimilates knowledge much better and much more rapidly when this knowledge is also understood with body and the emotions. In a living tree, the roots, the trunk, the branches and the leaves are inseparable: the sap which insures the life of the tree moves vertically through all of them. This is the prototype of what was previously referred to as the “revolution of intelligence”: the emergence of a new type of intelligence, founded on the equilibrium between analytic intelligence, feelings, and the body. It is only in this way that the society of the twenty-first century can reconcile effectivity and affectivity.

2.11 The Transdisciplinary Education as a Long-Term Process

Transdisciplinarity education clarifies in a new way a need which is presently felt more and more - the need for a permanent education. In fact, transdisciplinary education, by its very nature, should take place not only in teaching institutions, from the kindergarten to the university, but also in the work place - in fact, everywhere, and throughout our life.

In teaching institutions there is no need to create new departments and new chairs; this would be contrary to the transdisciplinary spirit. Transdisciplinarity is not a new discipline, and a transdisciplinary researcher is not some new kind of specialist. The solution would be to create workshops for transdisciplinary research within every teaching institution. These workshops would be the locus for gathering together a group of teachers and students from a particular institution who generate and oversee their own organization and are all animated by the transdisciplinary attitude. The same experiment could be carried out within various enterprises, and within other collectives, as well as within national and international institutions.

There is one particular problem which is posed by transdisciplinary education outside professional life. In a balanced society, the boundary between leisure time and apprenticeship time would gradually disappear. The information revolution could play a considerable role in our life for transforming training into pleasure and pleasure into training. The problem of unemployment of the young would certainly be alleviated by a hitherto unsuspected solution. In this context, grassroots efforts will play an important role in transdisciplinary education throughout life.

It is quite obvious that the various areas and ages of life call for extremely diverse transdisciplinary methods. Even if transdisciplinary education is a long-term, global process, it is still important to discover and to create places which help to initiate this process and insure its development.

The university is the privileged place for an education geared toward the exigencies of our time which could also be the pivotal place for an education directed not only toward children and adolescents, but also toward adults.

2.12 Peace and Transdisciplinarity—The Transcultural, Transreligious, Transpolitical, and Transnational Attitude

In the transdisciplinary perspective, there is a direct and unavoidable relation between peace and transdisciplinarity. Severely fragmented thought is incompatible with the research of peace on this Earth. The emergence of a culture and an education of peace require the transdisciplinary evolution of education and, especially, the transdisciplinary evolution of the university.

Instilling complex and transdisciplinary thought into the structures and programs of the university will permit its evolution toward its somewhat forgotten mission today – the study of the universal. The university could become a place of apprenticeship in the transcultural, transreligious, transpolitical, and transnational attitude, and in the dialogue between art and science which is the axis of a reunification between scientific culture and artistic culture. A renewed university would become the place for welcoming a new kind of humanism.

There is no need to invent a totally new University, but one needs to transform the existing disciplinary universities by adopting the transdisciplinary methodology as their complementary methodology.

2.13 Conclusions

Important steps in this direction were made in several countries [8]. In particular, PhD programs in transdisciplinarity are established now at the University Babes-Bolyai, Cluj-Napoca (Romania), Texas Tech University (USA) and at the University of Stellenbosch (South Africa) [9].

The transdisciplinary approach is realistic and even necessary for the survival of contemporary universities, placed in the chaotic context of globalization. One necessary condition is to understand what Reality is today. We are part of the ordered movement of Reality. Our freedom consists in entering into the movement or perturbing it. Reality depends on us. Reality is plastic. 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.

The emergence of a new culture capable of contributing to the elimination of the tensions menacing life on our planet will be impossible without a new type of learning which takes into account all the dimensions of the human being.

A viable education can only be an integral education of the human being. It is founded on a new type of intelligence, requiring the harmony between mind, feelings and body. The recent findings of neurophysiology show clearly the exceptional role of feelings in education.

Transdisciplinary education is founded on the inexhaustible richness of the scientific spirit which is based on questioning, and of the refusal of all a priori answers and all certitude contradictory to the facts. At the same time, it revalues the role of the deeply rooted intuition, of the imaginary, of sensitivity, and of the body in the transmission of knowledge. It is only in this way that the society of the twenty-first century can reconcile effectiveness and respect for the potentiality of every human being. The transdisciplinary approach will be an indispensable complement to the disciplinary approach, because it will mean the emergence of *continually connected beings*, who are able to adapt themselves to the changing exigencies of professional life, and who are endowed with a permanent flexibility which is always oriented towards the actualization of their interior potentialities.

Universal sharing of knowledge - a necessity of our world - cannot take place without the emergence of a new tolerance founded on the transdisciplinary attitude, one which implies putting into practice the transcultural vision. The transcultural attitude permits us to better understand our own culture, to better defend our national interests, to better respect our own religious or political convictions.

If the University intends to be a valid actor in sustainable development it has first to recognize the emergence of a new type of knowledge: transdisciplinary knowledge. The new production of knowledge implies a necessary multidimensional opening of the process of learning: towards civil society; towards cyber-space-time; towards the aim of universality; towards a redefinition of the values governing its own existence.

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CHAPTER **3**

Scientists and Theologians in Front of the Mystery

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Science and technology have their own distinct languages and modes of representing reality. These must be clearly distinguished in order to avoid naïve concordism. However, it is interesting to explore how the methods and logic used in one field can be applicable to the other, taking into account the specific constraints of each. The aim of this chapter is to show how the incompleteness of both the scientist and the theologian in their own field is a new way to consider the dialog between science and theology today. We will see that Christian dogmas-Trinity and Incarnation, as well as the biblical notion of Covenant-can be fruitfully explored through the logic of the “included middle” as applied to quantum physics. This application of methods from one field to another emphasizes that deep, common human attitudes enable both physicists and believers to explore the nature of reality without any confusion between the fields of science and theology. Common attitudes derive from the study of the logic of the included middle and its role in science and theology. Such a field of pursuit is called “moral philosophy” because it is related to critical analysis of the ethical principles involved in comparative epistemologies in science and theology. Taking into account the different domains of science, metaphysics, and theology, we will show how moral philosophy can be a new foundation for the dialog between scientists and people of faith. Such a dialog can perhaps be helpful in promoting quality in education and in supporting peace in the modern world.

3.1 On the Question of Reality in Science

3.1.1 General Overview

It is now generally accepted that the development of the hard sciences in the twentieth century (in particular in the areas of mathematics and physics) has

led to a reappraisal of the traditional philosophical notions of reality and meaning. In the area of the epistemology of science, the emergence of a new vision of complexity in the fields of quantum physics, thermodynamics, and cosmology has resulted in a redefinition of the word *reality*, perceived in scientific research as the relationship between subject and object.

The observer is part of the reality that he analyzes. The theory of measurement even demonstrates that, for a physicist, to know and to measure is to act on reality. It is a “reality of interactions” that is put to scientific analysis leading to a profound re-evaluation of the three dogmas of scientism: Laplacian determinism (notions of unpredictability and uncertainty), ontological reductionism (there is more information in the whole than the sum of its parts), and methodological reductionism (undecidability and incompleteness with the Gödel theorem). As a result, man has become an “interpreter” of a complex world throwing into contention such notions as the strong objectivity of the sciences.

Since physicists have been confronted with the complexity of reality, scientific thinking as a whole has undergone a profound upheaval as evidenced by the demise of the Laplacian dream, “the end of certainty,” or the withdrawal of foundation.

3.1.2 The Demise of the Laplacian Dream

Classical science was dominated by the notions of permanence and stability, predictions, determinism, and, ultimately, control. The idea of certainty in science was widely held and virtually synonymous with the “sharing of divine science.” The development of quantum physics and non-equilibrium thermodynamics introduced the concepts of uncertainty, incompleteness and undecidability into the sphere of rationality, which radically alter the status of knowledge and the place of the knowing subject. There was a radical change in scientific thought and this had a marked effect on peoples’ way of thinking in general.

Poincaré and many later scientists demonstrated that the “Laplacian dream” of determinism was an illusion. If, indeed, Newton’s laws allow us to accurately predict the movements of two bodies in motion insofar as their precise trajectories are known, the same cannot be said of systems comprising three or more bodies. Complete predictability is impossible; there is no general solution to the problem. Poincaré is also responsible for the notion of unpredictability that characterizes deterministic chaos (the unpredictable behavior of a system despite the fact that it is described in terms of the equations of determinist evolution). This determinist chaos can often be seen in nature. Sensitivity to the initial conditions renders the Laplacian dream obsolete: it is not because a system is subject to a formal determinist evolutionary law that this evolution is predictable. Therefore, in respect of our current understanding, a complete description of reality cannot be conceived of. It is important, here, to emphasize a key point. By accepting to replace Laplacian determinism and the idea

of certainty with determinist chaos and unpredictability, scientists opened new avenues for scientific progress. The idea of certainty seemed to be the only worthy basis on which to build a genuine scientific enterprise. However, this vision was, as it turned out, pessimistic and time (and its arrow) was just an illusion (Prigogine, [1]). Unpredictability and chaos restored the role of time, allowing it to play a constructive part in an “uncertain reality” (d’Espagnat, [2,3]). Here, the idea of probability was not introduced as a result of our ignorance but as the very result of evolution! Non-equilibrium gave us an idea of the potentialities of matter. Needless to say, then, that this change in worldview was bound to have an effect on the attitude of the scientist! For us scientists, the universe is not given—rather it is under construction!

3.1.3 **Something of Reality Is Beyond Our Knowledge**

Science’s claims of “completeness” that go hand in hand with its claims of certainty, presuppose the existence of a language that reflects the totality of reality. Wittgenstein’s studies demonstrate that the logical structures of language cannot be written within language itself (Simon, [4]). In other words, the medium in which (or thanks to which) we represent things is not representable (it cannot be expressed). There are concepts that are inexpressible outside of language. Is not the acceptance of the inexpressible a way of opening the door to the question of meaning while recognizing the contingency of man? Classical science with its dream of perfect predictability acknowledged its ambition construct a comprehensive system of representation. But Gödel’s work put an end to this. His findings clearly demonstrated that there are undecidable propositions, true arithmetical propositions that cannot be deduced from axioms and truly irrefutable statements (Hosftadter, [5]). Consequently, no theory can, of its own accord, provide proof of its own consistency and that complete self-description is logically impossible. Consistency, therefore, implies incompleteness and completeness can only be obtained at the expense of consistency. Here again, what progress!

Quantum physics is prime ground for showing incompleteness, this “thing that is beyond our knowledge.” Microphysics reminds us that man is not an independent spectator of the reality he explores but an integral part of it (we are “of the world,” in situ). The reality described by physics is no longer independent from the terms of description. This is not only because, as we know, man developed these concepts and theories but also because to measure and to know is to have an effect on reality or, rather, to interact with it. This interaction by definition modifies the object. Consequently, each measurement is marked by an irreducible indetermination expressed, in quantum mechanical terms, by Heisenberg’s uncertainty principle. This uncertainty appears, then, to be coextensive of the knowledge we derive from reality. There is a real limit to our knowledge of the quantum object. Something eludes us yet knowledge also progresses through the non passive acceptance of this incompleteness. I emphasize non passive acceptance, as Einstein’s resolve to find the flaws in

quantum theory (the search for hidden variables) was a contribution to the progress of knowledge.

Something is beyond our knowledge, something of the order of origins. Whether it be in the study of language (Wittgenstein), logic (Gödel), the structure of matter (Heisenberg), or irreversible evolution (Prigogine), it is apparent that similar conclusions are being arrived at regarding incompleteness, the horizon of undecidability and the impossibility of limiting truth to the totality of what can be said, whether this be formally demonstrated or directly measured. To accept that something can be formalized, is to accept that some aspect of that thing is necessarily missing. Constructing a theory of knowledge requires us to accept that something is beyond our knowledge. This does not represent a defeat of reason. Rather it is a condition of progress, of intelligibility.

The classical concepts of linear causality, reduction, completeness, and stability are replaced by those of sensitivity to the initial conditions, irreducibility, incompleteness, uncertainty, instability, and unpredictability.

Moreover, contemporary science invites us to get a measure of the positivity of this incompleteness that even appears to be a condition of knowledge. It is a good introduction to the question of the significance and the place of the subject in the exploration of the world of which it is a part! This is how scientific knowledge has progressed from certainty to uncertainty—and we reminded of the contingency and finite nature of man.

One can say that the scientism of the nineteenth century in Europe has been considerably weakened by quantum physics, which questions objectivity, Laplacian determinism, and the subject-object separability. Scientism is also weakened by the thermodynamics of irreversible processes, which questions the validity of reductionism, and also by the Gödel theorem, which considers the question of undecidability in mathematics. Such evolution is generally translated by the following sentence:

“Something of reality is beyond our knowledge” (**Barbour**, [6]).

Even if quantum physics gives new insights about reality through science, we must never forget the status of the observer in Kant’s analysis. But quantum physics has generated new insights into the subject-object problem, stressing the contextuality and relationality of reality. More and more, science is shown to correspond to “the game of possibilities” as said the Nobel laureate François Jacob comparing myth and science in their relation to reality:

Mythic or scientific, the representation of the world by man is related to his imagination. . . . To give valuable observations in science, one must initially have in mind some idea about what must be observed. We need to decide before the observation what can be observed, what is possible. A previous idea about reality is necessary. . . . The scientific investigation always starts with the invention of a possible world, or a fragment of this possible world.

Mythic thought also started in the same way. But then Myths and Science completely differ. (**Jacob**, [7])

Such an approach has been described in detail for exploring the relation between science, philosophy, and theology (Russell, Stoeger, Coyne, [8]).

3.1.4 The Withdrawal of Foundation

A characteristic of epistemological thinking today is to note what Ladrière has called “the questioning of the foundation, indeed, the withdrawal of the foundation” (Ladrière, [9]). According to Ladrière, this observation can be made through Hilbert’s project to found mathematics on logical atomism and the development of phenomenology (the attempt to reconstitute the movement of the self-construction of experience).

In these three cases, the method consists in discovering a privileged region that contains the guarantees of its own validity, and showing how, through appropriate actions, it is possible to shed light on the relatively obscure parts of the discourse on experience without prejudice to the region (the role of foundation played by this region). Ladrière shows that Hilbert’s project on the foundation of mathematics has come up against the limits of formal systems:

The demonstrations of non-contradiction (which are the main components of Hilbert’s program) can only in part be relative. The idea of a privileged founding domain is untenable (both because there is no way of “reducing” everything to such a domain and because it is impossible to identify a region which would be capable of founding itself in an absolute sense) (**Ladrière**, [9]).

According to Ladrière, what serves as a foundation at any given moment only constitutes a temporary pause in a process that is bound to continue. These are only the contingent conditions of the research, the temporary limitations of operational, conceptual, or experimental means of investigation.

There is, therefore, no essential difference between the founder (who is only ever improperly the founder) and the founded. There is no true discontinuity in their status. This signifies that this type of unshakeable solidity, this faultless consistency which was attributed to the foundation and which was transmitted to all that was founded is no longer looking so sound (**Ladrière**, [9]).

3.1.5 Bohr’s Complementarity Principle and Its Confrontation with Complexity

The history of how Bohr’s idea of complementarity has been examined by Gérard Holton (Holton, [10]). The key points of his argument are complementarity in quantum mechanics and the question of different levels of reality.

3.2 Bohr's Complementarity in Quantum Mechanics

3.2.1 Presentation

In quantum mechanics, the description of elementary particles (like the electron) that make up matter requires the use of terms that appear to be mutually exclusive and which we will call “contradictory” or “antagonistic” (A and non- A). For example, an electron is a well-recognized elementary particle whose trace and impact can be picked up by a detector (corpuscular properties). But its wave properties are just as well established and are exhibited in the phenomena of diffraction (with interferometry). To describe a particle, quantum physics refers to wave *and* corpuscle, even if experimentally the wave characteristic *or* the corpuscular characteristics are exhibited independently.

These two images of wave and corpuscle are mutually exclusive. In fact, a given entity cannot, at the same time, in our accepted usage of language be a wave (that is to say, a space that extends to a greater space) and a particle (that is a substance enclosed in a very small volume). With complementarity, however, continuity (the wave aspect) and discontinuity (corpuscular aspect) will be considered at the same time in the description of elementary particles. In this way, we find that there are numerous examples of contradictory couples (or antagonisms) in quantum mechanics: continuity-discontinuity, separability-nonseparability, symmetry and broken symmetry, local causality and global causality, for example. Thus a system composed of two elementary particles that is said to be entangled (both emitted by a same source for example) is said to be *non separable*. Nonetheless, the logic we derive from everyday life indicates that our macroscopic world is made up of separable elements even if interactions between these elements exist and can be determined. The question is, then, how to reconcile continuity and discontinuity, macroscopic locality and microscopic locality?

Among the different approaches proposed for resolving this question, the most convincing is the principle of complementarity as expounded by the physicists Bohr and Heisenberg. They believed that complementarity describes a phenomenon by two different modes that are necessarily exclusive. It is only by considering these two contradictory modes that one can start to understand the phenomenon:

“When playing with these two images (wave/corpuscle for example), going from one to the other and then back again, we finally obtain the right impression of the strange sort of reality which hides behind our atomic experiments” (**Heisenberg**, [11.12]).

Bohr and Heisenberg made use of the concept of complementarity on several occasions in order to interpret quantum theory. Hence, knowing the position of a particle is complementary to knowing its movement quantity (product

of mass by velocity). If we know the value of one with a high degree of accuracy then we cannot know the value of the other with the same degree of accuracy (Heisenberg's uncertainty principle). Yet we need to know both in order to determine the behavior of this particle.

A particle can be studied experimentally with a detector or an interferometer. In other words, according to Bohr, if one wants to talk about a quantum object it is better to do so in terms of corpuscle or wave depending on the way the experiment is set up and in relation to the question asked by the observer. No image is ever complete and it is necessary to make use of two contradictory images to describe the quantum object. The change this represents, compared to classical physics, is that the very definition of the physical measurements is directly affected by the procedures and measures used:

“The measuring procedure has a fundamental influence on the conditions on which the very definition of physical quantities in question is based” (**Jammer**, [13]).

In this way, Bohr was able to show how in quantum mechanics the fundamental premise of the indivisibility of quantum action, forces us to adopt a new method of description that can be called complementary. Any given application of classical concepts prevents the simultaneous use of other classical concepts that in a different context are equally necessary for the elucidation of phenomena. Let us emphasize here the importance of the coupling of *experimental conditions* and the *conceptual apparatus* that forms the basis of Bohr's complementarity principle. This principle is intended to determine the manner in which those concepts work, which plays a part in the understanding of the theories of quantum phenomena—a fundamental concept for the philosophical analysis of the idea of complementarity.

This “way of viewing reality” gives rise to a paradox, at the level of language, as in the case of the wave/corpuscle, locality/nonlocality couples. However, for Bohr, the paradoxes resulting from these double descriptions are, so to speak, put to one side by the fact that it is impossible to take two simultaneous measurements of the same object, those of its wave characteristics and its corpuscular characteristics. When one of these images is materialized, the other becomes virtually or potentially realized. Let us stress, however, that this complementarity has more to do with mutually exclusive aspects of quantum phenomena than a mere juxtaposition of images. The elementary particle is neither a wave nor a corpuscle but a “thing” that combines the two images.

Even if pertinent critics on the Bohr's ideas of complementarity have been made by other founders of quantum theory (Planck, Einstein, Schrödinger and de Broglie) and by contemporary physicists and philosophers (Bohm and Feyerabend for instance), it is still of great interest for both scientists and philosophers.

3.2.2 Different Levels of Reality?

The philosopher and scientist Stéphane Lupasco and the physicist B. N. Nicolescu made two little-known but nonetheless major contributions to the idea of complementarity (Lupasco, [14,15]). Lupasco's general idea was to propose a new logic, based on what the experience of microphysics was able to say and reveal about human thought. According to him, although Hegel and Bachelard were aware of the fact that classical science was ill-suited to describe microphysical experiments, they did not go far enough. Refuting classical yes-or-no logic, Lupasco showed that that only the logic of the included middle is capable of taking into account complete reality. The diversity of reality can be structured and contained in the triad, Actualization (A)–Potentialization (P)–State (T) (which corresponds to the included third term). The actualization corresponds to that which is experimentally measured. Potentialization is that which exists “potentially” even if it is not actualized (for example, the physical states corresponding with the wave function). State T implies a dynamic equilibrium between A and P. Basarab Nicolescu introduced the concept of levels of reality into Lupasco's system (Nicolescu, [16]). To properly understand this concept and in order to avoid confusion with closely related concepts of *levels of representation* and levels of organization, we offer the following analysis.

When the physicist wants to describe a quark for example, he starts by describing it as a purely mathematical entity (this is the first level of representation), then as a free particle (the second level) and, more recently, as a particle confined in the hadrons (the third level). In fact, these three levels of representation belong to the same level of reality, which we shall call the quantum level. Conversely, quantons (which correspond to a particular level of representation of the elementary particles) also correspond, as we have seen, to waves and corpuscles (another level of representation). But, in this case, these two levels of representation correspond to *two levels of reality*, to the quantum and classical levels in physics. At the level of the organization of matter, representations are either at the same level of reality, or a combination of several levels. Thus a level of reality will correspond to a family of systems that remain invariant under the action of one law. One can distinguish different levels in according to the scales used: at the level of particles, man or planets. Moreover, two levels of reality are different if there is a break in the laws, the logic or the fundamental concepts (like causality for example) when one passes from one level to another. The following paragraph applies such concepts to the wave-particle problem.

3.3 The New Logic of the included Middle in Quantum Physics

One possible solution to this situation of apparent logical paradox is to replace the axiom of the excluded middle of classical logic—something cannot be this and also that at the same time—argued by Aristotle, by the contrary axiom of

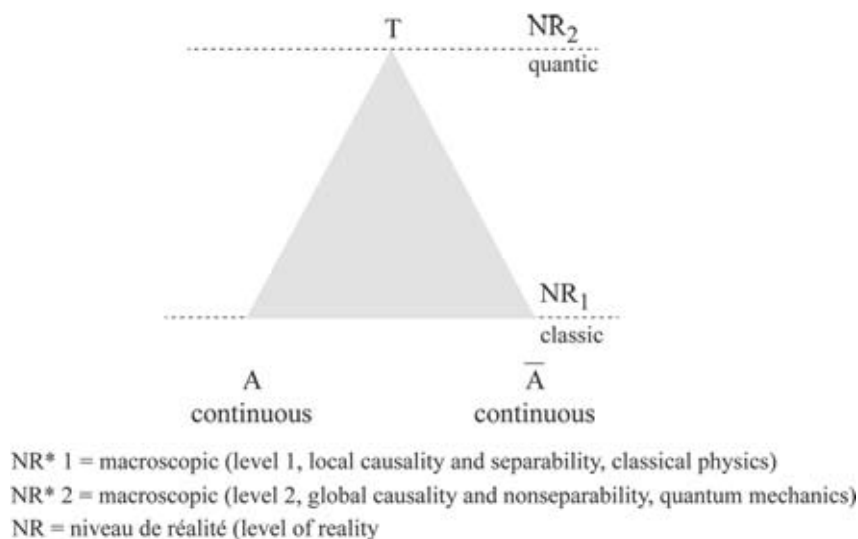


Figure 3.1: Levels of reality in the logic of the included middle.

the included middle, we have the idea that there is a third term T that is at the same time A and non- A . As previously introduced, by the term “level” we mean a group of systems that is invariant under the action of certain laws. The passage from one level of reality to the other then involves a breakdown of laws and logic, of fundamental concepts such as causality.

In analyzing the complementarity principle, the two levels of reality that must be considered are the macroscopic level NR_1 (related to classical physics with its appropriate and specific language and logic) and the microscopic level NR_2 (related to quantum physics with its own appropriate and different logic). The content of the axiom of the included middle becomes clear if we put the three terms A , non- A , and T on a triangle diagram with the dynamics associated with them, as shown in Figure 3.1.

Research at point T corresponds to research focused on a level of reality where what is mutually exclusive at level NR_1 can be unified at level NR_2 . It corresponds to the included middle for which point T is not at the same level of the contradictory logical antagonism. Notice that the antagonism is never completely solved. New antagonisms can appear from point T at level NR_2 . The figure is only a simple heuristic to represent the level structure of the included middle in quantum physics. In this representation, no basic contradictions with Aristotle’s logic of non contradiction occur because point T is not at the same level as the two components of the basic contradiction.

Contraries, contradictions, antagonisms, and opposites are terms that have evolved since the time of Aristotle. We propose the following definition of “antagonism”, both in science and (as we will see) in theology, consisting of

eight characteristics (Kaiser, [17]):

- **unity:** the complementary modes of representation are related to the same object. What appears to be a wave under some experimental circumstances and a particle under others is in fact the same object.
- **common properties:** going along with the unity of the modes, in the domain appropriate to atomic phenomena, these are rest mass, electric charge and spin angular momentum.
- **completeness:** of each mode in one experimental situation; the object may be completely described, in a given situation, in terms of the appropriate mode without any explicit reference to the alternate mode. Only if the situation changes does the alternate mode take into account.
- **co-exhaustivity:** together, the two modes are sufficient to simultaneously describe the object: there is no third mode.
- **equal necessity:** the two modes are equally necessary, of equal importance.
- **alternativity:** the temporal evolution of the physical entity proceeds by a continual alternation between one mode and the other as the entity passes from one situation to another.
- **co-inherence:** each mode exists potentially inside the other; in this sense, the an atomic object is both a wave and a particle. There is an inter-participation or co-operation between the modes.
- **mutual exclusivity:** the two modes are mutually exclusive in the sense that they are conceptually incompatible and cannot be combined into a single picture.

3.4 The Classical Logic of the Included Middle in Christian Theology: The “via Eminentiae”

“At the end of each truth, one must consider the opposite truth, the two opposite reasons. If not, everything is heretic.” (Blaise Pascal, [18])

This statement from the Christian scientist-philosopher Pascal asserts that the approach to truth requires the clash and synthetic combination of opposites. In theology, this insight has been called the “via eminentiae” based on the debate between differing views or perspectives since Thomas Aquinas.

Thus, God in the Bible is presented both as personal and non-personal, both humble and non humble-which means that He cannot be personal and humble as we imagine by simple, direct analogy to human attributes.

Indeed, one sees the formal representation of several logical antagonisms within the Christian tradition. For example, the history of the dogma of the

Holy Trinity clearly shows a continuous dialectical process of searching for non-contradiction (Bertrand de Margerie, [19]). This is detailed in the Quicumque Symbol of Athanasius (Denziger, [20]) which is a magnificent illustration to explore a unity of antagonisms, as we will see later on.

But the famous dogma of Incarnation is probably the best example of the use of the *via eminentiae* principle within theology. Jesus is held to be both true Man and true God, realizing on the Cross the unity of antagonisms “full power-no power.” On the Cross he reveals both who is Man and who is God. Then for the disciples of Jesus, the Cross unifies the antagonisms “to become themselves [vs.] to be completely dependent and given to God.” This opens a new way and power of life! One finds oneself in losing oneself !

This is not so far from Heisenberg and Bohr statement about the completely different wave-particle duality in quantum physics. As previously shown, they believed that complementarity describes a phenomenon by two different modes that are necessarily exclusive. It is only by considering these two contradictory modes that one can start to understand the phenomenon.

The question for the present analysis is to examine whether notions such as complementarity and included-middle logic used in science may be interesting for advancing the classical “*via eminentiae*” in theology. It will be necessary to show how such approach can be valid in theology, taking into account the specificities of each field.

In theology, a distinction separates the concepts of knowledge from revelation and knowledge from conceptual thought. For example, theologian Karl Rahner said:

Theology is mainly (i) the believer’s explicit awareness to revelation of God in History through His Word which is Revelation per se and (ii) the scientific method in order to gain insight into His Word as knowledge on newly acquired information. (**Rahner and Vorgrimler**, [21])

Thus, revelation is not separable from the experience of the community of believers in the Church in a peculiar social and cultural context. In theology, there always is “something beyond our understanding” that we call “mystery” and that is beyond the domain of logical analysis according to the empirical and logical scientific method. A mystery is not something we cannot understand. It is something we will never get to the end of (St.Augustine). A mystery is something in which the subject is involved, in contrast with an analytical problem independent of the subject. Thus, the question of the mode of representation occurs in theology as well as in science.

Kaiser [17], Barbour [6] and Reich [22] introduced the interest for theologians to use the logic of antagonisms coming from quantum physics. But they don’t integrate the very useful concept of levels of reality. So, let us see now how the new logic of the included middle coming from Bohr complementarity and Lupasco and Nicolescu’s interpretations can be pertinent to present the main christian dogmas.

3.5 Jesus Christ, Truly God and Truly Man

At the famous fourth ecumenical council of Chalcedoine (451 AD), the Church Fathers declared: Our lord Jesus Christ is one and the same Son...truly God and truly man...one and the same Christ—made known in two natures which exist without confusion, without change, without division, without separation; the difference

Thinking in terms of complementarity, using the eight characteristics previously presented, one can observed:

- **unity:** the divine and human natures are united, they constitute one person (*prosopon*) by virtue of their conjunction (*synapheia*). Christ is held to be one *prosopon* and one hypostasis in two natures (*duo physisin*).
- **common properties:** the *homoousion* does double duty by asserting a common substance as well as a single being. The hypostatic union implies a single person and a common subsistence. The pre-existent subsistence of the logos is the source of the subsistence of his assumed humanity, that humanity having no independent subsistence of its own.
- **completeness:** each of the natures or modes of being in Christ is complete, entire, perfect and fully real in itself.
- **co-exhaustivity:** there are two natures or modes in Christ, no more and no less. Both modes must be included in any reasoning about the person of Christ, and neither one can be eliminated in favour of the other.
- **equal necessity:** the two modes are equally real and equally true and necessary.
- **alternativity:** since time itself is an ongoing dialectic between God and the world, the life of Christ must entail a continual alternation between its own two modes. There are two reciprocal movements, the deification (*theosis*) of the flesh and the “inhomination” (*enanthropesis*) of God.
- **co-inherence:** the *logos* indwells or inhabits the flesh like a garment or a temple. There follows a reciprocal penetration of the humanity into the deity of the *logos* so that there is a mutual penetration (*perichoresis*) and co-inherence between the two natures.
- **mutual exclusivity:** in spite of their interpenetration the two natures or modes of being remain unconfused (*asunkutos*) and unchanged (*atrepotos*), each retaining its full integrity within the hypostatic union. This is due to the fact they are mutually exclusive, so that no compromise or reduction to an intermediate nature or mode is even conceivable.

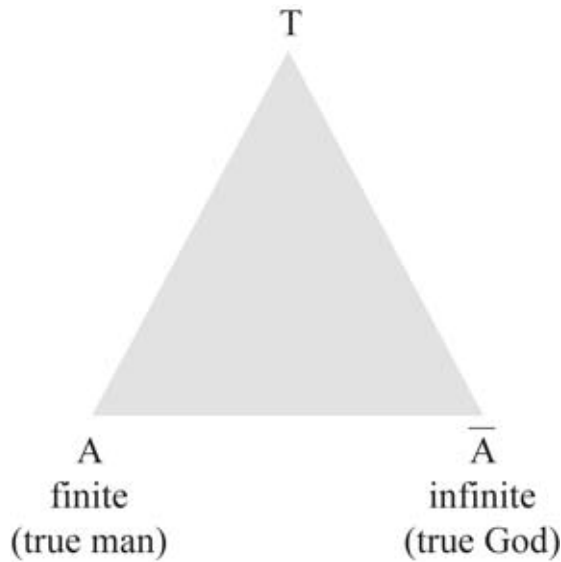


Figure 3.2: Representation of the dogma of incarnation in terms of levels of reality in the logic of the included middle.

It is clear in such presentation of the dialectic of the two natures of Christ that there is a specific coupling between experimental conditions and conceptual apparatus in theology as well as in science!

Thinking now in term of the included-middle logic, Figure 3.2 illustrates an analogous representation of the dogma of Incarnation in such a way, using the levels of reality.

In classical language, man is finite and God is infinite: Finite man cannot be infinite God! This statement defines reality level NR1 (bottom of triangle). In the Christian tradition, the unity of antagonisms between finite and infinite is realized by Jesus Christ, reality level NR2 (faith, top of triangle). Here, the incarnate Son of God, Christ, realizes the unity of antagonisms, particularly on the Cross (the death of eternal life). But for the believer, the Cross is still the sign of a “passing-through;” a sign of conversion that is never finished! Thus the believer goes by faith from level NR1 to level NR2, but never reaches point T. The novelty of Christ is given by revelation and is completely beyond what we can imagine.

Even if there is no relation between the status of quantum reality and the status of Jesus the Christ (obviously!), the antagonism of finite-infinite in theology in comparison with the continuous-discontinuous antagonism in science, along with their corresponding modes of representation, are quite analogous in terms of logic of the included middle. Analogy is here related to the mode of representation in terms of logic, not the attributes! The logic of

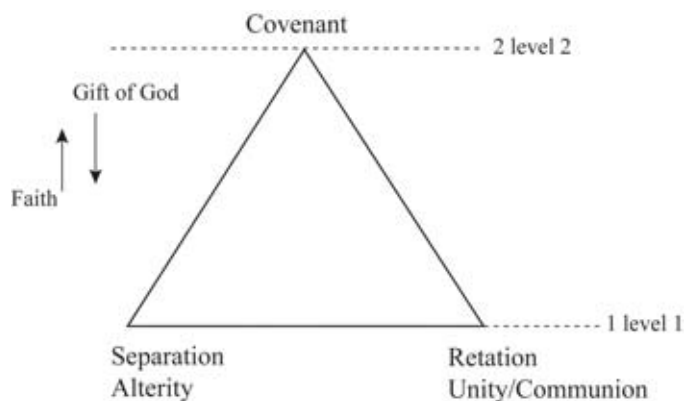


Figure 3.3: Representation of the biblical covenant between man and God.

quantum physics appears quite interesting for presenting the terms of Christian dogmas and to emphasize the potential logic with respect to reality of such formally paradoxical beliefs.

3.6 The Covenant in terms of Logic of the Included Middle

Another important point of the Christian tradition, the Covenant between God and Man in the Bible, can also be expressed in terms of complementarity using the logic of the included middle.

Creation is separated from God (one of the translations of “creation” in Hebrew means “separation”) and, at the same time, is in relation with God through the Covenant. Thus, the Covenant includes both the separation (alterity) and the relation (unity/communion), as shown in Figure 3.3.

There is a strong unity of antagonisms in the Covenant that allows both freedom of choice for man and the freely given gift of love from God to humanity. The love of God given to humanity is completely free, which is open to a free man’s response. The experience of faith is open to an understanding of the Covenant as a unity of contradictions that is never completely solved by man. Using the terms from the hylemorphism of Aristotle, one can say that the actualization of the separation induces the potentialization of the relation. Similarly, the actualization of the relation induces the potentialization of the separation. This is in dynamic equilibrium.

The actualization of the separation corresponds to the usual experience of “the God’s absence”! Such presentation clearly illustrates how faith corresponds to a dynamical research of God by man in a free relationship between God and man. The Bible shows a lot of historical examples of such actualiza-

tion/potentialization effects.

The dynamical equilibrium corresponds to a kind of “dash” from man to God allowed by the free love of God which calls the free answer of man. In this dynamical equilibrium through the presentation with the included middle logic, the fundamental alterity between God and Creation is clear, which avoids classical forms of pantheisms.

Thus, a true partnership is proposed by God to Man in the Covenant. The free love of God allows and generates the freedom of Man. Then, the sin of Man will in fact correspond to the rupture from Man of the couple alterity-unity, for instance when Man takes the place of God or when he builds some idols. In contrast, Man can become himself inside the alterity-unity offers by the free love of God. More Man becomes Man, more God appears both intimately linked with Man and completely “Other”!

Moreover, looking to Covenant through complementarity emphasizes the fact that God creates at each moment and not only at the beginning of time and space. The love of God gives being and life to creatures at once, and not only at the beginning of the world, in space and time! This way to present Creation in Christian theology is of prior importance in the debate between science and theology.

Finally, Jesus Christ opens New Creation through Cross and Easter. On the Cross, He realizes the perfect antagonism “separation-unity” with his Father, which opens to New Covenant between God and Humanity, God and Cosmos. In the daily life, this unity of antagonisms “full power of God-non power of Christ on the Cross” corresponds to the fundamental way for Church toward the God Kingdom! Then for the Christ disciples, to become myself is closely related to give myself to God.

Thus, quantum logic can be fruitful in exploring the biblical Covenant in its specificity!

3.7 The Doctrine of Trinity

The history of the Christian dogma of the Trinity clearly shows a continuous dialectical process of searching for non-contradiction (de Margerie, [19]). In fact, the entire history of the Christian dogma of the Trinity testifies to an enormous and fruitful conflict between excluded middle thinking and included middle thinking, said the french theologian B. Sesboué (Sesboué et Meunier, [23]). We will consider as an exemplary case the *Quicumque Symbol*, attributed to Athanasius (Denziger, [20]) and which played an important role in the development of the dogma of Trinity. Such a text cannot be read using binary classical logic.

To show the interest of the use of complementarity and of the logic of the included middle to present the doctrine of Trinity, one must develop more the notion of level of reality (for more details, see Camus, Magnin, Nicolescu, [24]).

We have previously shown that the connection between two contiguous levels is insured by the logic of the included middled and is graphically rep-

resented by a basic triangle : the contradiction (A, non-A) present at a given level of Reality, e.g., NR_1 is resolved in a non-contradiction via the T-state at a immediate contiguous level, e.g., NR_2 (or NR_{-2}). However the “final”, complete theory is not (and cannot ever be) found because in turn the respective T-state opens a new contradiction (A, non-A) at its own level, e.g., NR_2 (or NR_{-2}). This process continues indefinitely. The so called “Gödel-like structure of Nature and knowledge” (referring to the Gödel theorem), is precisely represented by this process: the contradiction cannot be definitively solved and there is no conceivable complete theory. The logic of the included middle resolves the contradiction at a given level of Reality while simultaneously opening the contradiction at a different level of Reality.

The iterative action of the logic of the included middle, represented by the triangulation shown in Fig. 3.4, implies the imbrication of levels and the coherence of Nature as a whole. A particular role is played by the three topological envelopes of all A, non-A and T-states, respectively, represented by the three closed loops in Fig. 3.4a.

The loops must be *closed* in order to insure the *coherence* of the transmission of information from one level to the other, in the entirety of all existing levels. Moreover, this coherence is not completely insured if the three closed loops run parallel to each other: they *must join together at least at one point* X. The situation represented in Fig. 3.4a is only the simplest one and is therefore in no way unique: the three topological envelopes could join together at several points, say X, Y, Z, etc.

As can be verified, this text demonstrates a perfect logical coherence if one performs the following correspondence at the level of language : Father \rightarrow the closed loop going through all non-A (potentialization) states ; Son \rightarrow the closed loop going through all A (actualization) states ; Holy Spirit \rightarrow the closed loop going through all T-states ; God \rightarrow point X (see Fig. 3.4b). For reasons of space we have limited ourselves here to only a few examples which will serve to illustrate this perfect logical coherence.

In the Quicumque symbol it is said : “*Qualis Pater, talis Filius, talis Spiritus Sanctus ; increatus Pater, increatus Filius, increatus Spiritus Sanctus ; immensus Pater, immensus Filius, immensus Spiritus Sanctus ; aeternus Pater, aeternus Filius, aeternus Spiritus Sanctus : et tamen non tres aeterni, sed unus aeternus; sicut non tres increati, nec tres immensi, sed unus increatus et unus immensus...*”

The word “increated” corresponds to the right of Fig. 4b, where no levels of Reality are present. The word “immensus” corresponds to the fact that the three topological envelopes in Fig. 4b cross both the regions of “created” and “uncreated”, encompassing everything which was, is and will be conceived by human reason. The word “aeternus” refers to the fact that strictly speaking, “time” is defined only in the left region of Fig. 4b, where the totality of levels of Reality is present. However, there are not three but only one “increated”, “immensus” and “aeternus”, because the three closed loops in Fig. 4b join at only one point (X = God) : “*et tamen non tres dei, sed unus est Deus...*”

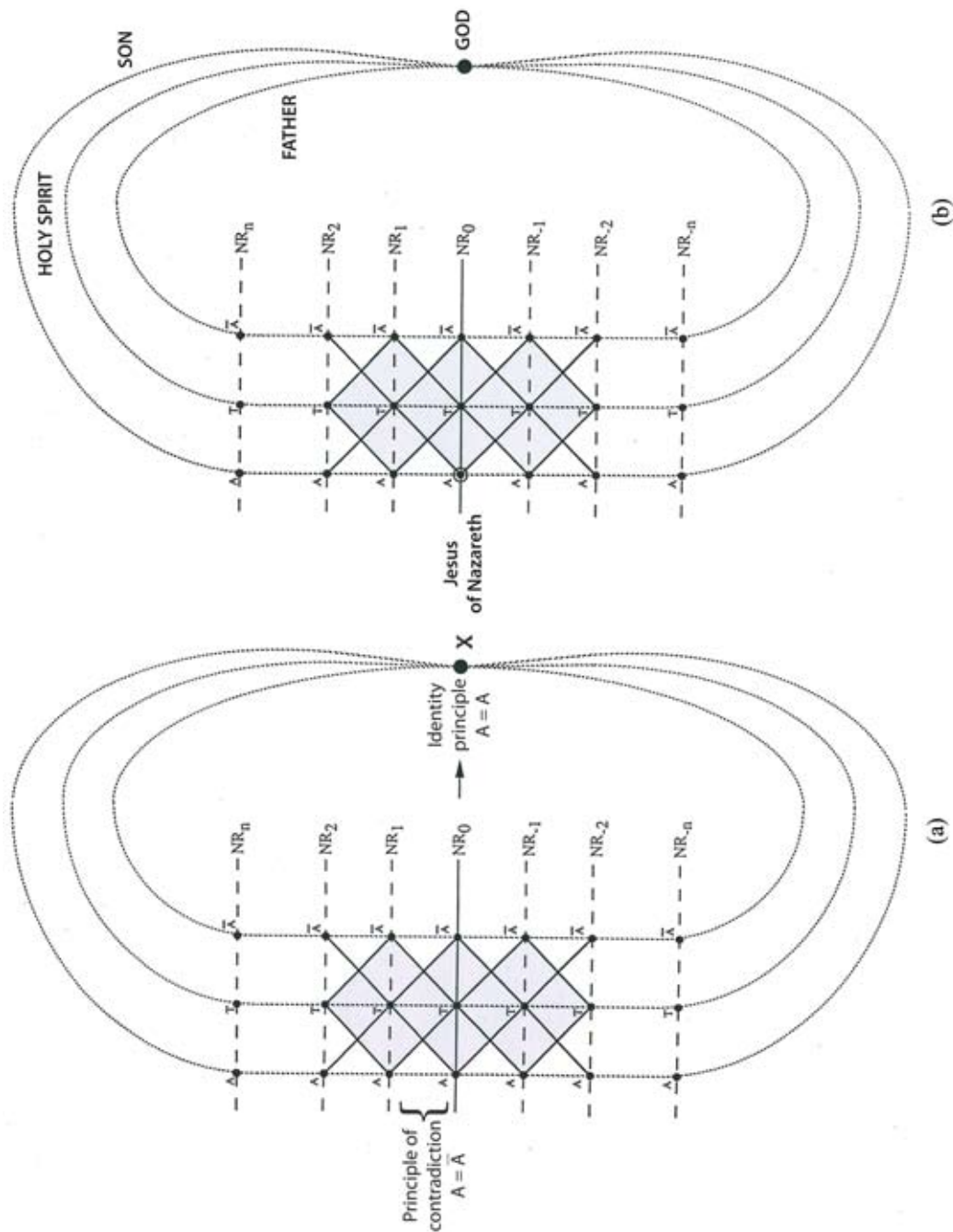


Figure 3.4: Graphic representation of the notion of generalized levels of reality (a) and of the Trinity Dogma in such terms (b).

The Trinity in Fig. 4b is certainly not a hidden quaternity, in spite of the presence of point X = God. This joining (identification) point belongs to the topological definition of the three closed loops and therefore cannot be conceived as an independent entity (on the mathematical, logical or symbolic level).

Finally, let us quote an extremely significant part of the *Quicumque symbol*: “*Pater a nullo est factus nec creatus nec genitus. Filius a Patre solo est, non factus nec creatus, sed genitus. Spiritus Sanctus a Patre et Filio non factus nec creatus nec genitus, sed procedens. Unus ergo Pater, non tres Patres, unus Filius, non tres Filii ; unus Spiritus Sanctus, non tres Spiritus Sancti ; et in hac Trinitate nihil prius aut posterius, nihil maius aut minus, sed totae tres personae coaeternae sibi sunt et coaequales...*”

The word “creatus”, as we’ve already said, refers to the left part of Fig. 4b (where the levels of Reality are present), while the word “genitus” refers to the right part of Fig. 4b. However, in a dialectical process, the term “non-genitus” acquires all its meaning through the crossing of all potentialization non-A states, while “genitus” acquires all its meaning through the crossing of all actualization A-states. Finally, the word “procedens” rigorously describes the role of T-states which is that of a link of communion and love between Father and Son, in agreement with the interpretation of Saint Augustine. The role of the T-states is also in perfect agreement with what it is said about the Third in Jn 14, 16; 14, 26, where it is designated under the double aspect of “Holy Spirit” (Holy Breath) and “the other Parakletos”.

Let us conclude by quoting the nice formulation of Bertrand de Margerie concerning the Trinity: “Unfathomable mystery does not contradict the rules of human logic at all”(de Margerie, [19]). Trinitarian language must remain, by definition, for ever unachieved; nevertheless, its progressive clarification is possible.

3.8 Moral Philosophy: A Common Ground between Science and Religion in front of the Mystery

According to the leitmotif of modern epistemology, in the analysis of the incompleteness of science as a whole, something is beyond our knowledge. The principle of complementarity is an interesting illustration of this. Contemporary science invites us to measure the positivity of this incompleteness, which now appears to be a very condition of knowledge. It is a good precursor to the question of the meaning and place of the subject in the exploration of the world to which it belongs. There is a withdrawal of foundation; “something is beyond our knowledge.” This “absence of fixed representation” starkly highlights the questions of foundation and meaning.

The progress of scientific knowledge forces man to accept his contingency and his finiteness. This is where we touch upon moral issues. If the search for

truth, in scientific, philosophical, theological, and artistic disciplines is a moral choice that could be described as innate, then running the risk of looking for this truth with a radically new logic and set of concepts could be seen as an further moral choice. We can, therefore, point to new values in the scientific method today. A critical analysis of the foundations of these values leads us to the area of moral philosophy.

3.8.1 An Initial Decision in the Scientific Method: Constructing Meaning on the Basis of Nonmeaning

The diagram of the triangle to illustrate complementarity (with endless possibilities for new levels of comprehension of reality, since antagonism is never resolved at point T), illustrates the withdrawal of foundation as already mentioned in light of the work by Ladrrière. There is the “undecidability.” Reason can rely on nothing but itself and, at the same time, experiences its own finiteness. Reason cannot be complete; something is beyond our knowledge.

Hence comes the initial decision of a subject: to construct meaning from nonmeaning. We have a good example of this with complementarity that aims to combine antagonisms depending on their levels of reality. This decision is an essential point in scientific reasoning as illustrated by Einstein’s sentence quoted Einstein speaks of a belief that takes us into the realm of ethics. The decision to construct meaning from nonmeaning can lead to the level of ethics according to the corresponding intentionality (personal decision) according to the commitment linked to this decision.

3.8.2 The Search for Meaning from Nonmeaning

It is in the search for truth that people from different disciplines (scientists, philosophers, artists, theologians) find themselves engaged in a moral choice that consists in finding the possibilities of meaning against what often appears to be a background of nonmeaning (the example of the importance of antagonisms). Every time thinking comes up against reality and bares its finiteness to represent it, there appears a basic dynamic for this reason that renders it capable of accepting new structures and building new concepts likely to favour progress in the intelligibility of reality. In this dynamic of reason, the choice of intelligibility of the world is central.

Moreover, as we have already seen, the conceptual means chosen to make progress in this intelligibility also constitute risky choice (for example positively accepting incompleteness, at the same time that the allure of completeness is still dominant). This reasoning has some link to the concepts of good and bad. To advocate certainty (or its opposite, uncertainty) is seen as positive or negative according to the individual. It becomes a question of moral commitment, of ethical decisions. Besides, the clashes of different schools of thought, in each discipline, serve to highlight opposing points of view that in science, for example, are of an ethical nature as well as a technical nature (see,

for example, the debates on Darwinism and the theories of evolution).

In Ladrière's discussion of the dynamics of reason, he shows that it is founded on a prior ethical consideration (Ladrière, [25]). The essential is defined by the movement toward a moral life, starting from a continuous search for new representations of reality and the acceptance of their existence. Reason is seen as a representational activity, which exists to analyze and understand the world. The necessary point of departure for this reasoning is the acceptance of a fundamental otherness, constituted mainly by that which resists our representations. There are moments in scientific research when reality manifests itself in a way that shows up the inadequacy of our modes of representation. We must, therefore, accommodate this "new representation."

This "acceptance" contributes in turn to realizing the knowing subject and the good scientist. The effect of this acceptance on the subject is an important element of the moral process. It is through perceiving that which "I am not" that I become myself as a subject. This otherness is not in itself a moral value, but it corresponds to a decision-making process that involves both recognition of otherness and an inclination towards unity. It is the openness to that which is other (thing and person) that falls within the realm of ethics. A new relationship with totality is initiated; a new interaction with totality and this engenders a creative process that presupposes an openness to universality.

According to Ladrière, not only does everyone receive the totality of the universe, through their personal creativity, but this creativity itself produces a new space for communication which surpasses prior inconsistencies.

All objectivity is, therefore, the external projection of that takes place on a practical plane, whereas each practical plane is crossed, in its own right, by the demands of its own externalization. When one wants to understand the dynamics of the link between an objective and a practical plane, reason can, in a third instance, discover on the one hand, that in all these constituent objectivities bound only by their external constraints, the effect of its own activity as part of the process, and on the other that this activity can only find self-discovery through the objective status that it has given itself (**Ladrière**, [25]).

Instead of considering practical human activity as a straightforward consequence of a subconscious process to be seen in the context of time and space (moreover this activity is already an integral part of the process), the opposite is also true, according to Ladrière. The operations of this subconscious process become evident in this human activity. We therefore consider morality to be a process, whereby the otherness of a totality perceived as external, the subject interacts with and become the creator of.

Bachelard inaugurated a movement to reconcile the spirit of contradiction and scientific thought; complementary thinking expanded the movement. Pascal's statement summarizes this well: "It is necessary to have two opposing

arguments. Without that there is no understanding and everything is heretical. For every truth we always remember the opposite truth" (Pascal, [18]). Bohr's treatment of the principle of complementarity shows us that the complementarity of antagonisms is a product of the activity of mind whereby the complexity of reality is rendered progressively more intelligible, with identity and otherness playing a tug of war [against a background of]. This perspective of the spirit in action takes on a moral dimension because it decides to create sense out of nonsense, meaning out of non meaning and derives meaning from "nonsensical" facts, and to be aware of otherness and universality.

All these points of view, based on the recognition of the unity of antagonisms (or which lead to such recognition) stem from "first-time experience," that of the link between subject and the reality to which the subject belongs, the link between the uniqueness of the subject and the multiplicity of the reality in which the subject acts. All this serves to illustrate the creative process that Ladrière talks about, Weil's position on the "search for the universal," or those of Levinas on the role of initial tension as a way of being receptive to the other (Weil, [26], Levinas, [27]). We can now discuss these points of view, which should help us to discover more about the foundations of the complementarity theory.

3.8.3 Weil's State of the Search Toward Universality

For Weil, a Kantian, strongly influenced by Hegel, there are many other perspectives from which to consider complementarity. In *Logic of Philosophy*, notably in the chapters "Non-Meaning," "Conditions," "Absolute," and "Work," he shows how philosophy is about a personal search for meaning in life and how it identifies the problems along the way that make this search difficult if not impossible. Weil identifies in man the finiteness of the knowing subject, incapable of comprehending reality without artificially constructing it, and his infinite liberty leading him to create a meaning through the rejection of violence seen as the refusal of a coherent discourse. Philosophy is about the making of a coherent discourse, one that makes sense, and which is based on knowledge (historical, political, economic, etc.); which have all influenced man's attitude in the past and present.

Philosophical discourse as a rejection of violence relies on a premise (the condition, our situation in the world) which may itself appear to make no sense. Weil distinguishes between discourse and language, noting that the latter falls under the heading of "the condition," (in the sense of an irreducible finiteness). It is important to insist on Weil's fundamental distinction between language and discourse. When man uses language he uses the language of a community, not the language of the "man in a specific condition." The discourse is a search for coherence that will allow the rediscovery of a universality lost in the condition. It is worth noting here that there is a problem with the scientific reasoning that sets out to describe a reality that it only has partial access to. In the process, the use of a classical language (in the case of quantum physics,

for example) invariably leads to contradictions.

According to Weil, philosophical discourse is based on the premise of existence that does not appear to have any foundation and is, therefore, without meaning.

“Inquiry shows how the manifestation of consciousness exists between meaning and non-meaning, both of which are constantly part of the discourse. For our present purposes it suffices to remember such opposites as language-condition, decision-situation, me-world. We can say that truth is a domain (condition, situation, world) and everything occupies this domain, revealing to us its existence, its non-meaning” (Weil, [26]).

Philosophical discourse as a rejection of violence is, therefore, based on a domain (condition, situation, world) that itself becomes meaningless through the act of grasping the domain. But even before this nonmeaning of the domain can be thought of as such in philosophical discourse, it is first perceived of as an incontrovertible fact of the “the gift of life.” “Lost” universality can only be rediscovered or touched through interiority and effective action. It is by such an action in the historical world that man can understand himself and, in so doing, enter a philosophical logic by looking for total coherence with the values he has recognized through thought (we find here something of the creative process described by Ladrière). It is through this process that elevation to the universal occurs, since

once the choice in favour of a coherent discourse has been made, the universal precedes the individual, not only in the transcendental sense but also in the most banal historical sense. Man is an individual first and foremost for the others he does not begin by being an individual for himself (Weil, [26]).

It is this elevation to the universal that confers value to all personal acts and which is the criteria for true moral philosophy for humanity. As Weil stresses, “reason is not circular.” It is something that is experienced in the absence of meaning.

It is a sign of the finiteness of human knowledge, of an “incompleteness,” as scientists would tend to say today. It is the action that accepts finiteness, the contingency of man, which opens the way to the universal. Underlying this process is the moral choice of coherent discourse (in this case, as a mean to reject violence).

This moral choice is not dissimilar to Einstein’s—and many others’—belief that the world is intelligible! At the same time something still eludes us. The subject must derive meaning from nonmeaning, by accepting the limits of reason and rediscovering universality through an action, a positive choice; this is the basis of the complementarity and of the structure of different levels of reality we have discussed in reference to Bohr and Nicolescu. It is this

elevation to the universal that confers validity on all personal action and which, according to Weil, is the only criteria for a true moral philosophy for humanity.

Weil's incisive analysis allows us to recover the distinction between the different levels on which we work. Here, it is the rejection of violence that allows us to pass from the metaphysical level (search for meaning from nonmeaning) to the level of moral philosophy (the subject finds meaning by rediscovering universality through action, a choice, in effect, which implicates him). As we have seen, this action contains an acceptance of finiteness and the contingency of man. Such "wisdom" (learn from man's contingency) provides a privileged space for dialogue with theologians (Magnin, [28]).

We have referred to the works of Weil and Ladrière in our discussion of the foundations of complementarity. This appears to be an illustration among other things of the problem of the Sameness and Otherness.

What is particularly interesting is that our approach, which started out by thinking about the current evolution of ideas in science, in fact leads us to moral philosophy by way of metaphysics (three quite different areas).

3.8.4 The Meaning of Mystery

The arguments we have presented so far can also be described in terms of a dialectic of mystery. What mystery are we referring to? It is the "mystery of knowing" that has been our theme until now, emanating from a discussion on the evolution of scientific knowledge. Einstein's assertion that "the most incomprehensible thing about the world is that it is comprehensible" and the demonstration of "fecundity" of the idea of incompleteness, are like two "signs" to the mystery of knowing in modern scientific reasoning.

One of the most interesting ways of rethinking the concept of mystery in the twentieth century was proposed by Gabriel Marcel (Marcel, [29]). He criticizes philosophers for "abandoning" mystery to theologians and popularizers. Marcel not only considers the mystery of knowing but also the mystery of the union of body and soul, and the mysteries of love, hope, presence and being. In respect to the questions we are concerned with here, the most interesting aspect is the distinction he makes between problem and mystery. The problem is a question that we ask ourselves about elements that have been laid out before us, as it were, and that are, generally speaking, external to us. Of course, if we think about it we have to acknowledge that there is always the link of knowing between them and us. But characteristic of this form of thinking that considers problems is the implicit postulate that the fact of knowing does not redefine the problem. Moreover, apart from the purely intellectual interest we might have in them, there are no negative repercussions on us. The problems of classical mathematics are the most obvious example of this. There is mystery, on the contrary, when the one asking the question belongs to the very thing about which he is asking the question, that is, the mystery of being, about which I can only inquire into insofar as I am.

A mystery, is a problem which encroaches on its own data ... it is a problem

that steps on its own immanent conditions of possibility. Or else: mystery is something I find myself caught up in and, I would add, not in a partial way by some predetermined or specialized aspect of myself, but on the contrary completely, since I constitute a unit which by definition can never quantify itself and which can only be an object of creation and faith (Marcel, [29]).

Mystery, therefore, breaks down the barrier between the “in me” and the “before me” which characterizes the domain of problem-solving, even if we know that the act of knowing is an intercession and that one can never attain an “in one’s self.” There is mystery of being that is also “the mystery of the act or of thought, which can also be translated as follows: we cannot ask ourselves about being as if the thinking that asks about being was outside of being.” There is mystery of knowledge: “Knowledge depends on a mode of participation which no epistemology can hope to account for since it is itself the source of enquiry” (Marcel, [29]).

For Marcel, mystery is neither the unknowable nor a sort of pseudo-solution. Far from being a “knowledge gap,” mystery is a call for exploration. This rehabilitation of mystery at a philosophical level (G. Marcel employs the term “meta-problematical” to describe mystery) allows for an interesting bridge with theology, as I have analyzed in my book. This is close to the approach of Saint Augustine, who said in another context, that mystery is not what one cannot understand but what one will never cease to understand.

With Marcel’s view in mind, let us now return to the questions of incompleteness, complementarity and the logic of antagonisms. This is an example of the “mystery of knowing.” The model relating to the concept of levels of reality expresses the mystery of knowing that the scientist is faced with. In science, we can also talk about the involvement of a thinking subject (man is a part of the nature he analyzes) even if the scientist’s commitment is not as strong as the philosopher’s, as defined by Marcel. We can even talk about the alteration of reality by the subject who is analyzing it even if, once again, the alteration is not as strong as in the philosophical question of being, as described by Marcel (the subject in physics is not personalized, the alteration of reality introduces itself by the measuring operations that itself is depersonalized).

Nonetheless the question of knowing in modern science refers the scientist to the mystery of knowing as so well expressed by Einstein. Hence, the search for the unity of antagonisms harks back to a “first experience” which is that of the link between the subject and the reality to which it belongs (the link between the unicity of the subject and the multiplicity of the reality in which it operates). The acceptance of the mystery of knowing is once again linked to the finiteness of man: it involves an implicit and explicit moral choice depending on the scientists! In the case of complementarity, incompleteness and the concept of the level of reality, we can talk more in terms of the “dialectics of mystery” in sciences (Marcel, [29]).

3.8.5 Opening Ways to the Mystery of Man

Twentieth-century science leads the scientist to ask about man's place in the history of the universe. This question arises out of thinking on the foundations of the major theories and the underpinnings of scientific reasoning. Classical science provided us with very mechanistic diagrams for representing the world, defining it as a large clock in which man is seen as a simple cog in this contraption.

We have been able to measure the influence of scientism in order to better discern what consequences the changes in perspective of contemporary science can have today on society's mentalities and ethics (Nicolescu, [16]).

"Scientific" objectivity brandished as a supreme criteria for truth, has had a far more profound effect than scientists could ever have expected. The subject has become the object (Weil, [26]). That man should be the "object" of knowledge is perfectly normal for the scientist. It is unacceptable, however, that in the name of scientism he becomes the object of exploitation, ideological experiences or scientific experiments, to be dissected, standardized, manipulated. Of course, this was not the objective of the majority of scientists who tried to establish scientific objectivity. What comes out of this is the "moral influence" that ideas and concepts that originate in science can have on society. In the sciences of the universe and matter the subject has been partially reintegrated, via the acceptance that it is linked to the object. The vision of an "uncertain world," in the words of scientists such as d'Espagnat and Prigogine, calls to go beyond scientific materialism, even if there is strong reticence among biologists.

The withdrawal of foundation discussed earlier reinforces this view. We must be careful, however, not to fill this uncertainty with a more-or-less disguised return to old certainties. The temptation to fill in the gaps of Gödel's incompleteness by a "God of the gaps" is just one example. Let us allow man to receive reality as it presents itself to us, let us give rein to reason that will be open to all eventualities, to be able to articulate the unicity of man and the multiplicity of reality. The mystery is not of the order of magic; it is of the order of intelligence that progresses without ever being self-sufficient.

Let us enter such a world. To find the meaning of this otherness and of this fundamental unity between the subject and reality is to make the choice in an uncertain world of positing, the possibility of an intelligibility, the existence of a meaning. To accept otherness, to avoid simplifying the complex, to think differently, this is what the scientist must choose—a moral choice, reflecting on the mystery of man in nature. In this way, fundamental moral attitudes can be called upon in all search for the truth, notably in science. We must have honesty in this search for truth, of course, acknowledgement of the foundation of meaning where human reason cannot come full circle, active acceptance of incompleteness of all knowledge and a dialectic approach whereby something will always elude us. We have to enter into an acceptance of a fundamental otherness, for the subject, (otherness looking for a link with unity), acceptance of a finiteness and of the contingency of the knowing subject and the choice

of finding meaning from nonmeaning. A certain humility will result, proof of progress of knowledge that will see the abandonment of definitive certainties for an incompleteness that does not deny the search for truth but which displays our own incapacity to reach it on our own, while making us more open to the importance of this truth. All this is covered by moral philosophy! It is on this note that it is interesting to assess the relationships between the scientist and the believer in their quests.

3.9 Conclusions: Related Common Attitudes between Physicists and Believers

Consequences of the analogous use of the logic of the included middle in both theology and science are interesting in terms of human attitudes about the nature of reality. My argument seeks to avoid comparing science and theology directly. It is more important to show that the use of paradoxical complementarity by the scientist can also be an interesting application for the believer. This analogy can illuminate the depth of Christian dogmas, which many people feel must be untrue because they seem *prima facie* to be logical self-contradictions. However, such an analogy demonstrates common issues between scientists and theologians/believers, in completely different fields. Therefore, one can propose the following attitudes to be common through analysis of included-middle logic and complementarity:

- Acceptance of reality as “reality of interactions” and as “something that resists simple representation”
- Positive acceptance of the incompleteness of our understanding of reality. Some aspects of reality are generally beyond our normal modes of understanding. Classical science used the terms “stability,” “permanence,” “decidability,” “determinism,” and “certainty” The evolution of modern science leads to considerations of “instability” of “chance,” “undecidability,” “unsettlement,” and “uncertainty” in our knowledge. It is essential to see that such an evolution does not correspond to a defeat of scientific reason, but, on the contrary, a condition of progress toward a deeper conceptual understanding of reality. Nevertheless, this evolution implies a considerable change of mentality for scientists. This is similar to a challenge in ethics where acceptance of human finitude is necessary, if unwelcome. This posture of humility is also the fundamental, necessary attitude for the believer facing the mystery of God.
- Partial understanding of reality. Despite the incompleteness of our understanding, the world is partly understandable! One can then perhaps say something about God!
- Acceptance and openness to alterity through the sense that reality is deep and resists easy understanding. Reality is always partly beyond

our compartmentalized representations. The same alterity is observed by the believer in theological research into God.

- Edification through confronting alterity. Moral lessons are learned in both science and theology by recognizing that we are subjects facing that which is innately beyond what we can easily confront, capture, and comprehend. Recognition of the depth and inexhaustibility of reality and the limitation of our concepts can be an important, morally potent lesson both in science and in matters of faith.
- Openness to the sense of mystery. This mystery is different in science and in theology, but is similarly significant in each (Magnin, [30]).

In conclusion, one can say that the incompleteness of our scientific knowledge opens new ground for clarifying dialog between scientists and believers. Quantum logic can be very fruitful for presenting the ways in which some Christian dogmas are in fact addressing deep issues. It induces common human attitudes between scientists and believers, which can be of great interest for education.

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CHAPTER **4**

Light, Lighting & Illumination in Transdisciplinary Meaning

Gustavo Avilés, *Light Designer, Mexico City, Mexico, Avilés; Translation and Drafting: Talina Águila and Paola Pasapera.*

This chapter recovers self-observation as means to revalue the way that we conceive light and lighting, taking into account that not everything in light is about quantifiable electric energy and sheer self-indulgence. Light gains significance as an inspiration to enchant the survival of a collective dream; as light that returns to the master beam of trans-perception. It transcends as provocative, irreducible, unpredictable, impossible to measure, in a permanent state of dissatisfaction. Light is sustained in its feminine nature, in constant struggle between the effective and the affective, measured in the border of logics and intuition, light, gas, the space volume of trans-discipline.

4.1 Introduction

We are witnessing a highly extensive array of changes that have taken place in societies, especially starting the 80's, and have shaped the line of events that influences one country to another, managing to erase distances and boundaries, establish new values and demands, modifying the system of consumerism and creating a new set of expectations and tensions that are embedded in the visual messages expressed by the cities and gathering centers of current societies.

In consequence, the new modes of material and cultural consumption in these areas have produced a context that shows a transition from elitist forms of cultural production to new cultural phenomena that, rather than being determined by numbers, are shaped by nature and can be defined by the masses.

This path towards settling a new relationship between the culture of elites and knowledge that is accessible to the masses, is inclusive of sectors of society that were previously alienated from concepts of cultural interest, but are now given access through exhibits – particularly those kinds of exhibits that, pursuant to the language of communications, are increasingly being conceptualized as “events.” These initiatives have drawn great attention thanks to mass communication, and because of curiosity and discussion that they generate.

In the wake of these developments, we are experiencing the contingency of a new attitude that is perhaps not entirely palpable, but is grounded in the transmission of knowledge through trans-disciplinary practice and knowledge-making.

Visual communication media are being reconfigured by a modernization of space in which renewed plans of action have brought out a driving force that lays out a series of demands that can become significant beyond their capacity as cultural forms of knowledge.

The result is a new strategy for movement that encompasses multiple methods of cultural intervention that can be reconciled with scientific communication and decision taking. In this sense, these new modes of intervention ensure that the ethical and aesthetic values of objects and subjects can now be supported and appreciated by anyone in a circuit of gratification that is not attached to a specific time. This approach can be seen at work in an emergent area of knowledge-production that is anchored in light and illumination as essential means of communication.

This is happening not with the simple purpose of making the apparent reality visible, but rather, to attend to new demands of communication that require being displayed and presented in such a way that they can express feelings, emotions and meanings.

4.2 Lighting in the Transdisciplinary Practice, Knowledge, and Vision

In this sense, lighting, as a trans-disciplinary practice, can not only make a fundamental contribution to the appreciation of a visual message that is set on an angle or point of view that considers outlines and colors; it can also elucidate the immaterial aspects of creation, the non substance of the most incredible and creative elements of its own interpretation. When we set the dimensions and establish a relationship between the illuminated object and the light that reveals it, *the included middle* comes into view, creating a terrain where the correct visual manifestation that appears through light not only evokes emotion, but also provides a key to comprehend what is exhibited or manifested. This can be perceived in any event that involves a method of visual communication in which light is manifested as an element that qualifies and configures the meaning that sustains it.

We can understand light in this regard not only as the manifestation that allows the physical visibility of things, but also as a means for the subject who sees to understand and think openly. This *third included*, transforms fact into experience and transcends from idea to intuitive feeling, this being the substantial foundation of the trans-disciplinary vision.

Under this light, the experience of visual thought leaves behind any structure of individualistic optic, generating a perspective of social projections that are unified to render an analysis of the common good.

The visual experience, which is surely not as considerable in terms of quality as it is in terms of quantity, is the vault that provides the greatest capacity to store the experiential knowledge that we acquire through life.

What do I mean by this?

Knowledge or, in other words, the data transmission phenomenon that occurs in the ordinary human condition, is, in one way or the other, introduced into our daily life in a highest percentage by visual experience.

If we know, it is because we *see*.

Vision not only implicates the physical experience of light that is cast on people and things, it is, even more so, the a-material element of understanding that allows things to unravel themselves, overriding fact with experience and experience with the interpretation of meaning, to progressively, through trans-disciplinary processing, transforming it into understanding beyond any risk or fear of mentioning in the creative consequences, manifested in love.

4.3 Visual Experience of Light and the Third Included

Paired to a high-risk attempt, trans-discipline invites us to think, liberated from the prison of the dualistic, bi-dimensional mind that is intellectual, logical, and pragmatic. The lived experience that is carried out through light is possibly, the most visible conductor of idea and knowledge transmission in which the presence of *the one who sees*, mentioned as the *third included*, is in consequence ineffable and infallible.

To *see* through light, can possibly provide the riverbed for trans-disciplinary knowledge.

We understand *seeing* not only as the physical visual exercise.

To *see* includes not knowing and not being able to describe what is seen.

To *see*, in this realm, becomes the trans-disciplinary action of sustaining a question that is previous to the answer.

In the analogy between the daily reductionist way of thinking and the trans-disciplinary outlook, lies a new utopia that runs throughout western culture and dreams of transforming night into day. Trans-discipline, in this sense, is resonance and visual echo of the desire to transform the obscurity of pragmatic-material thinking into enlightened intuitive-humanist thinking.

Looking at the differences between language and races, social and political conditions, the luminous posture of trans-disciplinarity is the possible manifestation of an ideological common denominator of unity and cohesion between the territories of knowledge.

Comparable to light manifest in lighting, trans-discipline works in the same way for all and everything, activating the utopia to the highlights in the development of knowledge and creation.

The new social model of thought manifests the result of relationship between science and art, which in essence is the nature of light.

The utopia that was conceived by Jules Bourdais while attempting to illuminate Paris with giant lamps directed from the highest city point embodies a historical reference that is not considered as trans-disciplinary but responds to its effect and

spirit. In this context, Jules Bourdais designed the *Tour-soleil* for the World Exhibition in Paris in 1889, to fulfill the dreams of a civilization that took up the endeavor of transforming darkness into light, forcing to eliminate any individualistic tendency and embrace an experience that amalgamated science and art, fused and confused in the vast and inexplicable intuitive experience of the emotional intelligence.

Current active sciences: math, physics, chemistry, economy, fused with energy, concept, expectations, dreams, hope, love, all manifest in light. But not only light displayed as electric energy in all its magnificence, even more so, the light of unification that is projected in the same direction of visual thinking and is enforced in the collective social experience. It is worth mentioning that this way of thinking does not recognize borders or territories of specialized property. It sets a relationship between the exterior and interior of the being under principles of inclusion, conjunction, and implication, recognizing and encompassing within this range, the reductionist postures of pragmatic logic.

In this direction, the visual experience of light is manifested as a catalyst and metamorphosis agent that generates a complex circular thinking in which cause and effect are the same in the lived experience toward the perception of *the included middle*.

An impressive idea turns into lived experience when light, as a luminous bearer, supplies the possibility of a conscious action of seeing that is invoked in the theoretical-narrative practice of Goethe when he comments, things exist because I see them, or when Nietzsche mentions that one exists through the eyes of another or when Gurdjieff affirms that I see, I see that I see, I see myself seeing that I see.

Antonio Gómez Yepes mentions that, in the trans-disciplinary perspective, a human being is conceived as a *Homo sui Transcendentalis*, a person who has been born again and whose potential is imprinted in the envision of his own being, including its own contradiction.

This is how light was imagined alternately as a continuous or discontinuous phenomenon, but never both at the same time. And so, the affirmation that light should be non-contradictory, whether it be continuous or discontinuous, was put in doubt.

Max Plank demonstrated, through studying the radiation of black bodies, that he could not become aware of the fine structure of energy without introducing in it an irreducible contradiction. Luminous energy is in a constant indecisive state that fluctuates between continuity and discontinuity, a state that should be labeled as a different concept.

This interaction is parallel to a self-contradictory-state, probably related to that current condition of believing in the “real” truth.

4.4 Effective and Affective Light Transmission

Rigor, openness and tolerance are three fundamental features of the trans-disciplinary attitude, which in direct analogy, correspond to three fundamental features of light, incidence, absorption, and transmission. The rigorous incidence of light projected onto an object, the aperture of light that is absorbed by the subject, and the tolerance to light that is transmitted onto the observer.

In most numerical practices, and in the pragmatic scientific study of light and consequently of lighting as well, the use of light is justified, quantified, and valued in terms of illuminance (the light that is projected) and luminance (the light that is

cast and absorbed by an object). This reductionist scope leaves out any notion that the latter can only exist in the evolutionary visual experience of the *third included* (the participant that *sees* it).

Visual experience amplifies the dualistic phenomenon of projecting light and measuring the quantitative result by considering the active and conscious participation of the subject that sees what is seen illuminated before its own presence.

We can surely find in this contradictory state a relation to the current condition that relies on the effective and cuts off any form of affective display.

Light is related to the non-contradictory forms of sensations, feelings and values, such as doubt, freedom, etc, which are subjective experiences that can be perceived as contradictory.

Hence, before this paradigm, it is possible to see an opposition between the effective light and a distinctly affective light. This clearly positions that illumination is not only manifest in electricity or other sources of material energy, making us aware that light is manifest in the state, condition, and nature of things and people that exist in terms of the light they manifest in both realms of actions and thoughts.

4.5 Reverberating Light

In this process of trans-disciplinary light, Alexandre de Salzman illustrates the *included middle* as the *reverberating light* trans-disciplinary interpreter and mentions:

For us, then, light does something more than tell stories about the sun, moon and stars.

We do not demand of it that it produce effects.

Nor must it make things pretty, nor evoke moods. It must only give to colors, surfaces, lines, bodies and movements the possibility of unfolding themselves.

None of these elements should act at the other's expense, least of all the lighting itself, which should function as a binding force.

A "reverberating light"—that is what we seek. Needless to say, such light must fill all the space at hand, including both the audience and the performers. [7]

Light manifests a wonderful trans-disciplinary foundation by revealing itself in the *middle included* as its own manifestation.

Mentioned in another way, light includes a process of potentiated contradiction, making the definition of the classic scientific reductionist posture more flexible.

Light is the third force that manifests not only the optical visibility of the relationship between subject and object. It provides room for the sacred to be unraveled, for illustration, for creative thinking and non-permanence, enveloping all things that swing between the positive and negative poles of nature, and that are sheltered in their own energy, and in the presence of the *included middle*.

4.6 Light: The Trans-disciplinary Place-Making Thread

This framework, in which the included middle gains significance, is also responsible for the paradigm shift in our place-reading and place-making activities [8]. Trans-discipline does not abide by the classical notion of place as a complete separate entity from subjects and objects. It is more consistent with the idea that place is projected in the dynamic relationship between space, humans, non-humans, and things. The skill to read into place is not attained solely through methods provided by rational constructions of knowledge. It must also be pursued through intuition, imagination, and lived body experience to access the un-measurable dimensions of place.

Place-making, based on the absolute notion of truth that allows no contradiction, formulated hegemonic storylines that excluded the voice of non-dominant groups. In contrast, the *third included*, embodies the subject that is sentient to the multiplicity of realities that place unfolds. This manifold dimensional condition engages historic, social, physical, spiritual, and imaginary lectures and enables simultaneous and diverse narratives to coexist in the physical expression of place.

In the trans-disciplinary context, light becomes the element that strands together the multiple planes of being projected in all the intertwined dimensions of place. Light bears both allusion and illusion that are means of invocation and evocation. Light, in a trans-disciplinary context, not only accounts for historic identity, uses and interpretations; it is also adaptable to new meanings, dynamics, and interactions that encompass distinct forms of alterity and reconciles past, present and future.

4.7 Conclusions

Lighting Design as a relatively new discipline, finds in trans-discipline a fertile ground to draw methods from other fields of study that can help co-create its base of knowledge, configure its value system, and validate its aesthetic-ethical tenets.

The trans-disciplinary perspective has given further meaning to light beyond its quantifiable attributes. Its manifestation is revalued as a phenomenon that threads multiple dimensions of time, place and being into narrative, changing the way we perceive and approach lighting.

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About the Author



Gustavo Avilés, (Mexico City, 1950). Studied Architecture at the Iberoamericana University from 1969 to 1974. Since 1984 he has been focused on Light in Architecture.

He is a leading Mexican Lighting Designer, lecturer, General Director and Founder of Lighteam Gustavo Aviles (1986), enterprise directed to Investigation and development of Architectural Lighting.

The dedication and purpose of developing a quality culture in architectural lighting, have conducted his trajectory to coordinate and teach in several Lighting Design courses (Post-Grade) in Mexican institutions, Mexico National and Autonomy University, Anahuac University, Iberoamericana University among other national and international Academic Institutions. He has been invited to lectures, courses, seminars and fairs in Milan, Portugal, Brazil, Argentina, Germany, Finland, United States and Greece.

His work achieves a wide variety of applications: residential, corporative, historical buildings, expositions, lighting master plans, landscape, among others. Some examples are, Design of Mexican Pavilion on the World Fair of Hannover 2000, Germany; Siebel Corporate, l'Etoile Rond Point, Paris; Chopo Museum, Mexico City; Lighting Master Plan for the City of San Luis Potosi, Mexico; Light Design Project for the Republic Senate, Mexico, City; Tlaxcala Modern Art Museum, Mexico; Perisur Mall, Mexico City.

He has collaborated with lighting design projects in association with Piero Castiglioni (Arch.) Milan; Maria J. Pinto Coelho (Arch.) Portugal; Carla Baratelli (Arch.) Milan; and Dieter Bartenbach, Austria, and other international lighting designers.

He has received in seven occasions the IESNA recognition Award of Merit Edwin – F. Guth Memorial for projects such as Jose Luis Cuevas Museum, Chapultepec Castle, The Flag Pavilion, TELEVISA, Master Channel Center, Sergio Hernandez

Museum and more recently for San Luis Potosi Lighting Master Plan. In 2006 he received from IALD (International Association of Lighting Designers) Special Citation for Sensitive use of colour and Light to respond to architectural form. Also in 2006 he received the National Award for Art Creators in the discipline of Architectural Lighting Design, in the same year he obtained from IESNA the AILEEN PAGE CUTLER MEMORIAL AWARD FOR RESIDENTIAL LIGHTING DESIGN. In 2006 he wins the prize of the audience for a lighting atmospheric installation "ON EARTH AS IT IS IN HEAVEN", in the Lichtrouten International Forum for Art and Light design, this installation was presented in the old cemetery of the city of LÃijdenscheid, Germany. In October 2006 he obtains the third place in the category City People Light in LUCI PHILIPS Awards for the San Luis Potosi Lighting Master Plan. Gustavo Avilés represents one of the professional and academic development line positions and he is one of the most enthusiastic on the National and International context. Hes member of Elda+, ACE, IESNA and founder of DIM with other Mexican colleagues.

CHAPTER **5**

From Transdisciplinary Theory to Transdisciplinary Practice: Artful Doing in Spaces of Imagination and Experimentation

Hans Dieleman, University Veracruzana, Xalapa, Mexico

This chapter links transdisciplinarity with reflective action and artful doing, as well as with the concept of spaces of experimentation and imagination. It argues that artful doing is a genuine transdisciplinary practice that is at once rooted in sensitivity, intuition as well as analytical rationality. It organically links analytical and feelings intelligence with the intelligence of the body. It goes on to show how artful doing can be studied, taught and practiced in spaces of experimentation and imagination. Such spaces invite to explore the world simultaneously on various levels of reality and through various activities such as analysis, introspection, dialogues of knowing, manipulating reality thus constructing alternative realities. The chapter analysis that working in such spaces implies hybridization of usually separated spheres as art, science, engineering, design, public policy, education, and more. Finally the chapter focuses on implementing transdisciplinarity in universities and identifies 5 critical aspects in the implementation process.

5.1 Introduction

There is still a lot of confusion around the concept of transdisciplinarity. I realized that after a visit to the new campus of the Autonomous Metropolitan University of Mexico-City, the campus “UAM-Lerma”. The following text was written on the wall of the main campus building:

Our reality requires that knowledge will be created through the conjunction of various points of view that together create the scope for transdisciplinary activities

Yet, the professors with whom I talked – they are working in the transversal research stream of sustainability - had a hard time imagining how transdisciplinarity could be implemented in the curricula. I noticed that the professors continued thinking in terms of established disciplines and fields of knowledge instead of thinking in terms of processes of knowing or ways to relate ourselves with our environment.

Without doubt this has to do with the dominant scientific worldview and its particular way of conceptualizing knowledge, knowing and education. Knowledge is phrased in terms of silos, containers, disciplines or fields of knowledge and education in terms of the transfer of those fields of knowledge. This seriously hampers a clear understanding of transdisciplinarity. Transdisciplinarity is seen as the ultimate step in a sequence of the disciplinary > multi- > inter- >transdisciplinary whereas every step marks a different way in which the disciplines relate to the object of study. It is correct but yet easily misunderstood.

We talk about multidisciplinary when various disciplines study, in one project, a problem or phenomena independently from each other. Interdisciplinarity comes into play when the disciplines transfer their methods to arrive at one more integrated understanding of a problem or phenomena. Transdisciplinarity is indeed a next step, but its essence cannot really be understood in terms of the relationship between disciplines and object of study. This immediately becomes clear when we look at the way Nicolescu¹ defined transdisciplinarity. Transdisciplinarity, he said, concerns that which is at once between the disciplines, across the different disciplines, and beyond all discipline. In other words, it is not so much about disciplines but about that what is “between, across and beyond” those disciplines. Its essence is to unite various ways of knowing and to relate us with the world in a more-than-disciplinary way. Understanding its essence implies leaving the classical scientific worldview with its established concepts of knowledge, knowing and education.

One of the professors at UAM-Lerma asked me more information on how to apply inter- and transdisciplinarity in a typical university setting, and after having returned from my visit I posted this question on the Cultura21 website¹, a website where artists and academic researchers with interest and experience in transdisciplinary practice unite. I immediately received a lot of feedback and two key words caught my attention while going over all the various comments, recommendations and observations: “sensitivity” and “action”. Transdisciplinary practice is – in addition to disciplinary knowing - about being sensitive in non-cognitive ways or in the words of Nicolescu about linking feeling’s intelligence with analytical intelligence and the intelligence of the body[2]. Transdisciplinarity equally is about knowing **through** action, as linking the various ways of knowing occurs **in** action.

The answers I received pointed at my own work on “reflective action and artful doing”, as well as on my ideas about working in “spaces of experimentation and imagination” [3] [4] [5]. Yet I never related them in an explicit way to transdisciplinarity. Nicolescu, being included in the mailing list, invited me to write an chapter for the *Transdisciplinary Journal of Engineering & Science of the ATLAS, The Academy of Transdisciplinary Learning & Advanced Studies*. So I decided to try to link my ideas on reflective action and artful doing in spaces of experimentation and imagination with transdisciplinary practice and education. The result is this chapter that basically has four parts: 1) transdisciplinarity, 2) reflective action/artful doing, 3) spaces of experimentation and imagination and 4) how to apply transdisciplinarity in a typical university setting. Before diving into the last three parts I first need to present the key elements of transdisciplinarity, in as far as and in the ways that I understand them. I try to do this as short and concise as possible, making extensive reference to the text “Transdisciplinarity, past, present and future” written by Nicolescu in

¹<http://listi.jpberlin.de/mailman/listinfo/international> (last accessed November 14, 2012).

2006² After this first part the chapter explores the links between transdisciplinarity, reflective action/artful doing and education in spaces of experimentation and imagination.

5.2 Transdisciplinarity

In the introduction I mentioned the importance of leaving the classical scientific worldview with its established concepts of knowledge, knowing and education. This is important as transdisciplinarity is based on the theoretical foundations of quantum physics, such as quantum indeterminism and the principle of superposition of quantum. With these principles (among others) quantum physics introduced a world that is very different from the classical world with its mechanical Newtonian and analytical Cartesian logic. The classical scientific worldview sees a world that is ordered by the existence of certain laws that function independently from our own observations, thus claiming the existence of order as well as of objective knowledge and truth. Quantum physics on the other hand, shows a reality that is not at all ordered, but an entity full of ambiguity with processes and relationships that are often conflicting, competing and complementary at the same time. Transdisciplinarity explores the epistemological, ontological and methodological consequences of quantum physics, and discloses a world of complexity and complexity thinking, as in the way Edgar Morin developed this thinking throughout his academic career [6] [7] [8].

Transdisciplinarity is rooted in scientific developments but is certainly not only an academic endeavor. Nicolescu explicitly refers to the important dangers the classical scientific worldview incorporates. “Objectivity”, he says, “set up as the supreme criterion of Truth, has one inevitable consequence: the transformation of the Subject into an Object. The death of the Subject is the price we pay for objective knowledge. The human being became an object – an object of the exploitation of man by man, an object of the experiments of ideologies which are proclaimed scientific, an object of scientific studies to be dissected, formalized, and manipulated . . . The Man-God has become a Man-Object, of which the only result can be self-destruction” [9]. Cristina Nuñez, coordinator of the Master program in “Transdisciplinary Studies and Sustainability” of the University of Veracruz in Jalapa, Mexico adds to this by saying that: “In the Age of Reason, the irrational is more active than ever...if we do not create new relationships with life and within ourselves . . . we will not be able to exist for long as human beings in this planet.” [10]. Because of these reasons, transdisciplinarity should be considered as both a transformative process as well as an epistemological, ontological and methodological endeavor.

Werner Heisenberg was one of the first to see the epistemological, ontological and methodological consequences of quantum physics. “The concept of “objective” and “subjective” – writes Heisenberg - designate [...] two different aspects of one reality; however we would make a very crude simplification if we want to divide the world in one objective reality and one subjective reality” [11]. Heisenberg also asserted that we make a too strong difference between scientific knowledge that describes the “real” world and other ways of knowing such as artistic, imaginative and spiritual knowing, that deal with not much more than ideas, concepts or experiences. This division has

²The text is available online and published in the book “Moving Worldviews - Reshaping sciences, policies and practices for endogenous sustainable development” (Haverkort and Reijntjes ed., 2006).

led to the widely accepted idea that “all knowledge other than scientific knowledge is . . . cast into the inferno of subjectivity, tolerated at most as a meaningless embellishment or rejected with contempt as a fantasy, an illusion, a regression, or a product of the imagination” [12]. Quantum physics shows that we need to rethink the claims of classical science such as the total separation between the subject and the object, the assumption that the material world is the only “real” world and the idea that science can develop independently from other sources of knowing such as theology, philosophy, the arts and culture, indigenous or spiritual knowing.

5.2.1 The Unity of Knowing in Transdisciplinarity; Axioms 1 and 3

The transdisciplinary response is that there are different ways of knowing and there is no hierarchy between them. By contrast, the different ways are complementary and – this is a key principle of transdisciplinarity – refer to different levels of reality. The notion of levels of reality is not used in a loose or metaphorical way, but is the very heart of transdisciplinarity and constitutes its key axioms. The first and ontological axiom of transdisciplinarity is that there are, in nature and in our knowledge of nature, different levels of reality and, correspondingly, different levels of perception [13]. Nicolescu, a quantum physicist himself, stresses on numerous moments that the concept of levels of reality - as well as reality itself – is not merely a social construction but that it has a trans-subjective dimension. The concept of levels of reality can be understood by looking at the world of quarks that is guided by different laws and concepts than the world of complex systems. In a comparative way the level of the material world and of traditional scientific knowing is governed by specific laws and concepts, and such is the level of for instance the imaginative world with imaginative and creative knowing and perception. The whole of reality is a complex structure of the totality of levels of reality and corresponding perceptions and every level is what it is because all the levels exist at the same time. No level exists in isolation. This last aspect is formulated in the third axiom of transdisciplinarity, the axiom of complexity.

Thinking for instance in the relationship between man and tree, the various levels of reality and perception can easily be illustrated. On a scientific or material level an important element of our relationship is that trees produce O_2 and process CO_2 to do so. We humans on the other hand exhale CO_2 and need to inhale O_2 to survive. This constitutes a symbiotic relationship between us, on one particular level of reality. There are various other levels of reality however where we find other types of relationships. In the course of history trees have served as protection for us against rain and sun. Without doubt they (together with rocks) have triggered our imagination and creativity and made us think of the concept of shelter and a roof to protect us from a harsh climate. This constitutes a different level of reality with different laws and concepts (Imagination, associative and lateral thinking, and creativity). Aesthetics is yet another level that makes us see trees as living sculptures with often incredibly beautiful lines, patterns, dimensions and angels. On this level many artists over time were stimulated to paint and sculpt trees, thus trying to explore the essence of our reality. Whenever I (Hans Dieleman) enter a forest and even when I am in the proximity of a few trees, I always and almost immediately feel the relaxing effect that trees have on me. This constitutes a relationship on yet another level, of emotions, with different laws and concepts. And this relationship is

equally “real” for me, or maybe even more real because it is what I immediately feel. On a spiritual level trees may represent wisdom and may be moderators that can help us enter in contact with Mother Earth, or help us find wisdom that is otherwise inaccessible.

Is this New Age sentimentality? Transdisciplinarity is not about that but aims to prevent that (I repeat): all knowledge other than scientific knowledge is cast into the inferno of subjectivity, tolerated at most or rejected as a fantasy, an illusion, a regression, or a product of the imagination. The goal of transdisciplinarity is to restore the unity of knowing, not by means of abolishing scientific knowing (or any other form of knowing) but to see all forms of knowing as complementary making up one complex reality.

5.2.2 The Object, the Subject and the Included Third; Axiom 2

One may want to argue at this point: “All this is fine for me, one moment I put on my scientific head, another moment my emotional head and yet in one other moment my spiritual head. This is actually exactly what I do”. The point however is not to separate the different levels of reality and knowing, but to integrate them and to find ways to pass from one level to the other. This is another crucial aspect of transdisciplinarity. Its second axiom (the logical axiom) deals exactly with that and states that “The passage from one level of Reality to another is insured by the logic of the included middle”. This logic fundamentally challenges classical logic as that is founded on the axioms that A is A and can never be non-A while there is nothing that can be A and non-A at the same time. The principle of the included third however states that A **can** be non-A, precisely because a third is included. But, and this is crucial, A can be non-A at another level of Reality.

This abstract part of the theory of transdisciplinarity is not so difficult to understand when we think of a concrete example. A room for instance can have a table (A) but cannot be without that same table (non-A) at the same time. That is, following classical logic. It is however very well possible that a room has a table and is at the same time without that very same table: it can have a table at the material level of Reality but be without table at the imaginative level of Reality, or the other way around. “Ooh, yes”, someone may want to respond . . . “of course, but in that case the table is just there in our imagination, whereas in “reality” it is not (or the other way around)”. This response shows how challenging transdisciplinary thinking is! The response clearly sees the “real” reality as the material reality and sees the imaginative reality as “just imagination”, The essence of transdisciplinarity – and its huge challenge – is to avoid making a hierarchy among levels of reality and corresponding levels of perception. The level of imagination is as “real” as the material level and therefor the table can be there and cannot be there at the very same time. *Apprehending* this and making it a familiar part of our understanding of reality is like a quantum leap or paradigm shift away from the classical mode of knowing and seeing the world.

It is not easy and a perfectly understandable question may be: “But then, where is that “reality”? Is it in our brain or imagination (subject) or outside of us (object)?” Nicolescu would answer this question in the following ways: “Knowledge is neither exterior nor interior: it is simultaneously exterior and interior . . . and the included middle logic is the tool for an integrative process. It allows us to cross two different

levels of Reality or of perception and to effectively integrate, not only in thinking but also in our own being, the coherence of the Universe"[14]. The use of the included third is a transformative process and [when this integration occurs (HD)] the included third ceases to be an abstract, logical tool: it becomes a living reality touching all the dimensions of our being [15]. The essence of transdisciplinary knowing is the hidden third that is the *interaction between the object and the subject through the transcendence of the subject*. This obviously can never occur when the subject is kept out of the process of knowing and exploring reality.

Knowledge is not "out there", neither is it "inside of us" and more importantly it is like a "reservoir of infinite potentialities". Where interdisciplinarity aims at "the transfer of methods from one discipline to another"; transdisciplinarity deals with "that which is at once between the disciplines, across the different disciplines, and beyond all discipline". This opens up an immense space of potentially available knowledge, and the essence is that it IS NOT but CAN COME INTO BEING. Nicolescu uses the metaphor of the galaxy to describe the immense space between and beyond disciplines. The separation of disciplines he says is "like the separation between galaxies, solar systems, stars and planets When we cross the boundaries we meet the interplanetary and intergalactic vacuum. This vacuum is far from being empty: it is full of invisible matter and energy. It introduces a clear discontinuity between territories of galaxies, solar systems, stars and planets. Without the interplanetary and intergalactic vacuum there is no Universe"[16].

Similarly, disciplines have little meaning when we do not see the spaces between, across and beyond them. When we want to reach a stage of more complete – transdisciplinary – knowledge, we need to explore the vacuum that is full of potential "knowing", find ways to open ourselves to this knowing and incorporate it in a more complete knowledge system. It is here where – in my interpretation – "sensitivity" and "action" come into being, or in other words the unity of analytical intelligence, emotional intelligence and the intelligence of the body. The included third only comes into existence in a process that is inherently "more-than-analytical" through integrating various emotional, imaginative and sensory ways to relate us with our interior and exterior world. It is like that because the other levels of perception (other than analytical/disciplinary) are based on non-analytical laws and ways of connecting us our environment.

The way to achieve the unity of knowing, and here we make the bridge to the second part of this chapter, is in action and through action. Only in action we can build bridges between different levels of perception and reality, such as our emotions, intuition, our body, our mental and our analytical capacities. It is in action that the hidden third comes into being.

5.3 Reflective Action or Artful Doing

Like scientific research, reflective action is a way to explore reality with the intention to understand it and/or to create a base for taking concrete decisions. But unlike the "classical" - cognitive and analytical - way of exploration, reflective action is at the same time rooted in sensitivity, intuition as well as analytical rationality. It was Nobel laureate Herbert Simon who laid the scientific foundation for the concept of reflective action, even though he did not use the term himself. Simon[17][18] studied how people make decisions when limited information is available, and discovered that

we use two different strategies. The first is using logic and ratio, and the second is using heuristics based on intuition and rules of the thumb. Simon observed that many successful managers frequently make decisions using heuristics, and with very good result. Gerd Gigerenzer, writer of “Simple Heuristics That Make Us Smart” [19] and very much working within the tradition of Simon, showed many case studies in which heuristics lead to better decisions than allegedly more sophisticated logical-rational procedures.

It should not be surprising. Using heuristics and intuition are very natural ways of understanding and relating us with the world, and of creating a base for decision making. However, the scientific worldview taught us during the past centuries that “we are because we think” and that we should focus on our cognitive and analytical skills to understand the world. Feelings, emotions and body intelligence were declared to be inferior to analytical intelligence. We decided that emotions interfere in negative ways in “rational decision making” and that it is better to exclude them as much as possible. As a result we unlearned to use our complete potential to relate us with the world, and we lost the ability to function as full and complete human beings. The process of rediscovering our comprehensive and natural potential started with Simon while he analyzed the use of heuristics. He discovered that it means using contextual information and mental maps instead of focusing on the narrow relationship between two variables. These mental maps enable us to see two variables in a wider context thus making decisions in contextual, intuitive and holistic ways.

5.3.1 Mental Maps

The use of mental maps has been further explored by Chris Argyris and Donald Schön[20][21] and Donald Schön alone [22] [23][24][25] and has led to the introduction off the term reflective action or, in the words of Schön, artful doing. A mental map, Argyris and Schön explain, is like a semantic representation of all the connections the brain makes with respect to a certain situation or problem, and it combines logical thoughts, images and associative thoughts. Every time we have to make a decision, we compare the situation that calls for a decision with similar situations of the past, using our mental map that is like a reservoir of stored images and previous experiences. Schön: “When a practitioner makes sense of a situation he perceives to be unique, he sees it as something already present in his repertoire. . . . It is . . . to see the unfamiliar, unique situation as both similar to and different from the familiar one, without at first being able to say similar or different with respect to what. The familiar situation functions as a precedent or metaphor”[26]. While taking decisions and performing tasks, we use our reservoir or mental map of previous life experiences, knowledge, feelings, emotions, implicit assumptions, cultural codes of conduct, routines and more. We constantly “map” situations we encounter by comparing them with the maps and images that we have stored in our reservoir of knowledge and experience. In a natural way this combines and integrates various levels of reality and various levels of perception.

Reflective action organically links analytical intelligence, feeling’s intelligence and the intelligence of the body. Yet it is not about these three types of intelligence in separation but really about the equilibrium between mind, body and feelings. Schön describes it as follows. Reflexive action is not reducible to knowledge and specific skills and is in fact not reducible to or deconstructable in any separate aspect at all. It is a sequence of actions to achieve a goal and when we know well how to do

it, we have difficulty saying how we did it. It is like riding a bike or car, playing a musical instrument, basketball or tennis. It is really an integration of experiences, skills and knowledge in action within an integrated system: the experience feeds the knowledge and the sentiments, whereas the knowledge and the sentiments feed the experience[27].

5.3.2 Reflection-in-Action and Reflection-on-Action

The game of basketball illustrates very well how reflective action works. In order to be able to play basketball we need to know the rules and strategies of the game, as well as certain facts like size of the playing field and meaning of lines drawn on that field (analytical intelligence). But that is not enough. We also need to be sensitive to the opportunities the game offers at certain moments and to take advantage of those opportunities. It is about being sensitive to the movements of the others, both in one's own team as in that of the competitor, and it is about being sensitive to one's own (corporal) possibilities to accelerate, intercept or score. It is all the time using intuition and calculating while the intuition is constantly nourished with the experiences gained through action.

The example of playing basketball show that action is a key aspect of knowing, as is embodiment. It is in action that we go from one level of reality and corresponding perception, to the other. It is because of this that action is so important, as well as thinking in action or reflection in action. Schön introduced a distinction between reflection-on-action and reflection-in-action. Reflection-on-action is having an evaluative moment or session after an activity or task is completed. This is often applied in all kinds of professional settings. Reflection-in-action is different and sometimes described as 'thinking on your feet'. It involves looking – while acting - to our experiences, connecting with our feelings, and attending to our theories-in-use (know-how). It is here where knowing or intelligence cannot be separated from action because knowing and doing are two sides of the same coin in a constant sequence of doing – reflecting – doing again – reflecting, etc.

Schön introduced the word "artful doing" as an alternative to reflective action because it involves a sequence of acts comparable to the one a painter applies while making a painting. The painter adds some color or form to the canvas, takes one step back, overlooks the result, goes back to correct or to add more color or form, takes one more step back, and so on. Schön phrases it as follows: "The practitioner allows himself to experience surprise, puzzlement, or confusion in a situation which he finds uncertain or unique. He reflects on the phenomenon before him, and on the prior understandings which have been implicit in his behavior. He carries out an experiment which serves to generate both a new understanding of the phenomenon and a change in the situation"[28].

The concept of reflective action or artful doing has been applied in various fields of knowing, and in particular in the field of organizational learning. The five disciplines in Peter Senge's famous book "The fifth discipline, the art and practice of the learning organization"[29] clearly echoes reflective action and artful doing. The word "art" in the title is not without meaning and refers to the importance of using more than analytical/cognitive rationality. Two of the five disciplines presented in the book are rather standard. They focus on "building a shared vision" and on "team learning". They can be found in virtually any textbook on organizational behavior. The three others however, that give answers on how to build a shared vision and

learn in teams, can directly be traced back to the ideas of Argyris and Schön. One is called the discipline of “mental models” and is exactly about learning to work with complex mental maps and about learning how to identify them in group work and group decisions. The discipline of “personal mastery” is all about knowing oneself as a complex person and is the “discipline” of functioning as a complex and complete person. The final (or first) fifth discipline is “systems thinking” which is about learning to see in contextual and systemic ways, going beyond simple linear relationships.

I want to make a plea here to also study and apply artful doing or reflective action as a really transdisciplinary practice, as it is an archetypical way to make the hidden third come into being. It is simultaneously intellectual and analytical, constructive and creative, social and communicative as well as sensorial and emotional. It therefore results in a more comprehensive understanding of oneself and of the world in general, and creates a more comprehensive base for decision making in various contexts, private as well as professional. Equally it has the potential to create various types of knowledge and knowing. It can create “hard” knowledge in the form of data or in the form of practical information or ready-to-use applicable knowing. Yet it also has the potential to go beyond this and to create symbolic and visionary knowing, as well as creative knowing and new ideas, concepts, products or systems. Finally it has the potential, because it links emotions, the body and analytical thinking, to give us (again) control over our own self and our destiny, reducing alienation and disenchantment. As such it has the extremely important transformative potential of, in terms of Nicolescu, changing us back from object into subject thus restoring the Man-God relationship.

Therefore I think it is important to study reflective action and artful doing as a genuine transdisciplinary practice, and to teach it as part of transdisciplinary education. One way to teach, practice and study it is in what I have called spaces of experimentation and imagination.

5.4 Spaces of Experimentation and Imagination

Artful doing or reflective action consists of a sequence of actions, but that by no means implies a linear sequence of very well distinguishable steps. Even though this clearly results from the text above, it is not immediately obvious how to apply it in a real life situation. Almost all projects all over the world – in public policy, in business, in research, in education - use a more or less standard scheme of organizing steps and activities that is based on the sequence of: “Formulate a vision” “Diagnose the problems” “Develop alternatives” “Seek consensus” “Take decisions” “Implement and execute”. This universally applied scheme is based on the traditional concept that one should think before one act and largely excludes the importance of reflection-in-action. Taking the concept of reflective action serious however, a logical consequence is to change this traditional scheme and replace it with a model that respects the essence of reflection-in-action where thinking and acting are intrinsically linked.

In a number of publications I have proposed to work in “spaces of experimentation and imagination”, spaces that do not start with an abstract vision but start at the other end: with the execution. They immediately engage in action and apply the constant sequence of action-reflection-action as a way to simultaneously create vision, diagnose, imagine alternative ways of defining the problem as well as the solution,

test and create a shared strategy based on consensus. Such spaces allow and invite to explore reality in various and simultaneous ways such as through analysis, exchanging life experiences, introspection, physically or mentally mimicking or manipulating reality thus constructing alternative realities. They invite to experience puzzlement, surprise and confusion and they seek to transcend existing boundaries[30].

Even though spaces of experimentation and imagination are organized around problematic situations their purpose is not to “solve the problem” in a narrow sense but to “engaging in the situation”[31]. This involves entering in contact with them, “talking with them” and seeing how situations “talk back”.

Engaging in problematic situations is establishing a relationship with them and to frame them, as well as to frame oneself in relation to that situation. It is like diagnosing, problem definition, visioning and testing alternatives in one and includes at the same time defining one’s own engagement with the situation. Schön proposes to actively test various ways to frame and reframe a situation and proposes to develop so-called “generative metaphors” that characterize the situation and generate the way problems are defined. “Through the discovery of new metaphors”, he argued, “new perceptions and explanations can be generated”. And, “the discovery of new and of generative metaphors is not an act of abstract conceptualization or visioning, but an act of being in contact with, reflecting on and above all experiencing the phenomena”[32]. The essence of experiencing is to contextualize situations and to connect with them while integrating different ways of knowing thus going beyond a mere analytical “diagnose” of a problem. Experiences are the adequate stages for transdisciplinary exploration and practice and for connecting us with the complex world around us integrating – in the words of Gregory Bateson - “hard” data and “soft” data present in any situation[33].

Spaces of experimentation and imagination can take different forms and various rather “classical” spaces are found within the arts. A theatre play is an almost archetypical space of experimentation and imagination, and so are many other art performances and installations. These spaces present “situations”, touch upon emotions and feelings and literally invite to reflect in the sense of thinking and rethinking and framing and reframing. Sometimes they also invite to participate, act and co-create, as for instance in the “Theatre of the Oppressed”, developed by Augusto Boal[34] and in “Social Sculpture” as developed by Joseph Beuys[35]. Forum theatre (one of the techniques developed by Boal) literally invites members of the audience to replace acting actors thus really reframing the situations acted out during the play. Shelley Sacks, former student of Beuys and now professor at the Oxford Brookes University, created various social sculptures that really “come into being” thanks to the participation of the audience. In the description of her “Landing Strips for Souls” she writes: “. . . I welcome everyone to ‘the place of questions’, outlining some of the choices we are faced with and the need to choose . . . the landing strip is used to welcome souls into the ‘imaginative space’ of the gathered participants. After a period of silence I open the space for discussion, which is part of the process of reconnecting with the world.”³

Reading a novel equally can create a space of experimentation and imagination, spaces that are primarily mental where the imagination and experimentation is hidden to the eye of an observer. Yet the included third is very real here as well and comes into being as a consequence of the interaction between the book and the reader,

³<http://greenmuseum.org/c/enterchange/artists/sacks/> (last accessed November 14, 2012).

as a real hidden third. Meditation as well is a way to open a space of imagination and mental experimentation, on another level of reality and in a very personal way. Games are yet another vehicle to create spaces of experimentation and imagination. Playing games can be helpful to feel and experience complexity and the functioning of complex systems, and thus are valuable tools in transdisciplinary education[36]. Finally, the creation of alternative realities as well is a very adequate form of transdisciplinary action. Nicolescu mentions in his 2005 article a visit to an Eco-village in South Africa and indeed, the creation of such an “alternative community” (like many other social experiments [37]) certainly also can be part of a transdisciplinary exploration of reality, and can thus also be called transdisciplinary reflective action.

Spaces of experimentation and imagination can take other forms as well, and can be created within any sphere of life like public policy, business, research and education. In the field of urban studies, where I currently work, I have come across many spaces of experimentation and imagination. Often the projects do not only work with a generative metaphor but equally use a conceptual approach that helps seeing the various dimensions of the situation simultaneously, thus avoiding a linear approach on just one level of reality. A classical and rather famous example is the project “Mouse Hole” in the city of Rotterdam, the Netherlands⁴ The “Mouse Hole” was an abandoned space in the city where various problems used to come together such as excessive dumping of waste and prostitution. Yet the space also was hosting an important water treatment system and marked an administrative frontier between two city delegations. Various engineering consultants were invited to create a plan for the redesign of the space and to find a proper place for the water treatment system, respecting the administrative demands of the delegations involved. They all failed as the various demands (technical, administrative, esthetic, ecological) were too conflicting. The project then was adopted by three artists who created a solution that enabled the integration of the various demands. The key difference in their approach was twofold. First of all they did not to focus on the designated problems, but on the area. They literally entered in contact with the area, identifying its typical and positive features and started to create a plan based on those features. The other part was to implement a paradigm change in the way to handle to water treatment system. The engineers all tried to obscure the technology as it was supposed to be ugly, while the artist placed the technology in the center of the space, thus reframing the sense of esthetics and giving the space the recognition it deserved as an important contributor of clean water to the city. The project received various prizes for its innovative approach, an approach that can be characterized as a typical example of transdisciplinary artful doing in a space of experimentation and imagination. Chiara Camponeschi’s book “The Enabling City: Place-Based Creative Problem-Solving and the Power of the Everyday”, presents many projects in various parts of the world mainly coming from NGO’s, that almost all open spaces of experimentation and imagining in urban contexts⁵.

Many projects in spaces of experimentation and imagination are “artful” in the sense of working with artistic expressions as theatre, performances, sculptures, music and more, as well as in the sense of being reflective-in-action. In some cases the objective is to create art in the traditional sense of a work of art. In many other

⁴<http://www.publicartonline.org.uk/casestudies/environmental/muizengaatje/description.php> (last accessed November 14, 2012).

⁵<http://enablingcity.com/wpcontent/uploads/2010/10/the-enabling-city2010-3.pdf> (last accessed November 14, 2012).

cases however, artistic expressions and artful doing are ways of exploration and ways of doing. They may very well result in what we normally call art and they simultaneously result in solutions for problems, new systems or new ways of seeing reality. It was like that in the “Mouse Hole” project and is very much like that in the project “Neighborhood Satellites Energy Harvests” presented in Box 1. This as well is a very interesting example of transdisciplinary artful doing in a space of experimentation and imagination currently being realized in Berlin, Germany. In this project the problem of urban CO₂-emissions is framed within the generative metaphor of the city as a field of numerous energy crops (emissions) that are out there to be harvested. Reframing the city in such a way opens a whole new range of actions to solve the emissions problem while at the same time establishing new relationships with the city.

A key characteristic of working in spaces of experimentation and imagination is the hybridization of what used to be separated spheres of art, science, engineering, design, public policy, education, urbanism, social work, environmental studies, ecological restoration and much more. It is through this hybridization that we realize transdisciplinary studies and open up the possibility to transcend and make new knowledge and insights come into being. There are probably hundreds of such hybrid projects in spaces of experimentation and imagination around the world, and we should study them as they can teach us how to work in transdisciplinary ways in concrete settings. Probably the only reason we don't do that is because we have not framed them as such.

The project “*Neighborhood Satellites Energy Harvests*”, developed by the Berlin based artists Hanspeter Kadel and Myriel Milicevic, reframes the city as a field of numerous energy crops that are out there to be harvested. Energy coming from heat produced by electrical equipment like air conditioners, vibration caused by heavy traffic, heat of light emitted in shop windows, or noise coming from a variety of sources as sirens and heavy trucks can all be turned back into usable energy. The artists designed a variety of simple and ingenious harvesters to collect energy coming from light, noise, vibration and heat.

The metaphor that frames the city and its related emissions problem definition unfolds immediately in a variety of actions to be taken on various levels of reality. On a creative level, the artists provide kits with instructions so people can make their own harvesters, and they organize workshops to help citizens to really build them. Simultaneously the citizens, with the help of the artists, make inventories of energy leaks in their neighborhoods, and explore ways to create a local micro-power-network using the self-constructed harvesters. In these moments they work in both the analytical as well as the creative levels. During the entire time the project invites citizens to look in new ways at themselves and at their relationship with the city, giving them the tools to actively interfere in that city, thus taking control and being creative. Finally the project potentially changes the relationship between citizens within their communities.

The harvesters in the micro-power-network really need to function well, or the project will be doomed to fail. The level of technical and analytical reality is crucial, but so is the level of imagination and of being open to new ideas and metaphors. When participants cannot link themselves with the vision that forms the base of the entire project, it will be difficult to have confidence in the project and to be motivated to really go for it results. This capacity to link to such a new and avant-garde reality depends on both one's personal characteristics (and relates back to knowledge of one self) as well as characteristics of the project. The success of such a project really depends on the capacity to link various levels to make it one comprehensive project.

Box 1: "Neighborhood Satellites Energy Harvests" as Space of Experimentation and Imagination.

5.5 Back to the Question of Inter- and Transdisciplinarity in a Typical University Setting

This chapter started with the question asked to me how to implement inter- and transdisciplinarity in a typical university setting. I want to address this question in an explicit way and the first thing to do is to distinguish well between inter- and transdisciplinarity. Nicolescu framed this distinction within the concept of horizontal and vertical complexity[38]. Where horizontal complexity refers to the complexity in one level of reality, for example the material level with its analytical way of knowing, vertical complexity refers to the complexity on various levels of reality. Interdisciplinarity is a way to cope with horizontal complexity while transdisciplinarity aims to address vertical complexity. Interdisciplinarity is a valuable response to the challenge of complexity, but only on one level of reality. Although the integration of various disciplines is important, it does not contribute to the important need to unite ways of knowing and restore the links between the object and the subject of knowing. That is why transdisciplinarity is important and fundamentally different from interdisciplinarity. This first of all should be recognized within universities.

Secondly there are changes in knowledge and skills to be considered. Transdisciplinarity requires the range of standard capacities and skills taught within the context of any academic discipline. On top of that it requires communicative and collaborative skills that we normally find in business school but that are certainly not standard in curricula outside of business schools. Beyond these "standard" skills, transdisciplinarity requires capacities and skills on rather different levels of reality and perception. An extensive level of self-awareness and knowledge of one self is important and this involves, besides rational-analytical skills, skills like daring to rely on intuition, daring to work in iterative schemes allowing oneself puzzlement and confusion, as well as skills that enable (re-) establishing sensory links with one's body. Therefore training the senses of seeing, hearing, smelling, tasting and touching/feeling is an integral part of transdisciplinary education. Learning to relate

ourselves with our environments equally is a challenge that implies capacities of conceptual thinking and the development of generative metaphors as new ways of seeing reality in an experiential way. Finally it involves organizational capacities and skills, necessary to create the conditions to engage in concrete action, as concrete action is needed to make the hidden third come into being, and to connect and unite various levels of reality.

Thirdly, curricula should ensure the integration of the skills and capacities through integrated reflective action or artful doing. Therefor a large – and crucial – part of transdisciplinary education should be project-based and action-based[39]. BUT (!), these projects should include reflective action enabling to change from one level of reality to another. And this calls for project-based and action-based education in spaces of experimentation and imagination. I will illustrate what this means around the concept of the ecological footprint.

Teaching the ecological footprint is a pretty standard element in environmental sciences curricula today. Usually the concept is introduced in an analytical way (presenting foot print categories, energy equivalents, level of the sustainable footprint, etc.) and students calculate their own footprint using a computer. It results in analytical knowing and in a feeling of guilt when the footprint exceeds the margin of sustainability. In 2002 I created a transdisciplinary project around the concept of the ecological footprint, called “Ego-Travels”. In this project students really engaged in the situation and were not merely confronted with “a number” (a footprint) but with choices for life that have ecological implications. Yet organizing such a project really involves many changes in the standard way of working and shows us what it means to work at once between and across disciplines, as well as beyond all discipline (see box 2).

“Ego-Travels” was an educational project realized in the Erasmus University Rotterdam in 2002. The project aimed at introducing the concept of the ecological footprint using the generative metaphor of the journey of life. The project created a space of experimentation and imagination that was – in the words of Sacha Kagan, one of the participating students – at the same time a (fake) travel agency, a performance, an installation and a party. The metaphor of the journey of life resulted in the idea to create a travel agency where students could book the journey of their life (their ego-travel) thus making them sensitive to the ecological impacts of their lifestyle.

The metaphor and concept of the travel agency immediately unfolded various activities to be realized simultaneously: to create a travel agency and a travel guide, to design a house style and logo, to formulate alternative “lifestyle arrangements”, to think in terms of payment of such arrangements and link those payments with ecological footprints, to think in terms of marketing of the new agency, of funding, of convincing students and the faculty of the relevance of the concept, and to be open to let students, sponsors or anybody else expand on the original idea.

Thanks to financial support of the Erasmus University and a Rotterdam based Green Shopping Mall the project could be realized and a party-center was rented to organize a party that was announced as the opening party of the new travel agency. Meanwhile the travel guide was produced and the costs of the arrangements calculated in ecological footprints of every lifestyle element, thus calculating the ecological costs of the specific journey a customer would choose.

During the party a DJ played ambient music, slide shows showed environmental effects of lifestyles and activities as a garbage contest and a fortune teller added to the environmental “experience”. The customers/participants, while entering the center, were invited to “book the journey of their life” and for this purpose a typical travel agency was created with desks, images on the wall and hostesses that persuaded the customers to book their travel. The hostesses then calculated the costs and invited the customers to pay. Payment was in the form of helping to blow up a big balloon that represented the globe and was hanging in the middle of the party. The amount of air the participants/customers needed to add to the balloon corresponded to the ecological costs of the journey they selected: the higher the costs the more air they needed to inflate into the balloon. Obviously the balloon grew rapidly and posed an ever increasing threat of explosion. Yet as in “real” life the party went on . . . until the moment the globe really exploded, showing that the world is not big enough for all our combined lifestyle aspirations.

Box 2: “Ego-Travels”, Educational Project Realized in the Erasmus University Rotterdam in 2002⁶.

Fourthly, engaging in transdisciplinarity within a university is a personal challenge for professors and students alike. I organized the project together with my students and they needed to engage in many activities that could not be accounted for in strict academic terms. In many ways the project crossed established boundaries and called for an enormous amount of conviction and determination to be realized. Such a project really exceeds that what is normally required from students, a university professor or faculty as a whole. The university professor remains professor but converts into a project manager at the same time. The student remains student but is a member of a workforce as well. Colleagues frequently look at such a project with suspicion and sometimes with disdain as “it is not academic”, and does not meet

⁶<http://sachakagan.chez-alice.fr/sust1024.htm> (last accessed November 14, 2012)

academic standards. Finally it is experimental and reflective and not at all straight forward or linear. As a responsible I was all the way confronted with uncertainty and puzzlement, not knowing (and not being able to know) if the project would end in a success or a big failure, equally not knowing how to define “success” nor “failure”.

Professors only can teach in such spaces when they themselves know how to link analytical intelligence with feelings intelligence and the intelligence of the body. They themselves need to dare to work in iterative and reflective – artful - ways and allow themselves puzzlement and confusion. It is a big step for a university professor that is used to work with his or her cognition and feels comfortable in a university precisely because it is a temple of analytical activity. That is why training professors in transdisciplinary artful doing is extremely important, and this training obviously can only be realized in spaces of experimentation and imagination.

Fifthly, the university as institution will need to make changes. It is important that universities create spaces within the curricula to engage in transdisciplinary practice, and designate professors who feel comfortable working in these spaces. The key in realizing this is, as almost always, engaging in a dialogical process that simultaneously involves initiatives at the top of the university as well as on the bottom[40]. Starting at the bottom however is crucial as experience with real transdisciplinary practice in spaces of experimentation and imagination certainly will reduce the confusion that still exists around the concept of transdisciplinarity, and will open ways to institutionalize it and change our universities.

5.6 Concluding Remarks

I like to finish making a reference to Mary Catherine Bateson’s book “Peripheral visions: Learning along the way”[41] (M.C. Bateson, 1994). The book is about how we make sense of life and Bateson’s answer is that we all the time make connections between seemingly random events and experiences, thus finding the underlying patterns. She makes a plea to organize education as much as possible in this same “natural” way: experience based, spiral and “along the way”. Often we do not understand all we experience in life, she says, and many experiences result in memories that are stored while only partly understood. New experiences however may put the stored ones in perspective so we later understand what we had not understood before. Because of that it is important to learn to make meaningful connections between different life experiences, and to find the underlying patterns. She describes her own book as “a book of stories and reflections strung together to suggest a style of learning from experience”. The book possibly shows the challenge that transdisciplinarity is placing on universities: to organize them as experimental and imaginative spaces for analysis, stories and reflections strung together in random ways thus stimulating a spiral and natural way of learning along the way.

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CHAPTER **6**

Engineering Transdisciplinarity in University Academic Affairs: Challenges, Dilemmas, and Progress

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Since the 1970s the notion of transdisciplinarity and pragmatic approaches to it have challenged the monolithic traditional orientation and procedures of academia. The long tradition of monodisciplinary academic departmentalization in higher education institutions has crippled the development of human knowledge, way of doing, and even world view; ironically, it has hindered understanding of the interconnected and interdependent ecological human and natural world. Monodisciplinary academic departmentalization has perpetually and inherently limited the discovery of knowledge and its application to complex real-life problems that demand solutions to assure a sustainable and democratic human society. This chapter presents a discussion of strategic engineering in higher education academic affairs aiming toward transdisciplinary teaching, learning, research, service, and curriculum transformation with emphasis on challenges, dilemmas, and progress.

6.1 Introduction

“The world has problems, but universities have departments” (Brewer, [1])

“Do you replicate what exists, or do you design what you really need?”
(Michael Crow, ASU president, 2002, Inaugural address)

The basic infrastructure of U.S. contemporary higher education institutions is based on the three pillars: academic affairs, administrative affairs, and student affairs. Among them, academic affairs, encompassing faculty, students, teaching, learning, research, services, and curriculum, is the essential element of a university; and it reflects the social responsibility of the university as the educational agency for the human community. In the 21st century, U.S. higher education institutions face a

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very different kind of challenge compared to the governmental engineering of geopolitical and geohistorical expectations of the educational responsibilities of universities in previous centuries (e.g., The Morrill Act of 1862; Servicemembers' Readjustment Act of 1944; Civil Rights Movement of the 1960s; *The Test of Leadership: Charting the Future of U. S. Higher Education*, a 2006 report by the U. S. Department of Education [2]) (further discussion see elsewhere, Hyun, [3,4]).

As a result of globalization, emergent problems of human society have become increasingly complex, interconnected, and interdependent in nonlinear modes (e.g., global public health, financial crisis, climate change, public education, etc.). These kinds of problems are neither confined to particular sectors or disciplines nor easily predictable. Human beings face nonlinear dynamics, uncertainties, and high geopolitical stakes in decision making, coupled with ethical dilemmas and complexity. As legitimized social agencies, higher education institutions have a major role to play in preparing the kind of well-educated, critical, knowledgeable, and flexible workforce necessary to contemporary and futuristic economic, social, transnational, and transcultural endeavors in the complex and diverse global human society.

In the 1970s and again in the 1990s, the focus was on challenging unrealistic and ineffective higher education teaching, learning, research, and curriculum that systematically lacked the full integration of disciplines necessary to understand and solve real complex human problems. Researchers have discussed how mono-, inter-, or multidisciplinary curriculum has led to limited capacities in preparing new workforces to deal with multiple layers of complex human problems in the current transnational and transcultural human society. Teaching, learning, research activities, service engagement, and degree programs and curricula in higher education have clearly revealed a need to transform beyond the monodisciplinary, transgressing disciplinary boundaries and leading toward transdisciplinary, borderless engagement (e.g., Darbellay, Cockell, Billotte, & Waldvogel, [5]; Hadorn, Bradley, Pohl, Rist, & Wisemann, [6]; Hammer & Söderqvist, [7]; Hyun, [4]; Jantsch, [8]; Kaufman, Moss, & Osborn, [9]; Kessel & Rosenfield, [10]; Klein, [11]; Klein, Grossenbacher-Mansuy, Häberli, Bill, Scholz, & Welti, [12]; Lawrence, [13]; Kötter & Balsiger, [14]; Max-Neef, [15]; McWilliam, Hearn, & Haseman, [16]; Mroczkowski, [17]; Nicolescu, [18,19,20,21,22]; Piaget, [23]; Pohl, [24]; Ramadier, [25]; Wickson, Carew, & Russell, [26]).

In the 21st century, discourse on change in higher education curriculum has moved from the monodisciplinary to the interdisciplinary, multidisciplinary, and transdisciplinary, reflecting an emerging understanding of the complex social ecology of the changing human world. A means to increasing integrated knowledge and practice without disciplinary boundaries, transdisciplinarity may ultimately provide an avenue for engagement that promotes full understanding of and problem-solving capacity directed at complex human problems that are no longer merely local issues but globally connected transnational matters. Transdisciplinarity is a democratic epistemology and action that challenges all of us in academia, industry, government, and various human organizations, both public and private, the basis of whose operation comprises all forms of existing disciplinary human knowledge, science, and technology (Hyun, in press). The essential purposes of transdisciplinarity are (a) to signify and to engage in a unity of knowledge and surpass mono-, inter-, and multidisciplinary approaches and (b) to build a capacity for human knowledge that is responsive to solve problems affecting real lives. Transdisciplinarity inspires us to ponder a unity of knowledge beyond traditionally accepted disciplines (Nicolescu, [20]).

Jean Piaget, a French-speaking Swiss developmental psychologist known for his theory of cognitive development and epistemological studies (generic epistemology) with children, introduced the term transdisciplinarity in 1970. Throughout his life, Piaget [23] argued that education is the only means to saving human societies from collapse, regardless of whether cataclysmic or gradual. A question, however, remains: What kinds of education might be introduced to learners, researchers, policy makers, and various practitioners that would lead to a unity of human knowledge capacity, practice, potentiality, and awareness beyond the disciplinary boundaries? To uncover the nature and characteristics of the flow of information circulating among the various branches of knowledge, to develop research in a new scientific transdisciplinary mode, and to create a global competence yielding educational capacity (de-educate, re-educate, and newly educate) in borderless disciplines—these are the goals of the university, the agent of higher education institution. One of the most critical and fundamental responsibilities of the university is to lead this transformation. The most legitimized social agent, creating, discovering, conveying, disputing, accepting, and disseminating various forms of epistemology and its agreement process, the university, an institutional organization, is a cultural artifact (Hyun, [3]). Among the most traditional of all institutions, it has been known as the one most responsible for changes in human history (Seymour, [27]). With this critical awareness of the role and responsibility of contemporary higher education, in this chapter I share how one public research university has made a strategic effort in academic affairs in building a transdisciplinary capacity for teaching, learning, research, service, and curriculum transformation, coupled with transnational and transcultural endeavors. The paper was originally presented at the ATLAS's Transdisciplinary, Transnational and Transcultural Biennial Conference, June, 2012, Taichung, Taiwan.

6.2 Academic Affairs' Strategic Approaches

6.2.1 Basic Guiding Principle

Transdisciplinarity does not entail new disciplinary knowledge; instead it involves an inherent and perpetual capacity of simultaneously deepening and extending disciplinary approaches for the improvement of borderless human knowledge and engagement. It inspires or triggers the emergence of new or different information and interactions derived from encounters among various disciplines and leads to new and different possibilities of understanding nature and engaging with reality. Transdisciplinarity does not require mastery of disciplines, but it motivates individuals to work toward openness by dialoguing, sharing, connecting, fusing, and surpassing existing disciplinary boundaries. In this borderless process, “*no single culture is privileged over any other culture. The transdisciplinary approach is inherently transcultural*” (as indicated in the Article 10 of the International Center for Transdisciplinary Research (CIRET, [28]), founded in 1987). Basarab Nicolescu [29] claimed that only the transdisciplinary approach can effectively reconcile the challenges of the 21st century. He further argued, “Universal sharing of knowledge cannot take place without the emergence of a new tolerance founded on the transdisciplinary attitude,” suggesting the necessity of putting transcultural, trans-religious, transpolitical, and transnational visions into transdisciplinary practice (p.1). The notion of Transdisciplinarity and its organic practice cannot be separated from Transcultural and Transnational engagement, and that, the triple T (TTT), has been my basic guiding principle in

leading and facilitating inter- and transnational endeavors for faculty, students, staff, academic units, and centers and institutes at the University of Massachusetts Boston (UMass Boston).

6.2.2 Institutional Background

UMass Boston devotes a high proportion of research and public service activities to the cultural, social, and economic development of the state. It is nationally recognized as a model of excellence for urban universities (one of the top 20 urban universities in the country). A comprehensive, doctorate-granting campus, the university provides challenging teaching, distinguished research, and extensive service that particularly respond to the academic and economic needs in urban areas in the state and their diverse populations. The six core concepts of the mission of the institutions are access, excellence, public service, innovation, economic development, and quality of life. With a growing reputation for innovative research addressing complex urban issues, the university, founded in 1964, is the only public research university in the metropolitan area, offering its diverse student population both an intimate learning environment and the rich experience of a well-known North American city. As of fall 2012, its nine colleges and graduate schools have served over 900 faculty members and more than 16,000 students at the baccalaureate (97 degree programs), master's (45 different degree programs and 16 tracks), and doctoral (more than 35 different degree programs including tracks) levels as well as 37 graduate certificates, including Certificate of Advanced Graduate Studies (CAGS), while engaging local, national, and international constituents through academic programs, research centers, and public service activities. The university, proudly hailing itself as "a research university with a teaching soul," has been increasingly recognized as a national model of excellence for urban universities.

At this nearly a half-century-old higher education institution, no strategic effort at UMass Boston had promoted a transdisciplinary emphasis in academic affairs for faculty and students for their research, teaching, learning, curriculum transformation, and professional development until AY 2008–2009, when the current academic affairs administrative leadership designated internationalization a strategic effort. Thus, a new associate provost position was created along with a new academic affairs office, the Office of Inter-/Transnational Affairs (OITA). With my scholarship in higher education curriculum along with administrative leadership experience in the internationalization of academic affairs, I was appointed associate provost and head of OITA. Since then, I have led the University in strategic planning and development and played a significant role in internationally focused academic and research programs based on transdisciplinary, transnational, and transcultural academic affairs, for example: increasing the strategic capacities of research and study-abroad academic programs for both students and faculty; streamlining administrative processes to enrich the TTT elements of teaching, curriculum, research, and community engagement; facilitating hiring, mentoring, and assessing faculty in light of TTT teaching, research, service, and curriculum transformation; building and enhancing international partnerships for TTT aim and scope in conjunction with academic units and programs; developing and providing funding programs and support for faculty, students, academic units, and professional staff for their TTT teaching, research, learning, and service engagement in local, national, and global contexts, etc.

6.2.3 Reframing Academic Affairs in Motion

The mission of OITA at UMass Boston is to facilitate the processes necessary for strategically integrating international (global), transnational (borderless), transcultural and national trends and policies into the *transdisciplinary* curriculum, teaching, learning, research, community engagement, and service functions of the university. The objectives of OITA are as follows:

- To promote involvement of all students in significant international educational experiences in the context of global–urban communities;
- To create and maintain a stimulating and supportive academic and cultural environment for and with students and scholars;
- To support transnational academic curricula that are transdisciplinary and trans-collegiate;
- To promote and enhance faculty’s teaching, research, and multiple forms of scholarship activities pertaining to global–urban matters and applying *transdisciplinary approaches*; and
- To ensure efficient and coherent coordination for campus-wide transdisciplinary, *transnational, and transcultural (TTT) academic affairs*.

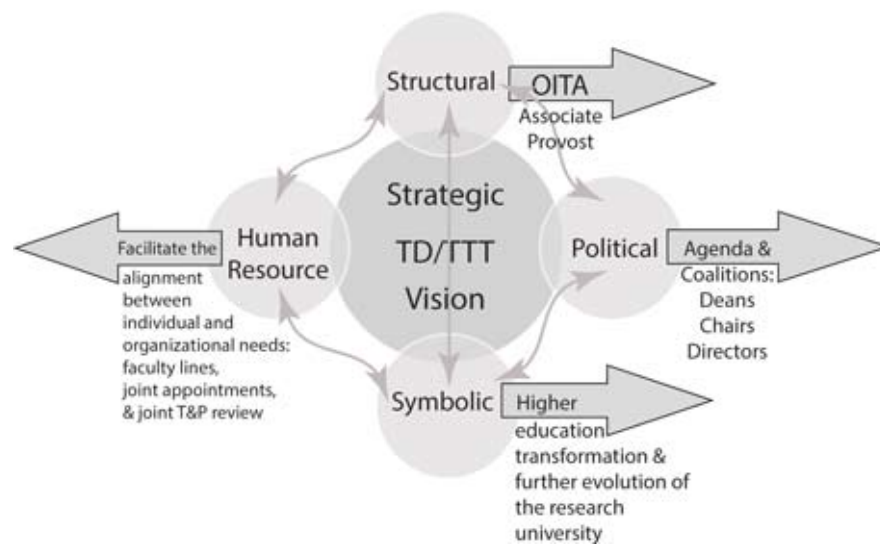


Figure 6.1: Reframing academic affairs in motion.

In the U.S. higher education setting, a transformative strategic evolution can take place neither explicitly nor implicitly without considering at least four domains—structural leadership, political leadership, symbolic leadership, and human resource management (e.g., Bolman & Gallos, [30])—especially if the strategic effort is to be collectively meaningful, thus leading to a lived experience with sustainable impact. The four domains were considered as part of the process of reframing academic affairs and putting the TTT strategic effort into practice, as shown below (see Figure 6.1):

- **Structural change and enhancement:** creating a new associate provost position with responsibilities as an executive leader charged with building institutional accountability and transparency in establishing strategic, inclusive, and systematic communication and engagement in TTT academic affairs.
- **Political inclusiveness:** promoting, valuing, and acknowledging TTT activities as essential elements in cross-disciplinary transcultural academic engagement on campus among executive leaders (e.g., deans), mid-level leaders (e.g., chairs and directors), and faculty.
- **Support of human resources and articulation of collaborative strategies:** facilitating the alignment of individual and organizational needs as a critical element of TTT, such as new faculty lines, joint appointments, joint tenure and promotion (T&P) review process, faculty cross-departmental socialization and mentoring to nurture TTT culture, etc.
- **Symbolic shared vision:** making TTT efforts publicly visible in the strategic mission of the university in conjunction with building its capacity as the “Research University With a Teaching Soul,” that is, our contemporary aim and future responsibility for the community we serve.

Traditional departmentalization in academia has been a fundamental, perpetual, and inherent block to imagining transdisciplinarity. In terms of academic-unit and departmental-level TTT engagement, however, I have always reminded myself that “we have to work with what we’ve got.” The pros and cons of individual unit-based academic affairs considered, three approaches to TTT have been utilized as follows:

At the individual faculty level:

- Facilitating individual faculty members’ imagination of the transdisciplinary teaching approach (e.g., by providing pragmatic tips for the development of transdisciplinary course syllabi in conjunction with using library resources and connecting with faculty from other academic departments teaching related courses)
- Facilitating faculty cross-border matchmaking for a transdisciplinary research project initiative and course/syllabus development
- Facilitating library support (VERY CRITICAL) in collaboration with library personnel (e.g., helping faculty to look for transdisciplinary materials, to build transdisciplinary online course resources, etc.)
- Developing, providing, and facilitating a formal Faculty Research/Study Abroad Program for TTT engagement in a global context
- Developing and providing various funding programs for TTT teaching, research, and service engagement with students in the global–urban community context for service learning-oriented problem-solving initiatives

At the department/program level:

- Facilitating department chairs’ and college deans’ cross-border matchmaking for development of new transdisciplinary Ph.D. programs
- Facilitating strategic committee selection from various disciplines, departments, and academic units
- Facilitating joint appointments, contracts, and T&P review processes
- Developing and providing various international funding programs for the infusion of TTT into the unit- and program-level curriculum

At the college level:

- Facilitating college deans' cross-border interaction for the creation of new transdisciplinary academic units, centers and institutes
- Facilitating college deans in strategic inclusive cross-border committee selection from various disciplines for new academic initiatives
- Facilitating college deans' in articulation and agreement in joint appointments, contracts, and T&P review processes
- Providing support and incentives at the college level for TTT initiatives

6.2.4 Outcomes and Progresses

Now, after four years and heading into the fifth year, the campus has begun a culture of imagination that allows faculty members, department chairs, and academic deans to experiment with transdisciplinary initiatives among themselves and with students and various community partners, for example:

- In collaboration with the College of Management, College of Liberal Arts, the College of Science and Mathematics, and the McCormack Graduate School of Policy and Global Studies, creating and offering new Ph.D. programs: first, Global Governances and Human Security with several international partners (Ethiopia, Brazil, etc.); second, a new business management Ph.D. program with a track for Organizations and Social Change (UK, Israel, China, etc.); third, in collaboration with the College of Liberal Arts, College of Nursing and Health Sciences and the McCormack Graduate School of Policy and Global Studies creating and offering a new sociology Ph.D. program with a track for Medical Sociology with several international partners (e.g., the Hannover Medical School and the International Academy of Life Science, Germany) and local hospitals, government organizations, and community health NGOs, to promote research initiatives that offer opportunities for real-life based problem solving in conjunction with public and global health and public policy issues for dealing with health disparity and social justice issues, etc.
- Creating a new transdisciplinary academic unit, the School for the Environment: In the final proposal for the development of the new school, the key orientation of the school was discussed, articulated by a transdisciplinary team of faculty from various academic units:

No longer can the environmental disciplines of policy, economics, and business be separated from the environmental sciences; furthermore, the metadiscipline of environmental science has reached a critical nexus, requiring universities to rethink how they teach students and train future leaders. Environmental problems do not recognize national borders; neither can environment training and research be limited by disciplinary borders.

- (a) Many of the benefits provided by the School intentionally blur the lines among teaching, research, and service, ensuring that the School capitalizes on opportunities provided by transdisciplinary collaboration.
- (b) We will create and strengthen transdisciplinary undergraduate and graduate programs through the development of a transdisciplinary Ph.D. pro-

gram and combine B.S. or B.A. and M.S. programs. We will foster opportunities for faculty to work across units and expand opportunities for new faculty through joint hires.

- (c) We envision the School strongly supporting research and doctoral education through the creation of research clusters and dedicated research assistantships and post-doctoral fellowships supporting a broad range of transdisciplinary research across the University.
 - (d) In partnership with governmental and nongovernmental organizations, industry, and communities around the world, we are committed to creating future leaders, immersed in transdisciplinary thinking and focused on developing sustainable solutions to the critical challenges facing our environment.
- Developing and implementing strategic funding programs for faculty, students, staff, academic units, and centers and institutes for TTT-related teaching, research, service, and curriculum initiatives (see http://www.umb.edu/academics/oita/oita_funding_programs_for_faculty_students_and_staff). As of AY 2011–2012, the University had a total 13 different funding programs to support faculty, students, and professional staff for their international teaching, research, learning, and professional development opportunities. In addition, separate funding supports academic units (colleges, research centers, and institutes) for their strategic TTT initiatives.

Because the budget issue is always a challenging matter, a new resource-generating program initiative has been proposed and in place since 2009: the International Visiting Scholar Academy (IVSA) program (http://www.umb.edu/academics/oita/visiting_scholars) designed for international scholars (professors, researchers, and postdoctoral students) from various disciplines who are interested in coming to the University to participate in a series of transdisciplinary professional development workshops with UMass Boston faculty and for their continuous improvement in teaching, research, and services related to their field. The IVSA program was strategically developed to build a culture on the campus among faculty and graduate students to experiment with transdisciplinary ideas with the guests (faculty from other countries with various academic and cultural orientations). It has also created a public comfort zone on campus and a willingness among our faculty, doctoral students, and local community members, in exploring and articulating their research and teaching in a transdisciplinary mode—a new intellectual imagination and possibility to advance academia that is much needed.

6.3 Challenges and Dilemmas

The progress made to date has been somewhat modest, but both concrete and organic. Meaningful and sustainable outcomes require long-term and strategic commitments, which continue to evolve because the core of this type of engineering of academic affairs depends upon collective human history and its dynamics that is always in motion with some degree of human unpredictability. A collectively real and sustainable engagement occurs at the academic-unit level only if both the visible and invisible cultures that constitute the unit have been nurtured collectively by the university mission and history.

A perpetual conflict, however, exists *between* the institution's historical identity as a commuter urban–public research university serving local and regional communities *and* the new strategic emphasis on transdisciplinary internationalization of academic affairs; hence, a double layer of challenges and dilemmas has fraught transformative academic engineering at this institution. The response of a typical skeptic may raise the following issues:

Why should a public commuter university be internationalized, not to mention the complexity of understanding what transdisciplinarity is really about and how to implement it? I get the idea of TTT, how the three aspects are interconnected. It sounds logical and scholarly, and I appreciate the notion very much; but is this transdisciplinary approach really possible? To date, most of us, literally everyone was hired by single department; and for a faculty member to fulfill the department's expectation in order for him or her to be retained, he or she must be successful within the department. Historically, many faculty members who have done interdisciplinary teaching and research have had difficulty earning a successful T&P review on this campus, even at the fourth-year review.

The foregoing is the product of innocent pondering with a historical memory, a response typically voiced by many faculty and staff members and administrators alike, all of whom were born, raised, and educated, have lived in the same city, and have worked at this university most of their professional lives. At this university, many individuals who belong to this “group,” and they have a profound connection with the university and the community about which they care deeply.

A well-respected senior faculty member, who has been teaching at this university since 1965, said:

This is a well-known commuter institution. We do not need to spend money to send faculty overseas to do TTT research. We'd better use that money for local students, providing more scholarship opportunities for them to come to the university for their college education. Besides this city is already international, and some of us are already doing interdisciplinary work. More and more are moving in this direction! We have served transnational and transcultural students since the beginning of this university's history! It is much easier doing faculty fourth-year reviews and T&P reviews within one department only, not with other departments. It's just problematic. Faculty are not familiar with this. One department may say yes; another department may say no. In a similar case, several years ago, we lost a very productive faculty doing what we call inter-/transdisciplinary research in the community to another university during the T&P review year.

A newly hired faculty member in an applied social science field sharing her concerns, stated:

My dean [hired by a previous provost] does not want me to engage in international activities, nor does she understand what the transdisciplinary approach means. She said it is just too complex to understand and do it. The dean said I may not be fully supported by other senior faculty when I go through T&P because our college's mission is serving

the needs of the urban community. That is one of the key expectations to get full support from other faculty when I go through T&P. The Dean said we have to work with the local partners for teaching and research, but I like the various funding programs the office [OITA] has, very impressive! I am very glad that I have accepted the position to join the faculty. I remember what the provost said during my job interview and know the provost wants us to engage in international endeavors with inter-/transdisciplinary matters. I am sure when we have new permanent dean hired by the current provost, the dynamic may and should change in my college and department. It seems happening lately. May I ask your office [OITA] to pay for my travel expenses for an invitation from a former colleague to make a presentation in Italy? In fact his area is economics, sociology, and psychology coupled with education; thus interaction with him in the field will be definitely be transdisciplinary in a transnational and transcultural context. Ha! I've got it now. And besides, I've never been to Italy!

This urban institution, which is the only research public university located in a large, well-known, metropolitan, international city, is in the process of a major transformation in order to become more responsive to the contemporary changes and needs of the life and future of the next generation. On one hand, infusing transdisciplinary internationalization into all aspects of academic affairs is one of the critical aspects of the strategic mission and profile of the university as well as its future. On the other hand, transdisciplinary internationalization is viewed as a “contradicting emphasis” by a good number of respectable and seriously dedicated faculty, staff, and administrators, who were hired by previous regimes with a different historical orientation. Mission driven visionary administrative leadership is one thing; transformative institutional culture change is another: Cultural change has been the most critical challenge in the strategic engineering of academic affairs at this urban public higher education institution.

6.4 Pragmatic Approaches Toward Transdisciplinary Transformation in Higher Education Institutions

At this point, based on what I have experienced so far, the following are pragmatic suggestions I would like to share with colleagues who may be responsible for facilitating the strategic engineering of academic affairs for transdisciplinary foci:

- Cross-disciplinary/joint faculty position articulation
- Cross-disciplinary/joint faculty search committee formation
- Cross-disciplinary faculty socialization for research
- Congruent tenure and promotion expectations (outside the monodisciplinary frame) [a new paradigm]
- Cross-departmental curriculum articulation and real-life problem solving-based research and learning experience at both the undergraduate and graduate levels (building for future faculty cross-disciplinary/transdisciplinary capacity)

- Both formal and informal curriculum for students' cross-border/integrative research experience
- Make sure you have a [trans]visionary leader at the head of academic affairs for the institution.
- Pay equal and balanced attention to strengthening both basic sciences [monodisciplinary fields] and applied sciences.
- Provide both visible (explicit) and invisible (implicit) "public" spaces in the campus culture for faculty, students, and community members in conjunction with transdisciplinary teaching, research, and service. In tenure-system institutions, outreach by well-established, scholarly senior faculty outreach to other departments and their experimental discipline-borderless involvement with junior faculty and students may be important elements for the new way of thinking and doing.
- Establish an incentive mechanism—even if it is small in scale—that encourages faculty members to explore teaching and research initiatives with colleagues in other disciplines.

6.5 Conclusion

Transdisciplinarity is a means to increasing intellectual potential and awareness inside and outside typical disciplinary knowledge without a border, ultimately inspiring effective engagement *in, with, to, and for* the human community for the public good. Thus, transdisciplinary approach is a democratic epistemology and action. In comparison with various other disciplinarity (monodisciplinarity, Interdisciplinarity, multidisciplinary), transdisciplinarity denotes different academic disciplines working together without a "border," with practitioners and nonacademic ordinary community people (including industry, business, public administration, nongovernmental organizations, etc.) to understand real-life issues and phenomena and to collectively solve problems. As a result of globalization, technological innovation and complex social issues that risk the humanity, much of the problems we face today require transdisciplinary knowledge and collective engagement that is both transnational and transcultural. For that reason, some universities have created degree programs or specific strategic initiatives to build transdisciplinary capacity via academic units, centers or institutes (see examples in McGregor, & Volckmann, [31]).

The transdisciplinary approach is a new form of *shared* research, *shared* learning, *shared* teaching, and *shared* problem solving for a *shared* social responsibility involving diverse sectors of the public and academia in order to meet the complex challenges of human society and its sustainability; it is democratic and ecologically sound (Hyun, [4]; Hyun, in press [32]). If we consider the history and evolution of higher education since the 15th century, the transdisciplinary phenomenon is a cultural artifact of 21st-century higher education. Within the parameters of the university, curriculum is the center of reasoning, the artifact of the university. If curriculum is the center of reasoning in the university—What is curriculum? What does the curriculum do to individuals and human society? Why is an infusion of transdisciplinary curriculum and research into academic affairs an inevitable consideration now? Is university curriculum a condition or capacity of academic affairs, representing collective epistemology, geopolitical agenda, or politically engineered sociocultural and socioeconomic intention to prepare the next generation for various

forms of engagement that may lead to socially responsive and humanistically sound action for sustainable human community?

Since World War II, the global population, crop production, and energy consumption have all increased dramatically. In addition to these physical entities, the total amount of human knowledge has multiplied exponentially in equally dramatic fashion—mass production, mass consumption, mass disposal, mass mobility, mass environmental impact, megaurbanization, mega-complex public health problems, and the tremendous educational disparity between the rich and the poor. Nowadays, one scientist often does not understand what is going on in his or her neighbor's laboratory. They cannot even communicate with one another: same topic of research but in different languages that are specific only to one's own disciplinary thinking. This phenomenon of compartmentalization poses the greatest obstacle to the initiation of transdisciplinary ways of knowing. When we confront a real-life issue that demands resolution, we need to combine or integrate different disciplines to understand and solve the issue along with educating students in this mode for societal sustainability. The contemporary phenomenon of transdisciplinary curriculum discourse in higher education is inevitably and paradoxically influenced by industry-driven globalization; thus, it could be a reactive cultural artifact. It is, however, also a socially responsive transformative movement that deserves our collective attention for this generation in human endeavor. And that attention is overdue.

A perpetual and historical hindrance, however, causes faculty and administrators to avoid transdisciplinary pondering and thus miss a lived collective experience for change. Such avoidance is deeply rooted in traditional academic departmentalization: Departmental specialization has been emphasized (e.g., Wilshire, [33]) as part of the academic capacity of the modern university, where junior faculty members are advised to remain "pure," not "polluted" by the perspectives of other disciplines, and to reject inter- and transdisciplinary engagements. Consequently, borderless transdisciplinary collaboration among faculty members from various disciplines in pursuit of a real life-based inquiry was not under deliberate consideration. Still and all,

"The world has problems, but universities have departments" (Brewer, 1999)

"The right package is always imperfect but is the best deal you can actually implement" (Bolman & Gallos, 2011)

And so we move forward!

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CHAPTER **7**

Mechatronic Platforms for Transdisciplinarity Learning

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This Chapter presents details related on the possibilities to use educational potential of mechatronic platforms for transdisciplinarity learning. Mechatronics, the result of integration of mechanics - electronics and information is a reach environment for active learning and understanding the basis of integration process, complexity and the role of the information flow between transdisciplinary objects (levels of reality) and transdisciplinary subject (levels of perception). The mechatronic identity based on the concept of complexity is trans-thematic one. The basis of integronics as a science of the integration processes are outlined too.

7.1 Introduction

The term mechatronics, patented by the Japanese at the beginning of the eighth decade of the last century, was used to describe the integration of three major areas of engineering: mechanical engineering – electrical engineering, electronics – control science, computer science [1, 2, 3]. The twentieth century was marked by three major revolutions: the quantum revolution, information revolution and mechatronic revolution [4].

Started in the ninth decade of the last century, mechatronic revolution has marked the transition from information-based society to knowledge-based society [5]. Integration is the paradigm of mechatronics[1, 2, 3] and knowledge is the result of structuring and integrating information. As integronics is the science of integration processes and hyperintegrated systems [3, 6], it deals with integration levels, integration degrees, hyperintegrated systems and the benefits of integration process.

Integration is not a useless process. On the contrary, integration gives new possibilities to control the systems. Integration gives the possibility to associate complementary elements, the possibility to connect, to form cycles and networks. But integration also gives the possibility to obtain a surplus of elements, a structural redundancy. In the case of hyperintegrated systems, where everything is linked to everything, the structural redundancy results in a fantastic combinatory redundancy.

Integration therefore gives to systems larger possibilities to maintain their identity despite the second principle of thermodynamics.

In the knowledge-based society, education and training efforts for the development of complex and integrative thinking are essential in order to stimulate creativity as a basis for increasing productivity in the knowledge production. At this stage, mechatronics is the educational environment for the development of complex and integrative thinking, too.

In vision of Stephen Hawking, English theoretical physicist, the twentieth century will belong to complexity [7, 8, 24]. The complexity is closely related to the idea of non - separability, which *seems to be a fundamental principle of all that is profound in the world*' [7, 8, 24]. Consequently, research and education of the future must be shaped by the force lines of complexity and non-separability.

In other words, *intrusion the complex and transdisciplinary thinking the structures, programs and areas of influence of the University, will enable the progress towards its mission forgotten today – the study of universality*. Emphasis is provided by Prof. Basarab Nicolescu, founding president of the International Center for Transdisciplinary Research and Studies, Paris [9, 10]. In [7, 11] it is shown that, in mechatronics, complexity is a thematic concept, as defined by Holton, which gives the depth of mechatronics identity, which is a trans-thematic one.

Mechatronic platforms are complex technical systems which integrates in their structure elements of mechanical engineering (mechanisms, mechanical transmissions, etc.), electrical - electronic engineering elements (actuators, sensors, micro-controllers, filters, amplifiers, etc.) and control science – computer science elements.

Mechatronic platforms can be: stationary, mobile, portable and virtual [12]. Stationary platforms include: equipment's for education and research that are fixed in laboratories. Mobile platforms are made of mechatronic modules in a reconfigurable structure.

They are used for demonstrations outside the universities (in schools, companies, etc.). Portable platforms are made of mechatronic modules of low-cost and low-weight; they make possible experiments everywhere and every time. Virtual platforms include virtual laboratories, virtual libraries and knowledge bases.

The educational potential of mechatronic platforms has been presented in [13, 14, 15], but when it comes to use their transdisciplinary potential, the literature lacks in providing edifying solutions.

The transdisciplinary methodology elaborated 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” [9, 10, 16]. 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.

Therefore, Basarab Nicolescu introduced a complementary transdisciplinarity concept defined as: “what is at once, between the disciplines, across the different disciplines, and beyond all disciplines,”; the finality of the transdisciplinary measure is the understanding of the world through the unity of knowledge [9, 10, 16].

In this context, mechatronic platforms are the basic infrastructure for learning transdisciplinarity, in order to stimulate creativity and growth of labor productivity in the mechatronic knowledge production. It is important to note that, disciplinar-

ity, pluridisciplinarity, interdisciplinarity and transdisciplinarity are complementary approaches.

Mechatronic knowledge is a technological one, or knowledge about how to manufacture intelligent products, systems and services [5]. Taking into account the trans-thematic identity of mechatronics, mechatronic knowledge is a transdisciplinary knowledge.

The identity of a subject to be taught can be: disciplinary (mathematics, physics, chemistry etc.), thematic (system theory-based on the concept of system) and trans-thematic (based on the complexity concept) [16, 17, 18, 23].

Learning transdisciplinarity is a major need in the knowledge based society. Integral education ensures the achievement of this objective. The concept is introduced in [12, 19, 20, 21, 22] and brings into attention educational and technological approaches where the subject participate in the educational process with his whole being (mind, emotions and psyche).

Thus, modern and interactive educational technologies will be based on hexagonal model for mechatronic integral education, elaborated in doctoral Thesis [16].

The proposed model is the key to strengthening the pillars of education in twenty-one century, presented in the Delors report [7, 11, 16]: learning to know, learning to do, learning to live with others, learning to be.

7.2 The Concept of Mechatronics

7.2.1 The Flow to Mechatronic Integration

The evolution and development of the human society is closely related to evolution in technology. This connection is easily understandable if we take into account the fact that starting from the Stone Age technology we are now in the information technology age.

The transitions between stages in human society development were caused by revolutions, often caused by great discoveries in technology (the invention of steam machine at the end of the XVIIIth century is one relevant example).

The twentieth century was marked by three important revolutions: the quantum revolution, the information technology revolution and mechatronics revolution. The basis of quantum physics defined by M. Plank at the beginning of the 1930s was the starting point for the information technology revolution. The information technology revolution has marked the shift from the industrialized society to the advanced information society.

The word mechatronics is generally taken as having being coined in the early 1970s by Tetsuro Mori of the Yaskawa Electric Co. in Japan [1, 2, 3, 4]. It is important to note that the word transdisciplinarity was used for the first time by Jean Piaget in 1970 with the occasion of the International Conference “Interdisciplinarity-Teaching and Research Problems in Universities”, held by Nissa University and organized by Organization for Economic Cooperation and Development and French Ministry of Education. Also, at that time (1970), Francois Jacob launched the book: “La logique du vivant” (The logique of living). In the book, the author used the word “integron” as integration messenger. Interestingly, from 1972 to 1982, mechatronics was a registered trademark of the Yaskawa Electric Co [1, 3].

The term was used to define the technological fusion: mechanics – electronics – informatics. Its meaning has been continually enriched as a natural consequence of

the technological development and, step by step, mechatronics has become a philosophy, the science of intelligent machines and the educational environment for integration thinking development in the knowledge based society. The flow to mechatronic integration is suggestively highlighted in Figure 7.1.

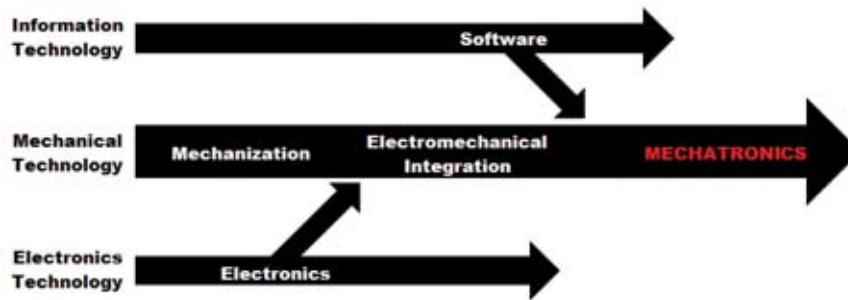


Figure 7.1: Technological flow towards mechatronic Integration.

Traditionally, mechanical technology dealt mainly with the problems of energy and material. The progress of semiconductors, especially integrated circuits, made it possible the integration of machines and electronics in one body. However, at this stage, the system could not have intelligence yet. Next revolution began with the appearance of microcomputers. Small and cheap microprocessors have been integrated into machines, and permitted machines to think and take decisions. Then, mechanical technology has changed to mechatronics by merging information-processing functions.

7.2.2 The Elements of the Mechatronic Technology

At this stage in education, developing the integrating design skills is just as important as developing the reading and writing abilities. Through transdisciplinary integrated perspective, the mechatronic offers the needed mechanisms for innovation in knowledge-based society.

Long before the word mechatronics came into general use it was recognized in industry that in order to facilitate innovation and increased efficiency in manufacturing and product design, it was vital for engineers and technicians from the disciplines of mechanics and electronics to work in synergy as teams rather than independently. Competing in a globalized market requires the adaptation of modern technology to yield flexible, multifunctional products that are better, cheaper, and more intelligent than those currently on the shelf.

Mechatronics represents an integrative vision in technological field, as shown graphically in Figure 7.2. The importance of mechatronics is evidenced by the myriad of smart products that we take for granted in our daily lives, from the cruise control feature in our cars to advanced flight control systems and from washing machines to multifunctional precision machines.

The technological advances in digital engineering, simulation and modeling, electromechanical motion devices, power electronics, computers and informatics, MEMS, microprocessors, and DSPs have brought new challenges to industry and academia.

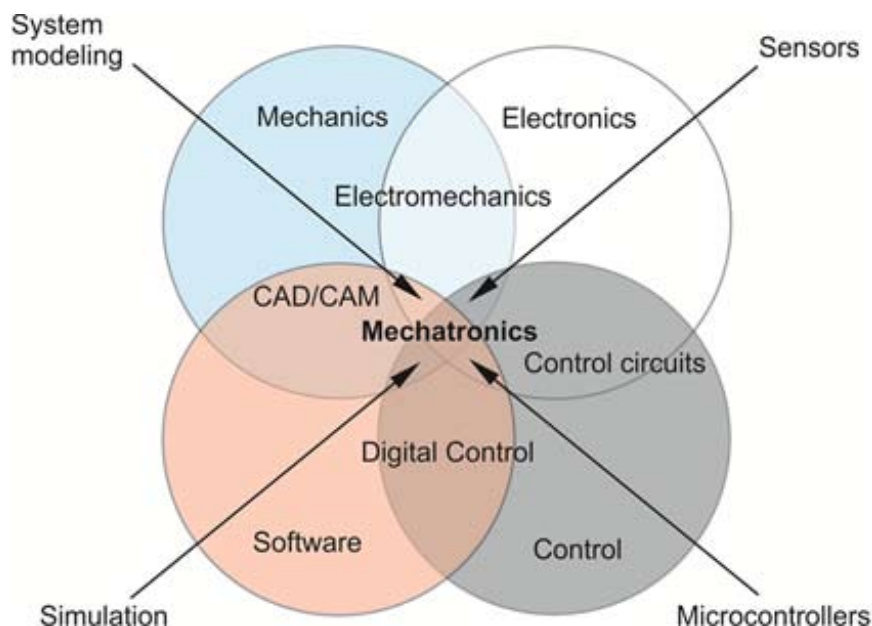


Figure 7.2: The elements of the mechatronic technology.

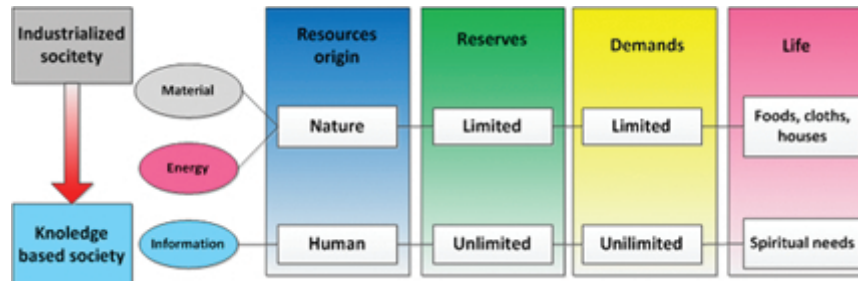


Figure 7.3: Material-energy-information relationship in mechatronic technology.

Based on Figure 7.3, we can analyze comparatively the three components of mechatronic technology. Comparison accentuates the origin of resources, reserves, demand and what means life in terms of these three elements. Analysis motivates the worldwide interest to promote this technology. Obviously, making products that includes more information (intelligence), their functional performance increase.

On the other hand, in this way the material and energy resources are preserved. But, less material and less energy means less processing, so less pollution. In this context it follows another facet of mechatronic technology: it is a no dissipative and less polluting technology.

The information is the most important element of the mechatronic technology, by comparing against material and energy. Why? Because: [2].

- satisfaction of the mind of human beings is caused by information;
- only information can increase added value of all things.

The value of information is evaluated by its freshness and not by its quantity, because the human mind always requires new stimuli. In other words, the value of material and energy depends of integration, but that of information depends of differentiation.

Mechatronic technology launched the challenge related on “sensitivity information”. The commercial value of the passenger car for example does not depend on its basic function only.

It rather depends on its appeal to human senses for example, style, color, and so on. Any machine sends information to stimulate the five senses of human beings.

In particular, products that are originally designed to output sensitivity information such as musical instruments, toys, dolls, and so on have become increasingly important in the knowledge based society.

7.2.3 Mechatronics and Complexity

Through a mechanism of stimulating transdisciplinary ideas and techniques, mechatronics provides ideal conditions to raise the synergy, thereby providing a catalytic effect for the new solutions to technically complex situations.

An important characteristic of mechatronic devices and systems is their built-in intelligence that results through a combination of precision in mechanical and electrical engineering, and real-time programming integrated into the design process.

Mechatronics makes possible the combination of actuators, sensors, control systems, and computers in the design process.

The mechatronic approaches are very knowledge intensive (Figure 7.4). They combine kinematics and dynamics, material technology, control engineering, information technology, micro technology, etc.

Mechatronic systems, being the product of an integrated design approach, are superior to any products that could emerge from traditional sequential engineering approach [16, 17].

The mechatronic approach is thus essential for the development of the manufacturing systems of the future. Evolution in the technological development means: micromechatronics, nanomechatronics and biomechatronics.

Furthermore, mechatronic solutions are applicable in many others sectors that are of significant importance to the welfare of the citizens, such as healthcare and transport.

The power of mechatronics approach can only be fully deployed if vast amounts of knowledge and expertise are correctly combined and canalized. Integration is therefore the key issue in the mechatronic discipline. Integration means, among others, the establishment of research teams beyond the borders of specific projects, existing institute or companies, with a profound transdisciplinary character.. Integration also means establishing the mechanisms that enable the joint management of these research teams. Integration of research resources is therefore a major undertaking.

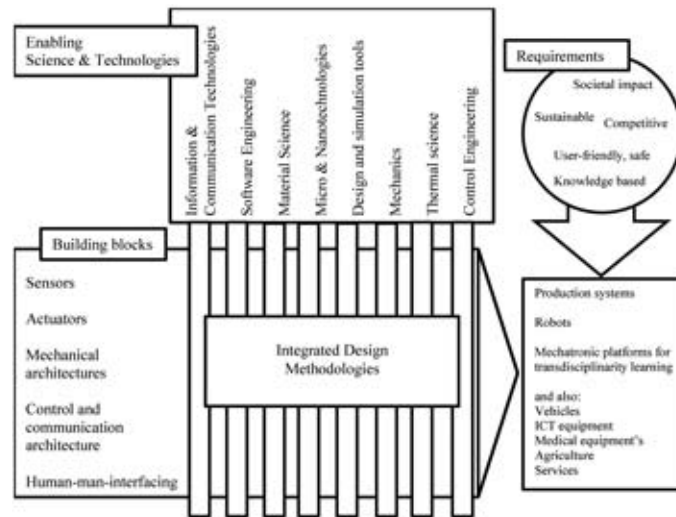


Figure 7.4: The complexity concept as basis for trans-thematic identity of mechatronics.

7.2.4 Mechatronics Philosophy in Engineering Practice and Education

Mechatronics technology development surprised the universities, which were forced to adapt their educational programs on the fly for the new demands. As a result of this laborious work emerged the mechatronics principles in education. These principles aim to develop systemic thinking and skills for team-work.

In mechatronics education affective learning is very important. Because of the important role of information in all fields of activity, it is necessary to redefine the objectives in educational process.

In this context, it is important to develop skills like: informing, mental, social and action training. Networking is the key in mechatronic education.

Mechatronics technology and mechatronics principles in education have led to the definition of mechatronics philosophy. For engineering practice this philosophy marked the transition from traditional engineering (sequential) to simultaneous or concurrent engineering (parallel).

In Figure 7.5a is presented the traditional approach and in Figure 7.5b the mechatronic approach. In traditional approach, controller is “attached” to system when in mechatronic design is “integrated”. In mechatronics design the system is seen as a whole. Informational chain has a more compact structure and interconnection through data buses increases the speed of information processing.

Mechatronics education provides flexibility in action and thinking, defining features of market economy specialist. Mechatronics creative valences were confirmed both in education, research and production. The economic results of developed countries are an irrefutable proof.

Mechatronics specialization does not mean ignoring super-specialization. High

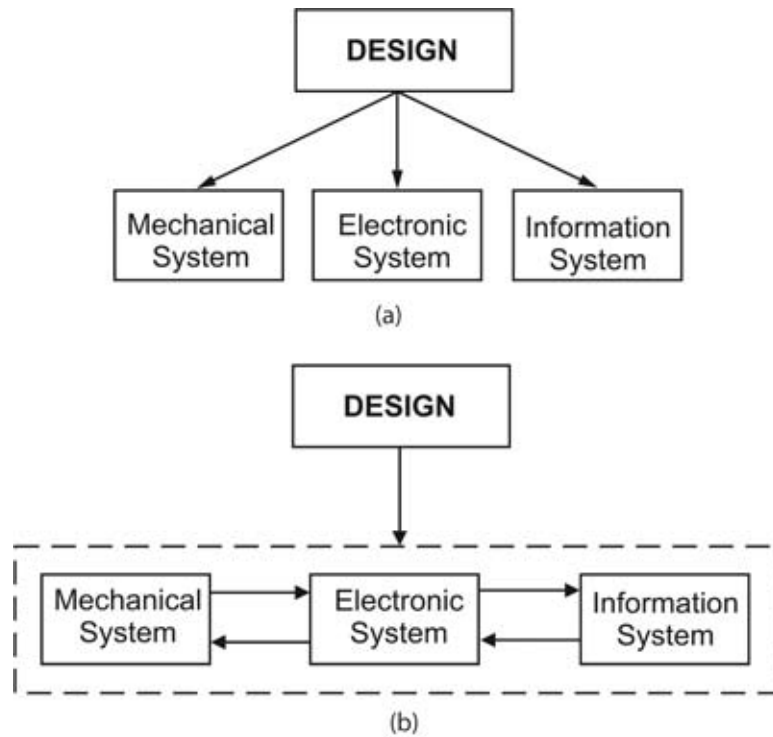


Figure 7.5: Traditional design vs mechatronic design.

performance is not possible without the contribution of super-specialists. Their presence in research fields and teams is designed according to the nature of the addressed problems. This relationship is similar to general/super-specialist that exists in medicine (practitioner doctor, specialist doctor).

Mechatronics training is practiced on all levels of education, proving beneficial in simplifying the problems of professional reconversion.

Undoubtedly, attending performance in research and design activities is inconceivable without a team-work. This is confirmed also by the works presented at international scientific events in different areas.

It is easy to understand that a surgical robot for instance, cannot be realized without a comprehensive team that includes doctors, physicists, biologists, mechanical engineers, electrical engineers, computer scientists etc.

Team-work skills are a major goal of mechatronics education. Multidisciplinary teams have proven their effective in sensitizing members on the need of optimal solutions for general problems.

Figure 7.6 shows the relationship between individual training and average level of knowledge of the team [2]. It's about a team that aims to design a precision robot. The average level of training, depending on their responsibilities in the team is shown in Table 7.1. The assessment is based on a given scoring between 1-5. This approach

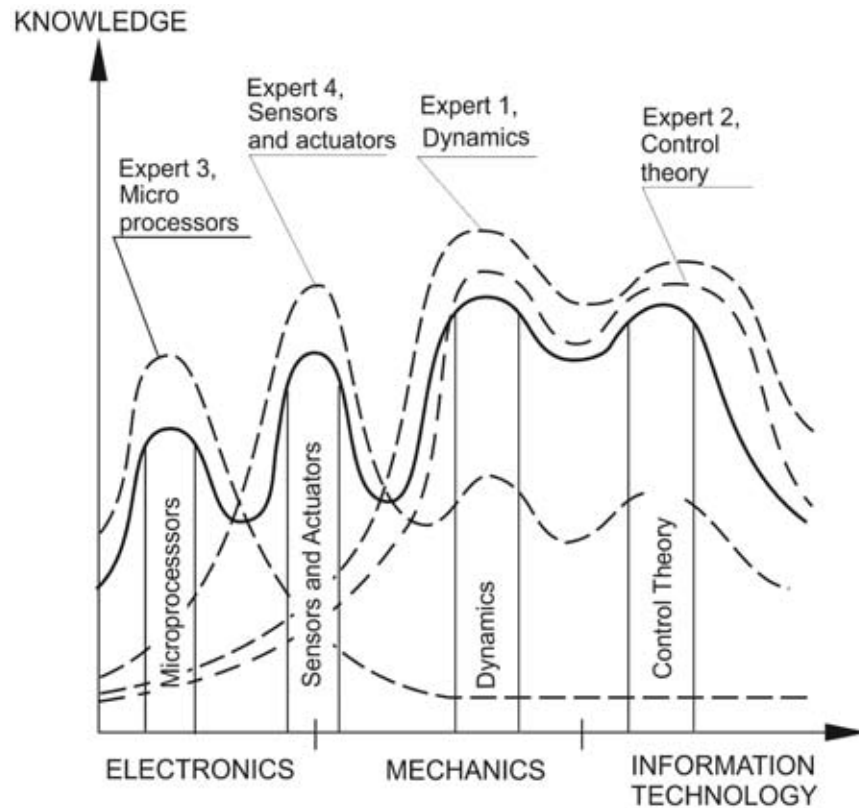


Figure 7.6: Relationship between individual training and average level of knowledge of the team.

is important in school education. By defining the curricular areas, the framework to move from a narrow approach imposed by a single discipline to a global approach was imposed. In schools, the general objectives cannot be achieved without the contribution of all curricular areas, so the professorial staff must constitute a team and act as such.

7.3 Integronics

Integronics is the science of integrated processes and hyperintegrated systems, as the human body is. It takes account of the indissoluble unity of the world in which we live and the need for unique perspectives on the world. The concept is illustrated in Figure 7.7. [12]. Unit: science, literature and art, technology, takes place in the framework of mathematics, cybernetics and philosophy. Basis of integronics is not only the world around it but also the gnoseologic drive unit, of the subject knowledge of this world. Because there is no physical, chemical and even of scientific or artistic

Table 1: The average level of team training.

Position/Score	Dynamics	Control Theory	Electronics	Sensors and Actuators	Programming	Management	Economy	Design
Project manager	3-4	3-4	2-3	2-3	2-3	5	4	4
Control Theory Expert	4	5	1-2	2-3	2-3	2-3	1-2	3-4
Dynamics Expert	5	4	1-2	2-3	2-3	2-3	1-2	3-4
Sensors/Actuators Expert	2-3	2-3	3	5	2-3	2-3	1-2	3-4
Programming Expert	2-3	2-3	3-4	2-3	4-5	1-2	1-2	3-4
Electronics Expert	1-2	3-4	4-5	2	2-3	1-2	1-2	3-4

knowledge, human knowledge is unitary.

Integration is a natural process in nature, which created forms and structures that promote development in this way. Based on superization principle, the whole, the system, has emergent properties due to the synergistic effect. In the knowledge-based society, efforts to promote the concept of integration in education, research and technology is a major need. Knowledge itself is the result of structuring and integrating information. ICT facilitates these efforts.

Integration is a principle of functioning of the human psyche, and it is integrated in the nervous system. In the literature are brought into attention approaches regarding philosophy of integration and logics of integration. Also, the messengers of integration are defined. In nature, the integration can be: genetic, through coercion, depending on your choice, random etc. Integrating systems can be: material-energetic dominant or functional-informational dominant.

In socio-economic plan, we need to consider different levels of integration: institutional integration, inter-institutional integration and integration at national level. Integrating the knowledge and the resources is the basis to stimulate initiative and creativity in education and research activities.

It is well known that an individual personality does not depend of the richness of his knowledge as his organizational and integration capability.

Vectorization of innovation by encouraging transdisciplinary approaches, integration of knowledge's and resources in education, research and technology is the basis for labor productivity growth in the production of knowledge. Mechatronics has opened unsuspected horizons in all areas, thanks to it's synergistic effect.

Studying the inextricable links between different objects and phenomena, integronics is trying to overcome the extremely narrow limits of particular sciences, but cannot replace them. Particular sciences have been developed as a result of the limited possibilities of man to comprehend the realities of the world around us. Need for progress removed the borders between sciences and the evolution towards interdisciplinarity and after all to transdisciplinarity. In this manner have appeared chemistry-physics, biophysics, biochemistry, etc.

Accentuating the limits of fragmented approaches and the need for a global vision, integronics try to avoid such situations, emphasizing more strongly that we need

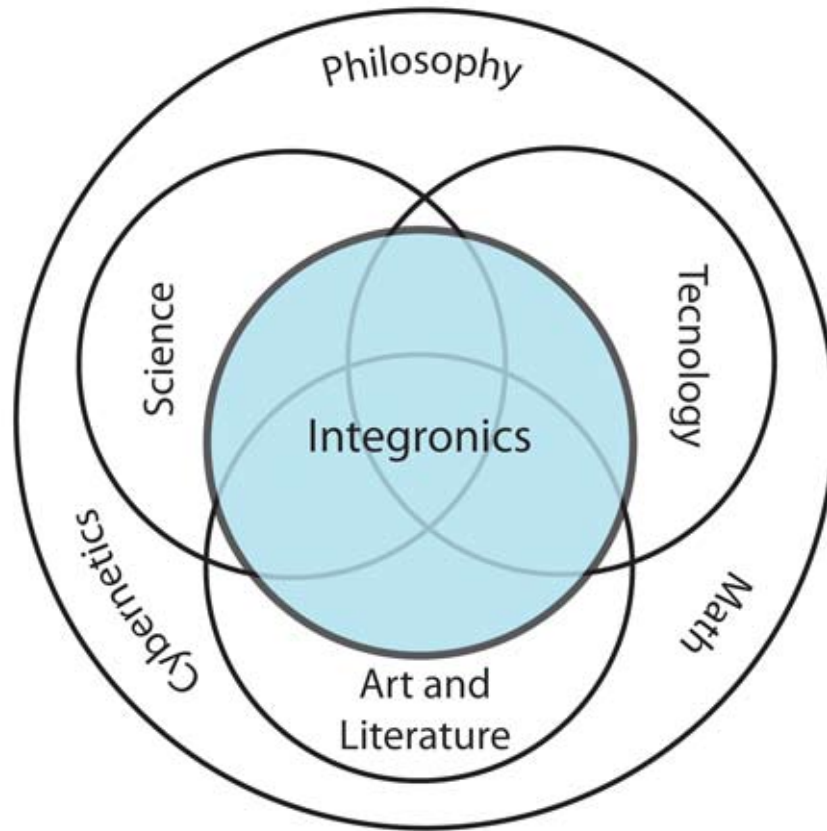


Figure 7.7: Concept of integronics.

to consider not only the subsystem on which to act, but also his links with other subsystems and finally the suprasystem of which it's a part. Integronics inscribe herself in the context of modern thinking which after all is a global, probabilistic, modeling, operational, pluridisciplinary and prospective one.

Integronics conception is one of the great gains of mankind due to the information revolution. It's very basic principle: the principle of order and systemic organization which is contrary to the second principle of thermodynamics, could be made due consideration of information. In the formulation of the second principle of thermodynamics information is not taken into account.

Extremely useful, this process of emergence of interdisciplinary sciences has not been sufficient to solve complex problems of this unitary world. It is natural, because, being more than the sum of its parts, the unity of the body for example cannot be restored by simply unifying neuroscience with the endocrinology or of psychology with immunology and the world alone cannot be retrieved by a simple unification of astronomy with physics, with chemistry and biology.

Because information is the key element in mechatronics, the impact of technology goes beyond areas of economics, being essential in the social, cultural environments etc.

This explains the great interest in the world to launch initiatives and develop special programs for this area. These approaches reinforce the belief that in the knowledge-based society, cultural relevance depends on technical, technological performances.

7.4 Conclusions

The development of the knowledge based society and the mechatronics as a technology to support such a society is a historical necessity. Since the word mechatronics was patented by Yaskawa Electric Cp.in Japan, the content of the word improved continuously as a result of the technology development. Step by step mechatronics became: philosophy, science of intelligent machines and educational environment for transdisciplinarity learning in the knowledge based society. The mechatronic paradigm is integration and its identity is a trans-thematic one. So, based on the hexagonal model for mechatronic integral education, the mechatronic platform are very efficient tools for transdisciplinarity learning, in order to stimulate initiative and creativity process..

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CHAPTER 8

The Unconscious of Economics

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Economical debates should begin by elucidating what the human being is, according to a theandric principle that unites man and his Creator, principle known by the Founders. Unfortunately, economy has been drifted away from its natural evolution, thus resulting into a nothingness of meaning. The philosophical and religious roots have been lost, the founding myths, forgotten, or a science that forgets its roots cannot but wander aimlessly, exposed to every misfit. The present study is a new attempt to heal, at least partly, the “great social disruption” (Fukuyama), but also the inner tearing, centered on the economical being, including his unconscious, the emergence of the feminine principle and the necessary psychologisation of the economy.

8.1 The Return of the Goddess?

Everything in the Universe exists and evolves together as an endless and living hierarchy. Our role, here, is to sublimate matter and adorn the world. This is the meaning of our current existence: to impress the seal of the spirit on matter. The spirit and the world co-build the spirit and the world. But do we, really, do this? Or do we do precisely the opposite? Yet we expect only good things to befall us... I hereby inform you that we are in a free fall; modernity, a *hybris*, has done nothing but accelerate it, by “freeing” man from under the Father’s tutelage, and the desert of faith extends everywhere around us.

We have to return to myths, to archetypes, to the site where the magic of the world abides and from where it overspreads. We have to return to unity, to the dyad, the triad etc., to the night-time dreamt story of creation... No era and no man could ever drop off the shirt of myth or could ever escape his own shadow. Nor could he ever shed current predicaments, such as globalization. The history of globalization is mined by the globalization of history. Globalization is an almost chimeric project, to accomplish the “Great Round Figure”, *ouroboros*, of an undifferentiated world and of a horizontal history. Otherwise, it is not an absolute novelty, if we take into account the archetypal perspective of myth. Maybe the first form of globalization occurred immediately after Genesis (“Be fruitful and increase in number. Fill the earth and subdue it”), with man’s setting into history.

In the aftermath of Genesis, man started to “know,” as well as to lose in terms of consciousness, which became insufficient and incapable to stand up to conflicts (on the contrary), to their global spread and to the massification of death. We are now dealing with a nightmarish globalization of evil, with the triumphant advancement of the profane, to which scientific rationality is also circumscribed, a secularization haunted by all sorts of illusions and a quasi-permanent conflict (historians argue that during the past 5,000 years of patriarchate, there have been 27,450 wars, i.e., on average, one war every other month).

In the European consciousness, historians have dreamt of themselves as descendants of the prophets. However, they have separated themselves from theological doctrines and from the mystery of the divine, and they have chosen the so-called scientific de-mystification, in a process that has led to the loss of significations. Hence the remarkable series ofgnoseological failures of positivism. Historians’ day-time consciousness has led them to crystal-ball futurological prognoses that are totally disconnected from authentic prophecies, for the latter cannot occur in the absence of a mystical experience, nor without the opening of heavens outside and inside our selves. Without this experience, we can only grope, with the help of technological gaps, for the chiaroscuro in the thicket of various hypotheses and we are left with the so-called fatalities. Without this experience, historical truth remains still mystified, opaque and deviated.

It is possible to recover historical consciousness and myth with the help of faith, in a sort of “psychologization” of historical analysis. History is not just the product of community or individual will or interest, but also of a non-will of the collective unconscious (Jung) which governs, from the shadow, with pure objectiveness, the nicely flowing archetypes, the alternation, the metamorphosis and their intertwinings. This is Braudel’s *histoire longue durée*, or the Indian perspective, the Manvantara cycles with their ubiquity-filled eras called Yuga.

The essence of anything political remains the falsification of truth. The historical moment, the event, is trans-lated, not only in a figurative understanding. This is called propaganda. Archives remain with the victors. Beyond commensurable causalities, quantifiable effects, economic, social, or ethical perspectives, lies endure, both in their struggle with the guerrillas of democracy and with the shadows of the “Great Rulers” in dictatorial societies, or with the ascending community-type archetype. Yet, in time, from this underground of history, ascending currents bring forth the truth to the light. In the supreme instances, in akashic chronicles, it is known anyway, and recorded for eternity. This is what we have to appeal to in order to rid ourselves, quickly, from lies.

Contemporary history is marked by the Dionysian, by the immanent, by secondary principles. A flat landscape (see Th. Friedman), always in reconstruction, a crisis of heroes and models, conflicts between generations, anarchy, fragility. Some believe that the return of the Goddess, of the Great Mother—the invisible instance of democracy—is expected, and there are Yoga variants that are working for this purpose. The very waterfall-like collapse of dictatorships would be the result of the ascension of matro-centric values, of the New Feminist Canon which is eliminating the last patriarchal sequelae, totemic figures of the Great Father. Yet, I believe that this would be nothing but a new immanent religion, a new heresy introduced on the political agenda, a la Dan Brown. Or, as I was arguing earlier, what we need is transcendence, authenticity, and truth.

8.1.1 The Rehabilitation of Myth

History emerged from and it will end in the whimsical idyll between *mythos* and *logos*. These are the only life-giving entities in the cemetery of profane events. They bind man to his unknown side, which the Greek rationalism has never managed to do. Our religious, economic, cultural and political imaginary is haunted by all sorts of more or less camouflaged myths. I find this natural since, after all, history must have a soul too, one with many secret nooks, indeed, some of which have never been seen.

Myths are handed down more frequently along feminine transmission lines; they belong to the feminine canon; they are tempting, wise and cunning like the snake and just like the snake, they also change their skin from time to time, so as to be born again and offer, maybe, another meaning, another interpretation of subconscious events. Thus, each time they surprise the level of reason and of the unconscious consciousness.

Aristotle argued that man is defined by his soul, therefore man's history cannot be defined otherwise. The latter is gathered in symbolic, irrational archetypes, which deposit essences, images and identities, as our folk stories do. Now, myth has returned, throwing into crisis the modern objectivism and the Cartesian rationalism and making our supernatural familial again. Baudelaire considered that myth has the highest degree of scientificity, because only it could understand universal analogy (the *analogon* supports the hermetic principle that what is above is beneath as well, and what is in something large is in something small as well) and thus it converts the undefined numinous at a mundane, defined level.

Myth is inexhaustible, as a thousand-sided crystal, each reflecting a story. A myth can be born out of nothing and be perfectly functional and persistent. It coincides with man's first expression when meeting God, the unknown, and it persists precisely because the meeting with the God is not over yet. Its hermeneutics can only be creative, as Eliade said. Myth cannot be conceptualized; it is redundant, a-logical, and its relations with geometry are among the poorest. For some (Levi-Strauss, Taylor, Frazer, Harrison), myth attempts to give a religious explanation to the world; for others (Eliade, Jonas, Jung, Campbell), myth is compatible with science and it cannot be suppressed. For Campbell, religion perverts myths, trying to interpret them. Myths retell a sacred history, such as the creation of the world by gods, in a forgotten, primordial time. Whereas archaic myths were religious, myths camouflaged in modernity are touched by secularization.

Myths allow the return to a time of origins, which can have therapeutic purposes, because life can be lived from the beginning again, and man can be symbolically born again. Then, myths allow one to encounter divinity and the afterlife; they justify death. Retelling myths has regenerating virtues because it sends back, at ritual level, to the source of life. For Levi-Strauss, myths take the image of primitive science; for Eliade, the entire science is a myth of modernity; for Jonas, myths describe a being's place in the world. Since even Communist atheism needed myths, just like the entire modernity in fact, this means that they have a bright future ahead.

Sacred texts teem with myths; Jung and modern psychology consider them "original revelations of the pre-consciousness...involuntary manifestations of unconscious psychic events", be they individual or collective, by interiorizing them. Freud thought the same, that the past lives in us and that psychological analysis is, ultimately, nothing but an archeological site opened in the Daedalic underground of the unconscious, from where the most valuable elements of culture, of shared individual and collective

patrimony, and of history are extracted.

8.1.2 Psychologization and Feminization

Lately, there has occurred an intense psychologization of history. More recently, the latter has also been subjected to a change of sex, in the sense of its feminization: history has become the mirror in which Venus has been venerating itself..., “the vague spirit of the valley”, as Lao Tze would say, where mythology has been ceaselessly whispering. Plato’s mythical vision, as well as Spengler’s Faustian vision, are currently undergoing a new vital impetus. We shall also mention here Toynbee’s enigmatic “x factor”. Also, even more recently, drawing on *The Republic*, Fukuyama considers that no theory or history led by economic will can be complete without a spiritual component, which is indispensable in the shaping of man and in the construction of the *polis*. “Myth’s vital lies” (Gilbert Durand) are presented to us as indispensable during the most archeolatrous time of history, where they substitute historicism’s “objective truths” and become acts of faith in a yet unborn science, or acts of global, non-differentiated knowledge.

Antonio Tabucchi, the Italian writer, thinks that “history is what explains the spirit of peoples”; my belief, however, is situated precisely at the opposite pole, in the sense that it is the spirit of peoples that explains their history and not the other way round. As Jean Favier said, “what perfects man is his horizon: the one of waves and of heights, the one that can be seen and the one that can only be guessed, the material one and that of dreams. The horizon shows everyone the hierarchy and the limits of his or her needs and possibilities. There is the horizon that one accepts and the horizon that one distances himself or herself from. The former is sterile, and it exists. The latter is only an idea and it is fecund. Both have the relative character of the spirit and of the moment. Delimitating them, they define humans and things, resources and partners”¹

8.2 The Unconscious of Economics (II)

All instruments of anthropology and psychology must lie on the economist’s desk. In fact, all sciences of the man are, in turn, each other’s auxiliaries. Economics borrows the shade and the color of the ideas of its time, and sometimes it determines them, as is the case with globalization. As far as method is concerned, it must not be separated from the laws of history, nor from the laws of nature, although we can notice how scientific objectivity is substituted, slowly but definitely, by an entire literature of non-verified and non-verifiable truths. A new economic science is being configured through the works of Graham Wallas (*Human Nature in Politics*) and R. H. Tawney (*Religion and the Rise of Capitalism*)— both Weber’s successors, and through the works signed by M.I. Ostrogorski, Robert Michel, or Charles A. Beard.

Two thirds of the population of India, i.e. 800 million inhabitants, live on less than two dollars/day, yet all estimates converge towards the idea that within a generation, India will equal the United States in terms of GDP. Economy undergoes a process of self-revolutionizing, whose main engine of growth is demographics, in obvious contrast with Malthus’ theories. History is made by simple consumers. If

¹(from History of Money. The Emergence of the Businessman during the Middle Ages, Bucharest, Artemis, 2012, p. 9).

history has a meaning, this meaning is now consumption. The latter could eliminate war and achieve universalist utopia. Called upon by the project of a global economy, economists descend in the analysis of peripheries, of the behavior of the masses and of marginal groups, by accepting the first suggestions of cultural anthropology, by accepting to research what pertains to the invisible as well: energies, the imaginary, behaviors, mentalities, the psyche, sensibilities, representations and so on, vague terms based more on the unconscious latch and on the functions of the unconscious.

Holistic *patterns* are imposed in the study of the economy, and even symbols, in which the question and the answer, the path and the goal, the search and the finding are presented as embracing each other, just like in Daoism. As Jung argued, symbol is the best description, or formula, of a fact. As I signaled on another occasion, it is necessary to have a new gnosis; nothing occurs by chance. Economics approaches this so-far “mined field” rather timidly, but definitely. It probably feels that irrationality is looking for the code to de-mine and decipher the respective field. Thus, economics becomes a sort of psycho-economics, whose main active agent is, probably, the collective unconscious. Considered in context, economic spaces become some characters who perform in a planetary play, and social preoccupations decrease in importance, while the relevance of symbolic and cultural concerns increases. Or, as Nietzsche argued, “any culture is a network of myths”. The imaginary perceived by Le Goff will allow our access to much more satisfying realities, thanks to changes that were made possible at the level of mentalities. The history that we live is derived from myth, but it can also become its drifting apart, a “fantastic transcendental” form (Durandin).

Beyond any shade of meaning, latest evolutions indicate the confusion of positivism and its porosity to the unseen. By perceiving time as present continuous (Eckart Tolle), we can capture the unconscious structure of each institution. Behind the busy history of the economy, of governments, crises, markets, famine, one can see apparently immobile histories, for they are histories which repeat themselves cyclically. There is a subconscious history, which endures in time—what Braudel was about to notice by analyzing long terms, but he missed it. Moments of rupture, such as revolutions, are cases of psychic delirium. As Emmanuel Todd argued, their progress generates regress. The dawn of modernity is marked by psychic phenomena par excellence. Economics must accept the huge role of the collective unconscious, its functions, as well as the role of the imaginary, of mentalities, of energies. Great economic events are the result of archetypal disputes, of canonic fault-lines, following “lines of meaning”, of which ideas and images give a more precise account than the events themselves. The unleashing of the revolutionary spirit cannot have rational explanations.

The orientation of economics towards the Psyche is not disconnected from the explosion of the irrational, which accompanies great ruptures, though it is not always an orientation towards *fides* as well. This is the only way to break the code of modernity, which makes it possible to identify its causes and evolution. The exploration of the human psyche, the study of behaviors, of sensibilities and representations, can only bring benefits to economy. No will and no consciousness, irrespective of how vane it might be, can pretend to control the true meaning of *homo oeconomicus*' behaviors, choices, decisions and deeds, performed together with his emotional, codified avatar. Meaning is always younger than the event (see Jean Mary Vaysse, *The Unconscious of the Moderns*, Bucharest, Ed. Trei, 2004).

History itself challenges us to reopen the classified files of economics for the later

has “bitten” from the human species. Through mentalities, behaviors and ideas, man continues to be a gatherer, a cultivator, a tamer, a hunter, a warrior, a conqueror, a magician, a priest, a nomad, a sedentary and, especially, an interlocutor of the God and a contemplator of heavens. Via images, words and action, we are forever re-actualizing original scenarios so as to defeat the existential anxiety of our time, by creating a space to breathe, in which humans live the experience of survival.

There is no unique meaning, nor a definite meaning in this world. Man explores ambivalences (Yin-Yang), analogies (“what is above is beneath as well, what is in something large is in something small as well”), the correspondence in a present that is continuous (the Stoics) and accomplice of beginnings (the natural order), by metabolizing the terror of linear time through fictive or virtual narratives. In comparison with the quantifications of economics, the vague, the sensoriality, the polyphony of reality capture the emotional, feminine slope of the unconscious, the perspective of the heart, its sight which makes facts transparent. The femininity of economics fulfills the function that corpus callosum has in the cerebral structure, i.e. to connect specialized, discriminant hemispheres, which can offer a better understanding of unity, of the world as a whole, as the disposition to create a cosmos, to bring order to this uroboric *unicum*. The feminine is capable of much more compassion towards man.

The feminization process changes formal logics and forces us to be trans-disciplinary, or at least to accept the included third party and the levels of reality. A woman can easily offer forever different answers to the same question, or a single answer to several questions, cannot she? And then reality will surprise us less with its crises, which we have attempted in vain to formalize. The truth is something more profound than its historical variant and it cannot be captured only with the help of reason. It requires more intuition, the valorization of emotions, and vision, all annexed to duration, to the qualitative, circular time and not to the devouring, linear time that overwhelms us with events. This is how the structures of the collective psyche—the real *homo oeconomicus* that can make both the past and the future productive in the present—get activated. This economic agent highlights the nature of power and of institutions in the most realistically possible way. It is meta-social, the very *topos* of the emancipation of individuals and communities.

The community spirit is patronized by the archetype of the feminine, which is the most seductive and probably the most capable to control the social body. At the same time, it is also the most familiar to democracy; it bears the memory of man’s first settlement in history, in the first communities, as well as of the first feminine revolution: agriculture. Ideologies are—on the contrary—myths confiscated by the masculine archetype, rationalized myths in the service of power. Ideologies emerge when economic and social actors decide to become directors. In fact, they become the prisoners of another unconscious myth, apart from their will and consciousness. No one can ever escape from such an archetypal prison service, except through Trinitarian revolution. Those who do not try to be worthy in their endeavors towards the mystery of the Trinity remain subjected to all types of dualisms.

8.2.1 Myth—the Revelator of the Unconscious

The myth is the revelator of the non-will and non-reason of man and of communities. Through it, history becomes bearable; it acts as a buffer against the siege of time; it captures unconscious pulses and transforms history into “natural order”,

as divine order that has been socially transposed. Un-historic, non-objective and universal, myth founds the universals of culture and translates the ecumenism of symbolic thinking from the vast realm of the unconscious, where lies our best part, the protective and inspiring matrix. Economic performance is based, first of all, on man's psychic virtues. The latter are forms of capital. Symbolic thinking deals with the patterns in which economics rests, within which events are distributed and redistributed as if attracted by a natural magnetism.

Similitudes between the economic cycles of communities, the synchronism of discoveries and the evolution of arts, indicate an undergirding complicity in the underground of human communities, the existence of a common calendar of the human species and the working presence of some archetypes of the collective imaginary. Behind the visible history, there is an entire meta-structure that orders, sets everything into harmony, in continuity or synchronicity, while giving all surface things a direction of movement. Ideas and projects are, first, spontaneous creations of the unconscious psyche, which escape the control of will. They are pure nature. They indicate the truth, in agreement with our deep nature, which is as perfect as an unwritten number, when our consciousness has steered away too far from its fundamentals and has thus hit a deadlock.

The mythical is the reflection of the psychological beyond the personal level. Blocking or forbidding the myth can cause terrible damage in the existence of communities, from neuroses to biological death and social implosion (see the case of communism). Ideologies pegged on utopic structures (the case of Nazism) represent myths confiscated by force and put in the service of the masculine archetype, of power, force and violence and that were imposed to communities, ages, individuals. Their intolerant nature attests their deviation. The map of the human genome comprises 3.2 billion chemical components, of which 99.99% are identical among all individuals. Consequently, human diversity unfolds within the remaining 0.01%. Here lies unity! This is the "invisible hand"! Thus, human activity becomes ordered and intelligible to everybody.

8.2.2 The Engagement of the Conscious with the Unconscious. The Erotization of the Relation

H.-R. Patapievici justly warned us that we should always consider the seen and the unseen, the consciousness and the unconscious, together, because this is how they are manifest, as in the engagement of spherical and linear time, as in a repeatable cycle of births and destructions, of re-births and re-forms. It is only together that we can enter the "eternal eighth day" and acquire the means of salvation, for this is the purpose of any human activity.

The psychologization of the world, and in particular of the economic world, can offer an urgent and vital answer to our anxieties, to our anxious ek-sistence, brought about by the terror of linear and finite time, by the memories of the original sin and of the Fall, by the despair to understand faith etc. One can live much more peacefully in eternity. One would make long-term investments and saves, and behaviors would become more rational. It is only under the burden of the ephemeral that the irrationalism of history, pathos and its various apocalyptic scores can be understood. *Obscurum per obscurius.*

The psychologization of history translates the recognition of the emergence of the feminine principle in a world quartered in the concentration camp of another

archetype. Man returns to the bosom of Mother, of the goddess, where he rediscovers love, the true connector of the universe. The religious man is thus recuperated, but in a trans-doctrinary religiosity, in the esoterism of religions. We call this a reconstitution, a renovation, a renaissance of a tradition in which equal participants are the Greeks and the Romans, and the Bible. It heavily relies on intuition, on the imaginary, on symbols, myths and archetypes, which meet a responsible necessity and have the function to uncover the most intimate secrets of being. It penetrates towards the Creator through the creation, in full harmony with the laws of creation, with the laws of nature. The praise of creation is the praise of the Creator.

It is a vocation of our culture to look beyond the surface of events for deeper and ultimate significations, and to express them through symbols. This is Goethe's dream to fly beyond the image.

8.3 Conclusion

Actually, the dividing line between mythos and logos is imaginary, which means that we can talk, without any problem, about the logos of myth. The history of humanity starts with the logos. It is a project of God—therefore a mystery, a divine work of the Spirit, which takes the shape of a cosmic destiny. This is the creationist or transcendentalist approach, which is opposed by the evolutionist, immanentist approach. Logos and Eros express the two irreconcilable approaches, the sacred and the profane. However, I believe that the two are intertwined in a form of co-working. It does not seem too daring to me to argue that God has created evolution as well, as in Hindu metaphysics.

If history has a meaning, then economics has meaning as well. It is a theognosis. By exhausting the paths of mundane, rational knowledge, or by noticing their insufficiency, we have undertaken an attempt to explore the unconscious, what can be known via myths, symbols and archetypes. The unconscious is a larger and less known, yet omniscient, part of our nature, which has much to offer to knowledge in general, and to economic knowledge in particular. We have thus suggested a psychologization of economics, which could explain many mentalities and behaviors that ultimately generate economic facts. Psychology also contributes to the economy of our salvation.

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CHAPTER 9

Deal with Complexity and Risk in Professional Relationship: The Transdisciplinary Logic

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If the individual is a black box, an encounter is a risk that has to be managed. In everyday life, no one stops to think about relationships. Unless they serve an intention that “is not self-evident”, that makes an unusual emotion emerge. Do we think about the way we say hello to a colleague, unless we intend to get something from this “hello”? The transposition of the human relationship in the professional environment leads to a change in the reality level: putting on the clothes of a character and playing his part in a logical context that serves the aim and the plan of the organization, that itself is under the pressure of a demand that is quantitatively insatiable, and technically extremely demanding. Since the creation of wealth does not rely on an open-ended honey pot, de facto, the performance requirement becomes both an individual and group concern. The organization performance cannot suffer from the excessive variableness of the professional character's reactions. Paradox among the paradoxes, getting the best out of the relational potential of a system that is organized, focused, constrained, would then consist in establishing an evolutionary relational framework to control, without killing it, what, out of the professional environment, comes within what is uncontrollable and spontaneous. How then, can we deal with the complexity and the risk in relationship, leveraging the transdisciplinary logic?

9.1 Dealing with Complexity and Risk in Relations

9.1.1 Ordinary Complexity and Risk in Relationship

Complexity, What Do You Mean?

He who doesn't try to define complexity never meets it! Complexity is a fashionable buzzword, disturbing as well as convenient, often used inappropriately to refer to a problem as hard to work out as to solve.

In fact, complexity is radically distinct from simple, identity-related, defined, driven by norms, governed by the standard logic of single causality, linear, non-contradictory, anchored on a unique reality level.

Non-normative, illogical, evolutionary, rich and diverse, unstable, unspecified between the two poles of a contradiction, never reaching exclusively one or the other, ... tuned into at least two reality levels, complexity is indefinable ... at best complexity can be illustrated. The universe, the living, the human and his relationships, the thought, epitomize complexity: The individual is both – at the same time – this and that: open and impenetrable, adaptable and limited, contextual and identified,

self-sufficient and dependent, individualistic and systemic ... more or less according to situations.

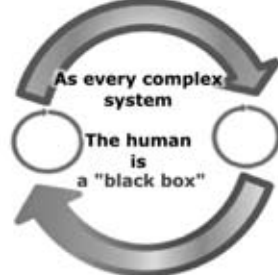
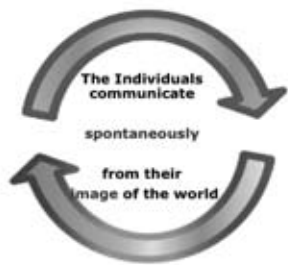
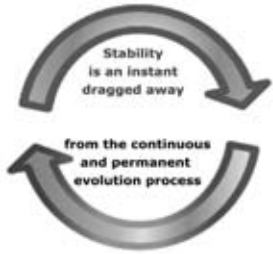
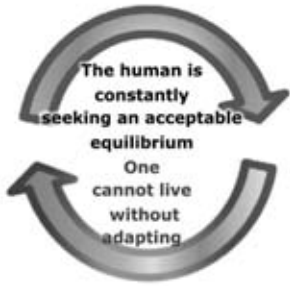
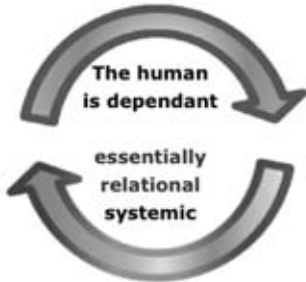
The Human is a “Black Box”

More than any other complex “system”, the human is a “black box” and nobody knows how the situation will be “digested” and what it will lead to.

Clever, sensitive, reactive, affective, emotional, relational, varying depending on context, the human is intrinsically variable. He looks at his life pursuing its course behind the scenes of his field of vision and through the narrow window of what he has learnt, as if he was producing the world without seeing himself acting and interacting in it? Deprived of his own image, of his external voiceprint, more or less conscious of the impact of his presence, of his contribution to the creation of reality, the human dreams of himself under all circumstances. The way he would liked to be looked at, the way he thinks he is expected, hoped, the way he sometimes idealizes himself, hoping that this will secure his most vital links. “Driven” by his emotions, the individual acts and reacts constantly to go beyond the initial antagonism between the mental and what moves it, at the same time tuned into his complexity, unable to master it, and into his wish to succeed in doing so. And sometimes he deludes and avoids himself, so that his is not disappointed by himself or to protect some of his illusions and utopias.

An Encounter is a Risk That Has to be Managed

If the individual is a black box, an encounter is another one! Relationships are vital for the dependent beings that we are, they are quasi-instinctive, since they are essential, natural and spontaneous. Rarely identified as an activity, even more rarely as a skill, the relationship is intimately linked to our person, at least to what our behaviors unveil about it, depending on contexts.



In everyday life, no one stops for a while to think about one's relationships. Barring a specific circumstance or difficulty, barring a notable change, unless one serves an intention that "is not self-evident", that makes an unusual emotion emerge. Do we think about the way we say hello to a colleague every morning? Unless we intend to get something from this "hello"? Then the relationship leaves its routine context to become strategic, and it obeys to another thinking logic. Whatever the issue then, the amazing thing is to see how the relationship activates the emotional potential of every individual, as if the encounter, in a very archaic manner, was activating basic fears.

Does the relationship carry the risk with such a load, and is the danger involved, whether real or symbolic, that vital? It is as if, being only through his relationships, the individual was symmetrically giving to them the power to annihilate him?

Indeed, the unknown can be destabilizing, and the unknown is the initial factor of an encounter. The variableness of the components of the context being infinite, the encounter between two individuals will always happen in a new context which will make of every new encounter "a first time", ... who would pretend that the weather has no influence on the mood of the protagonists?

Moreover, is there the slightest hope of control on the events beyond their statistical predictability and their approximate modeling? The immanence of the renewal of things, characterized by the illogical, the multifactorial, the unpredictable, the unstable, the discontinuous, the ephemeral ... does not allow sure transpositions, knowing that "other things can never be equal".

The unpredictability of an encounter is necessarily dramatized by the relational antagonism that prevails: will the interlocutors find a way to accept each other and let the dialog settle? The initial issue in every interaction lies in the consideration that they grant to each other from their own person, each one of them aiming at the confirmation of the self-image he or she wishes to "defend", and of the behavior that could flatter him or her in this situation. At a level at least compatible with the uncertain representation he has of himself in a referring circumstance.

Once the recognition step is over, the encounter comes straight to uncertainty, fate, risk, inherent to the confrontation of the sensitivities, visions of the world, points of view, convictions, of the characters and of the persons they shelter. The system made of the two present interlocutors has all the characteristics of a complex system, and of course it has its own emergent properties, (sensitivity, efficiency, equilibrium level, etc.) that appear only afterwards. The reciprocity involved, the inner regulation process of each one of the protagonists more or less consciously actualize their emotional state, their assessment of the situation, serve as a basis of their discernment that, consequently, induces their adaptation responses to the context. With this permanent double adjustment movement, a relationship has to be managed as a risk. Assumptions and bets, careful provocations, precautions, questioning and validations, appear in the interaction. Consequently, knitting the relationship presupposes the flexibility, the mobility in the relative positions, the agility that allows to go from one reality level to another in order to reconcile the points of view.

Language is a Complexity Factor

In an interaction, language (we should say languages) is a media that creates a gap between the observed tangible – what happens and what spreads out for each

interlocutor – and what the communication renders.

The meaning of the words, the temporal interval, the memorizing of a frozen snapshot dragged away from the continuous and permanent actualization of the world, the person interpretation via their various characters and their contextual logics, the various reality levels that are used, determine the way things are worded, absurd and paradox being emerging figures of this.

Consequently, every agreement is based on a misunderstanding since anyone spends his life communicating from what is, in his view. From what the languages encrypt and distort, sometimes on purpose, in favor of a reassuring though sometimes unsatisfactory intersubjectivity.

9.1.2 A Professional Organization is a Complex Relational System

The Professional Relationship Complexity

A professional group is a key element of the economic and social system, central player of the adaptation of societies and place of integration. Workers, employees, executives, make up the “social fabric”. This grouping of individuals without any prior reciprocal affinity predispositions, finds its *raison d’être* through the individual necessity to earn one’s living, under the pretext of a collective aim that promises wealth.

The transposition of the human relationship in the professional environment leads to a change in the reality level. The professional relationship complexity covers new issues for the person: putting on the clothes of a character and play his part in a logical context that serves the aim and the plan of the organization. In particular, in certain contexts, adopting “unassumable” positions in a private situation.

The Professional System Puts Some Pressure on the Relationships between the Individuals

Every professional system controls the interactions between its elements, on various levels simultaneously. After a frenzied contractualization, the entity synchronizes its piloting system and the evolution of its countless reference frameworks to which its activity relates: national or international framework, economical framework, intellectual framework, scientific and technical framework, social framework, political framework, legal and regulatory framework, financial framework, etc.

The collaboration between an employee and their employer is defined by the employment contract: whether a date of “natural” ending exists or not, the presentation of the mission and of the actions to be undertaken, the notification of the relationship of subordination, of the rules of discipline ... Playing the game, the employee must take on objectives, submit to the assessment of their contribution, put their spontaneity and free will between the parentheses of their action. In this lies a major and permanent complexity factor of the relationship between the organization and the employee: how to deal with the last identity references of the individual – his emotional potential, his difference, the urge to establishing himself as a thinking personality having the power of controlling that personality – and the necessity to get a positive collaboration from the person?

How everyone will find a mean of establishing with their peers relationships that are constructive enough to meet the aim of the organization, the ambitions of

its founders, creators, investors. Granted with the prerogatives, the insignia and the attributes of his office, will they go as far as to embrace the designs of the organization, thus finding again what they abandoned of their power and freedom when they signed their employment contract?

From these relationship modalities, basically depend the performance of the group, the quality of its products and of its results.

The Professional Relationship in the Shadow of Tabus

The relationship remains taboo in the professional sphere, for the same good and bad reasons as in the personal life. Enough to be overshadowed or often brought up “indirectly”, as a potential issue that has to be kept secret so as to avoid hindering the achievement of the collective plan.

Not being a calibrated, defined, standard and interchangeable supply that can be shaped, the relationship IS FRIGHTENING: potentially carrying some form of judgment, blame, criticism, divergences, seat and vector of the emotions that the professional character would like to master or to deny, since the “moods” in a professional environment can be damaging, even more so than getting angry ... or not assuming enough a distinct identity.

The relationship remains a synonym of out of place affectivity, femininity-related, and feared because of its potential dangerousness in case of demonstrated intrusion. Moreover, noteworthy is the fact that the words “influence”, “relational strategy”, “opportunisms” are most commonly linked to a negative intention, or to a strategy of ... inhumanly efficiency.

Conversely, the relationship is sometimes experienced as fascinating and very intellectualized: seeing through the interlocutor is the ultimate power of those experts “who know”, and the insignia of recognition of “the initiated”. “Position”, “pathos”, “affect”, “search for meaning”, the medical vocabulary of the deterministic pathologic labeling is often used by the “informed” manager.

9.1.3 Augmented Man, Increased Complexity?

Augmented Man

The end of the world’s bipartition has brought us back to its wholeness et to the explosion of the demand for comfort. Doing away with lots of limits, the incredible train of progress creates new boundaries. Contradictions and tensions move, giving rise to new bipolarities, seeds of the dynamics of the infinite renewal of things.

Speed, dematerialisation, digital technology, information technology, medias, planetary and satellite interconnection networks.... The consumer expresses a demand that is quantitatively insatiable, and technically extremely qualitative.

The advent of a second world, virtual and interconnected, stands in the way of what is tangible, disrupting the relationship between the human and their environment, denying separation, transcending the body limits, challenging the questioning that was previously expressed about reality. Armed with usurped powers, the individual extend himself by fusion – confusion – of the biological and the technology, of his own intelligence and of an added artificial intelligence, relegating any “corporal consistency” of himself in favor of the image that he projects on the screen of life. Where is the beginning and the end of what exists? The faster we go, the less time

we have, and how can we gain even more time? Deemed time-consuming, complicated, old-fashioned, the human relationship is sometimes treated on the same level as the dematerialized information transmission, in the name of convenience, speed, and a cold “efficiency”. When will quantum computers, teleportation, appear?

Increased Complexity?

The objects from daily life, co-authors of ordinary life, trivialize the feats of technology, as much by their functional accessibility as by their more than advanced home features. More and more integrated by medical intervention, the embedded technology leads the user to assume spontaneously the capabilities, promoting the value of an extra extraordinary that must be constantly reassessed, participating in the imaginary extension of the persons and in the inflation of the characters that they play.

How can the “augmented man” resist to the pressure et to the magnetic power of progress that haul him up to performance level which remained unreachable until now, validating the illusions and the utopias of omnipotence, that lead to the negation of obstacles, effort, and frustration? Consequently, how the individual could abandon the idea of maximizing simultaneously the yield of his various social positions, sometimes antinomic, with no concessions to the uncertainties of complexity, to the interdependence, to the risk, to the reciprocity of the commitments, henceforth too “burdensome”.

9.1.4 The Professional Organization Faced with the Demand of “Augmentation” of the Customer

The Customer’s Law

It is impossible for a professional organization not to meet the requirements of the customer, its growth driver above all, its employee also.

The periods when a balance exists between supply and demand are shorter and shorter, if any. The way the customer anticipates plunge the enterprise in an uncontrollable racing to feat. “Once and for all” is an expression that has disappeared. Failing to anticipate the advances in science, what professional group can content itself with being a “follower”, or with playing minor parts?

The “Economic Intelligence” is Relational

Innovation, urgency, fund raising, return on investment are the key words of the economical and globalized piloting. In turn, to face these challenges, the “professional organization” can only behave as a tyrannical user, greedy for the resources that give it the power of creation.

At this stage in our evolution, the human resource might be more than ever the key to performance. Any marginal progress mobilizes transdisciplinary and transcultural skills, that only a “smart” cooperation can combine, arrange, juxtapose in the service of the objective. Solutions appear due to the confrontation of the specialties, skills and capabilities, the relational ability fostering the strategy to which the flexibility, agility and mobility contribute. A collection of great minds not having a good manner with people is outdated. Operating with a “relational economy” do not bear fruit anymore. The “economic intelligence” is transcended by doubt and relationship.

Change cannot be considered as a transient temporary state anymore. Adaptation, change, renewal, those terms eventually join to form one body with the operating cycle of the professional organizations, this cycle being itself fully conditioned by the market demand. Of course, the managerial practice is all the more claiming all the attention since the renewal cycle is short. Change requires a close presence, both regulating, supporting, and also, with a special responsibility. A manager solicits his teams like a project driver does: in an ultra-constrained framework in terms of resources, timeframe, risks and quality. He's got to deal with the global complexity, in a context of the world competition, embracing vast and deep technical fields, he's got to take on the daily whirl, relying on "responsible", "useful", "efficient" relationships.

Thus, the professional system must be open, in a waking state, able to capitalize on the dynamics of antagonisms at every level to feed its mobility and its adaptability. Likewise it must be able to rely on a "conductive" internal relational fabric, taken over by efficient infrastructures, fed by an ordinary creativity and by the opportunist collaboration of all its components, in relation with the potential of the context. The quiet, efficient creativity, lodges itself between persons, in the solidarity to which constraints, obstacles and difficulties give birth. In the reciprocity also, in the open-mindedness that encourages the expression of doubt, the exposition, the basic risk taking, the doubt that leads to confrontation through a learning approach based on experimentation and adjustment.

9.1.5 Piloting the Professional Relationship

Since the creation of wealth is not a matter of transcendence, and does not rely on an open-ended honey pot, consequently the performance requirement that is placed on the shoulders of the managers becomes both an individual and group concern, for a primary and simple reason that should be kept in mind: the distributed wages are debited from the wealth that is collectively created. Consequently, a professional group cannot rely on the uncertainties of the interpersonal affinities to succeed, its objective not being to change it into a vacation club but rather to encourage the establishment of Responsible, Useful, Efficient relationships.

Minimizing the Variableness in the Relational Performance

The organization performance cannot suffer from the excessive variableness of the professional character's reactions, this character being himself under the confusing influence of his own person since in a close interaction with this person. Even if an employee under contract is bound by the constructive reciprocity of his contribution to the result. Eventually, the multiplicity of the interactional levels and the variableness of the associated behaviors, combined to the fate of the occurrence of events, could expose a professional entity to a near-untameability of the relationships among its elements, and consequently to a global loss of efficiency.

Both creation and achievement need a relational base that is predictable enough to ensure the right level of confidence allowing for the risk taking and the fertile cooperation. A professional team does not get the same results when it is led by a manager or by another one, a manager's action does not produce the same efficiency with a team and with another one, in an organization or in another one. With the same resources and the same manager, in another context, a team will not

achieve the same results. The multifactorial variability of the output is less and less acceptable, even less that it must be approved by the finance.

Paradox among the paradoxes, getting the best out of the relational potential of a system that is organized, focused, constrained, would then consist in establishing an evolutionary relational framework to control what, out of the professional environment, comes within what is uncontrollable and spontaneous. Indeed, an additional reference framework, but also a space into which the characteristics of the individual and global relational efficiency could fluctuate with no impact on the result quality. Accurately and firmly controlled, the individual creativity can then express itself through a personal interpretation of the office, while preserving the necessary leeway ensuring the minimal fulfillment of the individual.

A permanent Reading of Contributions

Getting the Relationship out from its Obscurity

Exposing the relationship as a capability, an activity, a skill that is perfectible, both related to identity and strategy, opens the doors of new possibilities for anyone. Consequently less experienced as a deterministic factor than valued as the central potential of success, the relationship can be considered as an individual and collective development project, out of the judging or frightening framework of the moral if not pathological labelling.

When this happens, the irrational nature of the relationship can be softened if its ternary dynamics and the energetic emotional load that can be exploited, are put into light. But this does not mean that the relational risk has been swept away, on the contrary. It can be managed in a responsible way like any other risk, especially as the source of an antagonism between the best and worst, that, according to the occurrences and the context, can emerge under its conciliatory form.

Such an exposition of the Responsible Useful and Efficient relationship would allow a kind of control, and would make anyone accountable for the piloting of their activity. The objective being to put into light the creation potential of the exchange, to get the best of it in a very pragmatic way by dealing with all the aspects of its complexity.

A Process

To achieve this, eventually, one should establish a reference process that would focus on the permanent regulation of the “professional relationship efficiency”, identified as strategic before any other, carrying the characteristics of the relationship into the limits of a variability that is appropriate to the organization’s requirement in terms of results. Even though the management processes are the least formalized, no doubt that placing officially and explicitly the relationship efficiency at the highest ranking of the key processes of an organization, means a lot. From an incentive and strategic perspective, it would even be wise to outline its objectives and to make of it a criterion for appraising the individual performance.

Concomitantly, the exposition of individual and collective development objectives, would draw in the landscape of the system the conception of an ever possible improvement of the cooperation.

Aiming at a Responsible Useful and Efficient relationship, means establishing a structural characteristic that extends to the whole system, all levels and all stages

of the completion of the product or delivery being taken into account. Establishing efficiency as the main thrust, as being an integral part of the social contract of the organization, can only lead to a spirit and to behaviors that foster in the long term the adaptability of the system and of its aim.

9.2 A Transdisciplinary Logic to Deal with Complexity and Risk in Relationship

Nowadays, the words objective, result, speed, and profitability, structure the way a manager expresses himself. How to answer these injunctions when dealing with the human relationship, its dilution and its mediatization, its contradictions, its emotional and affective components, the urgent constraint for adaptation and change, the necessity to reconcile multidisciplinary and multicultural points of view...?

9.2.1 Elements of Logic

The Logic of the Included Middle is Transdisciplinary

Complexity has its own logic. Dynamic and pragmatic, it focuses on the interactions as a determinant of any system, of its characteristics and of the results it achieves. Applied to piloting the relationship, especially in a professional context, the logic of complexity allows to avoid the traps in communication, to deal with constraints, and to go beyond lots of resistances and relational problems. It allows to go from what is potential to what is actual. The logic of the included middle is ternary, transdisciplinary (see Figure 9.1). It includes the standard logic, uses the properties of systems, leverages the adaptation and regulation dynamics of cybernetics, deals with non-normativity, contradiction, paradox, or ambiguity.

The logic of complexity, also called logic of the included middle is the logic of conciliation. It is especially efficient to allow the change of individuals and groups. The aim of the following is to highlight the inner workings of the logic of the included middle in order to suggest some relational piloting tools that are easy to implement, and efficient in “almost all” situations.

- The logic of the included middle allows to get out of the destructive relationship between the 2 poles of a contradiction, through the simultaneous existence, at another reality level, of a singular Third (middle) within which the opposites coexist, without merging and without totally excluding one another¹ (see Figure 9.2).
- A reality level is “a set of systems invariant under the action of a number of general laws”. From a reality level to another, “there is a breaking of the laws and a breaking of the fundamental concepts”².

For instance, in the professional relationship area:

- valuing the doubt as a resource / wanting to be right despite all opposition;

¹Bulletin Interactif du Centre International de Recherches et Études transdisciplinaires no: 14 - Avril 1999.

²“Qu’est-ce que la réalité” Basarab Nicolescu, Editions Liber, 2009.

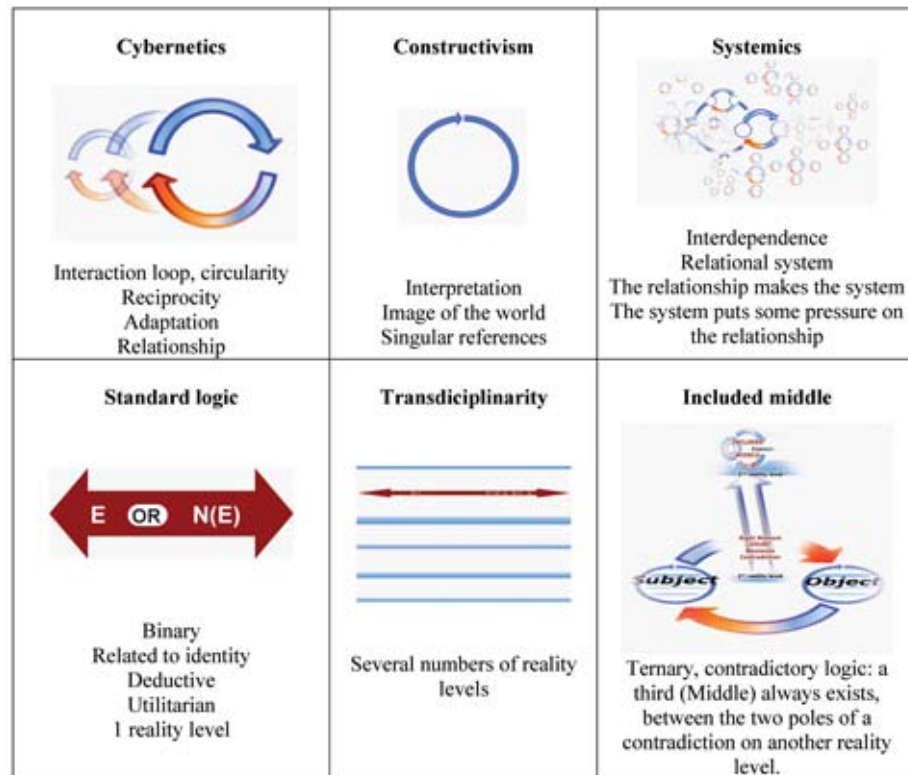


Figure 9.1: The logic of the included middle is transdisciplinary.

- dealing with the vagueness, the uncertainty and the unpredictable / acting only when there is no doubt;
- trying to be useful and efficient / seeking objectivity, neutrality, truth;
- choosing one's responsibility / being subject and executing;
- using gaps as a support for constant adaptation / pointing mistakes and sanctioning them;
- being future- and solution-oriented / seeking the causes ...

The logic of the included middle is ternary and dynamic, iterative; it considers at least two reality levels (see Figure 9.3).

- On one reality level, the 2 poles of a contradiction obey to the antagonism principle: the actualization -A- of one of the poles drives simultaneously the potentialization -P- (repression, latency) of the other, which never disappears.
- The 3rd pole emerges from the reciprocal relativization of the 2 others, among all the intermediate degrees of the actualization/potentialization, to a perfect, rigorous equilibrium, at which the two opposed actualizations cancel each other

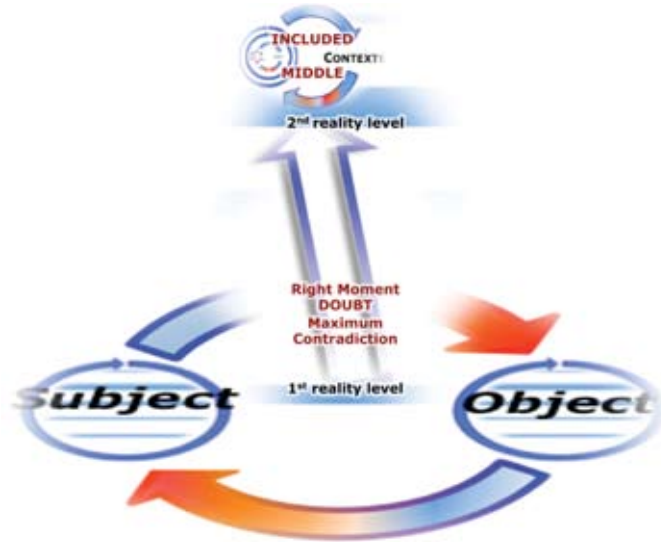


Figure 9.2: The logic of the included middle, is the logic of the conciliatory option.

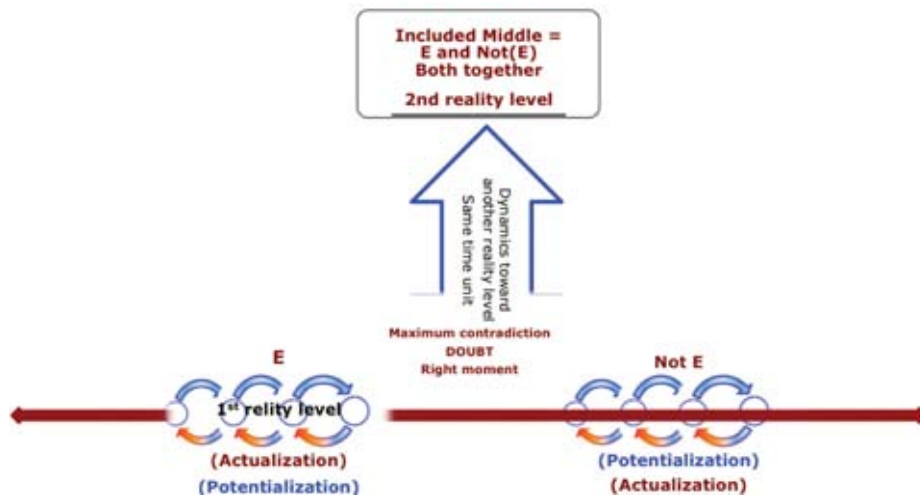


Figure 9.3: The “3D” relation.

out. Maximum antagonism point between the two opposites, the 3rd pole is consequently the place where the doubt lies, the right moment, the dynamic basis from where, at the same time and on a second reality level, simultaneously emerges the Included Middle that brings together the opposites without merging them. (Cf Basarab Nicolescu)

$$\mathbf{A}(E) \text{ OR } \mathbf{P}(\text{Not } E) \Rightarrow T=(E) \text{ \underline{AND} } (\text{Not } E)$$

The Logic of Complexity Includes the Standard Logic

- The standard logic is analytical, deductive, utilitarian, efficient to understand the mechanical progression of the sequences, the breakdowns ...
- Single causality logic, the standard logic is binary, linear and related to identity, it considers a unique reality level. Also called logic of the Excluded Middle, it is based on the premise of non-contradiction, which excludes the simultaneous existence of the two contradictory aspects of one element. Unless it creates a paradox or an absurdity whose only way out could be the reciprocal destruction of the two struggling poles of the contradiction.

It excludes the existence of a middle between two contradictory terms.

The Logic of Complexity Leverages the Systems Theory

- The human is relational, systemic.
- The individual related to his environment constitutes an open system, that is organized, self-regulated, basic.
- The relationship is omnidirectional and multifaceted (multicausality and equifinality).
- Every individual is an element from many systems at the same time.
- The relationship makes the system on a second reality level, with characteristics and singular achievement capacities which differ from those of its various components on the first level (see Figure 9.4).
- Reciprocally, the system controls the individuals to maintain an acceptable equilibrium, given its own constraints.
- Every system is a system of systems.
- The interdependence “produces” the butterfly effect.

The Logic of Complexity Leverages the Dynamic, Iterative Principle of Cybernetics

- Information makes relationship.
- One cannot live without communicating. In itself, presence is communication.
- One cannot live without adapting.
- One cannot live without influencing.
- Information and reciprocal adaptation answer, follow different thought progressions and make up the interaction loop.



Figure 9.4: Elements in relationship make a complex system on a second reality level.



Figure 9.5: Reciprocity, interdependence in interaction loop.

- In an interaction, at best the issuer controls the information they send to their interlocutor.
- Reciprocity structures the interactional face to face: no one can evade his/her responsibility (see Figure 9.5).
- The relationship is built through the sequence of interactions, from regulation to adaptation, from one change to another (see Figure 9.6).

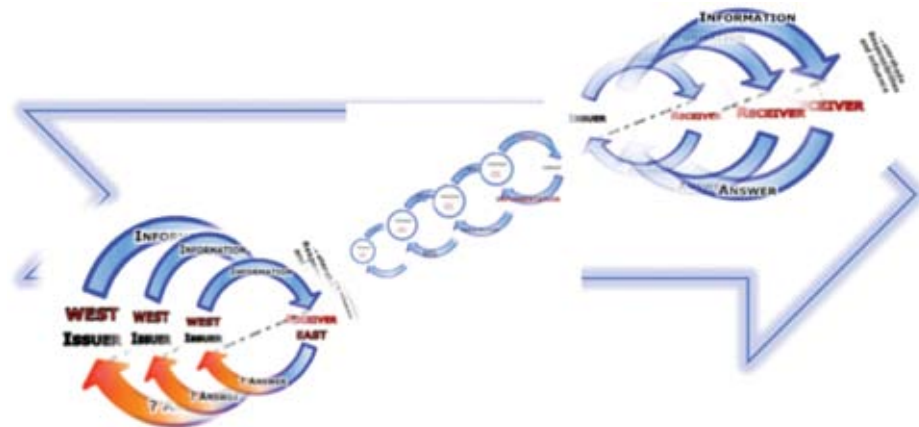


Figure 9.6: continuous adaptation, and change from one reality level to another.

The Logic of Complexity Deals with Non-normativity

- One cannot live without interpreting.
- Truth, objectivity and neutrality are subjective constructions, without normative opposable value.
- Subjectivity echoes non-normativity.
- There is no absolute normative reference, opposable whatever the context.
- The reflexive skill refers to reflection, imagination and self-concern (see Figure 9.7).
- The human doesn't see himself acting, he has no conscience of the mark he leaves, he dreams of himself the way he would like to be seen, he deludes and avoids himself
- The "intellectual" area is the one of all possibilities, of theory, abstraction, imagination ... as well as of rationality, will, and control.
- The world of reflexivity goes round in circles, in a tendency to be self-sufficient.
- Language mediates, encrypts, creates a gap between the tangible and the rendering of it (see Figure 9.8).
- The individuals communicate reciprocally from their interpretation of the world (see Figure 9.9).



Figure 9.7: From world experience to the internal reflexive image of the world.

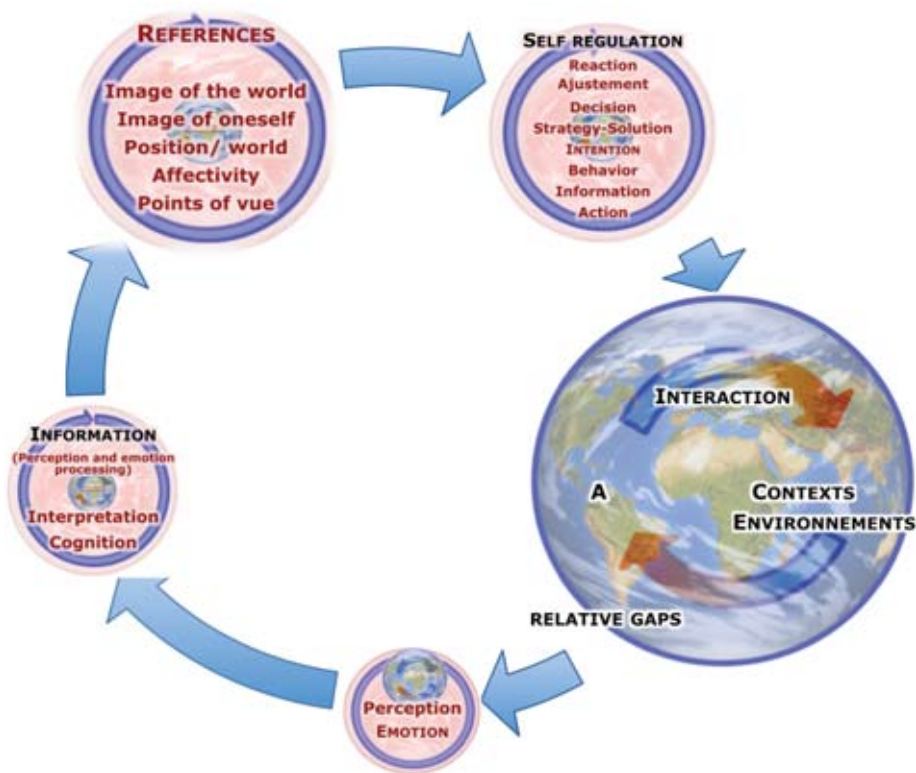


Figure 9.8: Reflexive process of creating the image of the world and behavior.

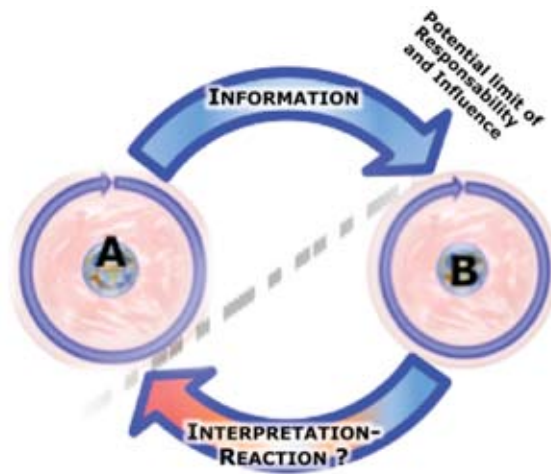


Figure 9.9: The reflexive loop and the interactional loop feed themselves reciprocally.

9.2.2 References and Supports in Piloting the Professional Relationship

Three Piloting References

9.2.2.1 Sample Founding Changes in the Reality Level ⇒

- shaping the strategic relationship / relying on the uncertainties of the contextual variations;
- making complementary what is contradictory / fighting against, conflicting, creating dilemmas;
- valuing the doubt as a resource / wanting to be right despite all opposition;
- dealing with the vagueness, the uncertainty and the unpredictable / acting only when there is no doubt;
- trying to be useful and efficient / seeking objectivity, neutrality, truth;
- choosing one's responsibility / being subject and executing;
- using gaps as a support for constant adaptation / pointing mistakes and sanctioning them;
- being future- and solution-oriented / seeking the causes;
- aiming at minimal relevant objectives / aiming at excellence at all costs;
- adopting the efficient relational strategy / doing psychology;
- combining reflection and action / becoming aware without taking action;
- replaying an unsatisfactory interaction / what is done is done.

9.2.2.2 Aiming at a Responsible Useful and Efficient Relationship ⇒

- practicing pragmatic empathy, inducing useful and efficient reciprocity;
- focusing on the interlocutor, seeking his/her logic, aligning his/her answers in order to pilot the dialog;
- agreeing on action references that are explicit and relevant in the context, aiming at minimal objectives;
- putting relational strategy in the service of the result, using the potential of the context;
- looking after one's communication: mix of languages, perceptive and careful questioning, and inductive rephrasing and communication;
- practicing flexibility, mobility and relational agility: chosen and assumed responsibility, relative position, reality level;
- adopting the iterative dynamics of constant adaptation and regulation;
- combining reflection and action.

9.2.2.3 Inducing and Driving Change ⇒

- ensuring that all dispositions of precaution, experience and common sense have been implemented;
- the initial risk review is the founding act of every change;
- establishing a close, specific and identified support process;
- inductive relationship and communication lead to change: deconstructing, de-framing, re-framing, provoking, calming down;
- when common sense doesn't go in the right sense, one

Piloting Supports

9.2.2.4 Pragmatic Empathy

- “Having a good manner with people” is a living skill that has to be practiced, fed and kept alive.
- The constructive reciprocity feeds on relationship:
 - the presence, time and attention that one gives and displays (look, focus), are marks of consideration; “In a negotiation, the less you have to give, the more you have to receive!”
 - “offering” the expression space to the interlocutor.
- Creating a relationship between two people is an unknown, a new system whose characteristics and result arise from the face to face, and always subject to the variableness of the context:
 - every encounter is a first time, a risk in itself, that has to be prepared and managed as such;
 - the sensitive and reactive individual is a black box, he is unpredictable, changing, contradictory;

- an encounter is an emotional confrontation that opens with the reciprocal confirmation of the interlocutors;
- each interlocutor brings his/her own world, with which he/she is in an intimate, affective and identity relationship.
- Empathy contains the Responsible Useful and Efficient relationship, and deploys it at the same time:
 - recognizing the interlocutor in the legitimacy of his vision of the world in order to open empathy to constructive reciprocity;
 - establishing the interlocutor as an auto-regulation barometer induces the relational agreement; an information efficiency reads in the answer; “What is not alike contrasts ... what contrasts prompts the other part reciprocally”;
 - making incentive “narrative rephrasings” using the logical references of the other avoids projection (“putting oneself in somebody’s place”, aiming at persuading, imposing one’s point of view, come down to conflicting);
 - apprehending the potential as well as the limits of the other in the situation, so that the included middle emerges from the relationship and through the interlocutor (the included middle doesn’t exist at first sight)¹;
 - assigning strategically the meaning of things to the other, using his differences, his need of contradictory assertion, to make the cooperation “ego logic”, seeking complementarities, that promote emulation and co production (see Figure 9.10).
- From a spontaneous influence to a strategic, Responsible, Useful, Efficient influence:
 - seeking the other’s point of view in order to accompany him/her in the relationship towards the result;
 - agreeing on an exclusive shared reference, determinant of the Useful and the Efficient, third mediator and catalyst in the relationship (see Figure 9.10);
 - putting forward one’s own share of responsibility, taking the initiative, gives some visibility, and allows to manage the context, if the relationship is packaged with the right communication;
 - developing the appropriate adaptability to the variableness of situations and to the unpredictability of the behaviors that are met: agility from one reality level to another, flexibility and mobility regarding one’s relative relational position;
 - using what is latent, highly potentialized and limiting in an interaction, leads to a change in the reality level;
 - anchoring the relational strategy in the vision of the world of the interlocutor;
 - positioning oneself as a resource, opening the dialogue to the third, consists in escaping from the relational, emotional and affective field, in order to avoid any sterile a priori.

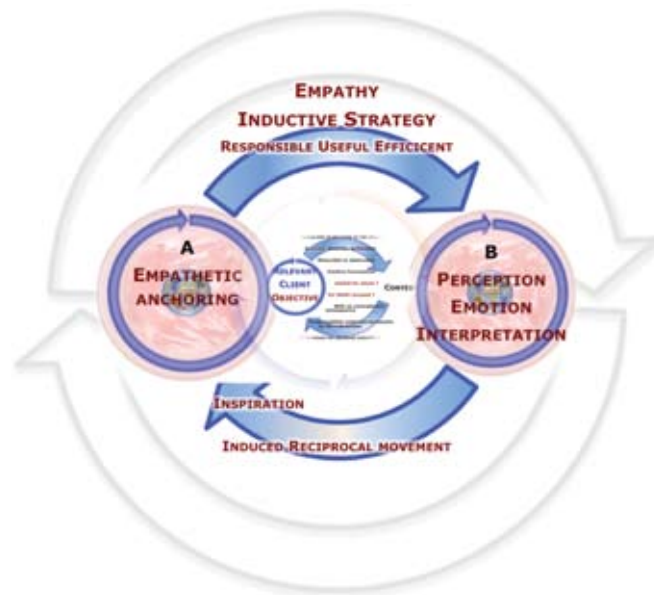


Figure 9.10: “Using” instead of “fighting against”, knitting the co-realization with the relationship.

- converting DOUBT into a resource: every limiting thought or emotion can and must be used;
- one can always replay an interaction that doesn’t seem satisfactory;
- capitalizing on the energy that emerges from the antagonisms at all levels: differences and gaps, related to chosen and validated references, are contextual information that prompts to movement;
- giving up trying to control what is uncontrollable, working with one’s illusions and utopias.

9.2.2.5 The Relevant Objective is Third, Regulator and Catalyst in the Relationship

- Without any normative opposable value, and the constraint of the result required by the system, the useful and efficient relationship exists only in reference to a norm of action that is contextual, explicit, shared, relevant with regard to the constraints of the system (see Figure 9.11 and 9.12).
- Agreeing on the relevant objective is a founding step of every collaboration.
- The relevant objective is third, regulator and catalyst in the relationship, it allows for considering another reality level, and projects beyond the tricky relational situations (see Figure 9.13).

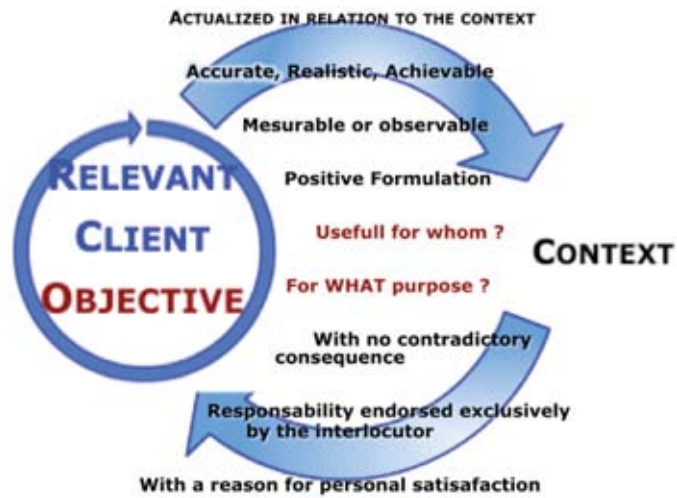


Figure 9.11: Criterias of the relevant objective.

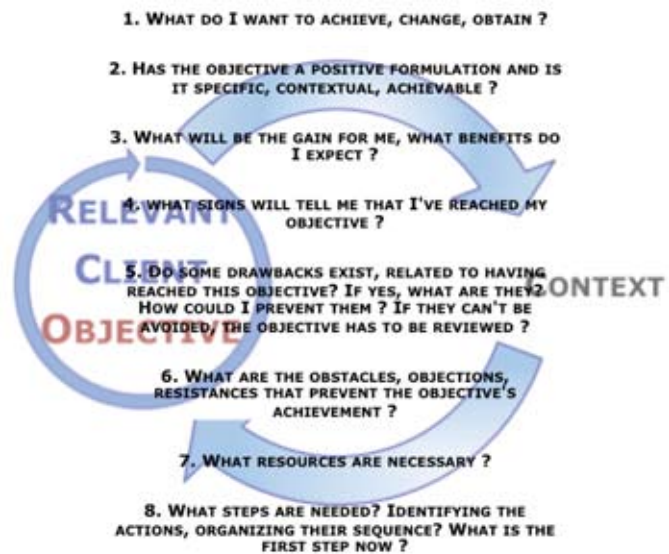


Figure 9.12: A question list to check the relevant objective.

- The vision is a middle/long-term projection of the initiative and adaptation capacities of the organization in the service of its mission, of its object, of its end. It clarifies itself at a certain point through a project and through objectives that divide and split themselves (see Figure 9.14).
- Relevant objective, project are interactional references that actualize and adapt

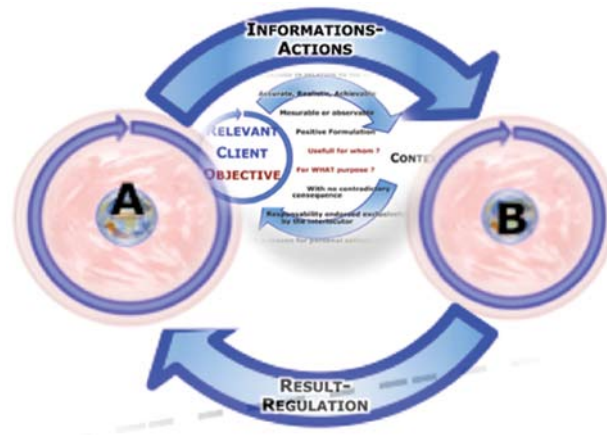


Figure 9.13: The relevant objective is third, regulator and catalyst.

themselves:

- its definition and its realization are synchronized with the evolution of the context;
 - the realization of the objective always serves a client, whoever he is (see Figure 9.15).
- Process, project, objective are founding references at every step and at every level of any realization. The relational dynamics is central, between the individuals and between the functional sub-systems, for the sequencing and coordination of activities. This way, contributions and responsibilities are valued for autonomy and quality. Towards a matrix organization?

9.2.2.6 The Choice of Responsibility: From Determinism to Relational Strategy

- The circularity of communication and relationship, interaction loops sequence, lead to the superimposition of the interactional WEST-EAST poles that meet and mix up (see Figure 9.16).
 - Every adaptation answer becomes an information that, in turn, gives rise to an adaptation answer, thus creating an endless renewal process;
 - Every end is the beginning of something else, the expression of alternation and of constant renewal in the course of a process;
 - Impermanence is the essence of continuity, of the living, of performance; Stability is an illusion, equilibrium is precarious, an instant between the end of something and the beginning of something else;
 - The defined, the identified, is deprived of its qualities since they only exist through emergence, expansion;
 - What is “apparent” is already in decline and in conflict with what is “new” and invents itself.

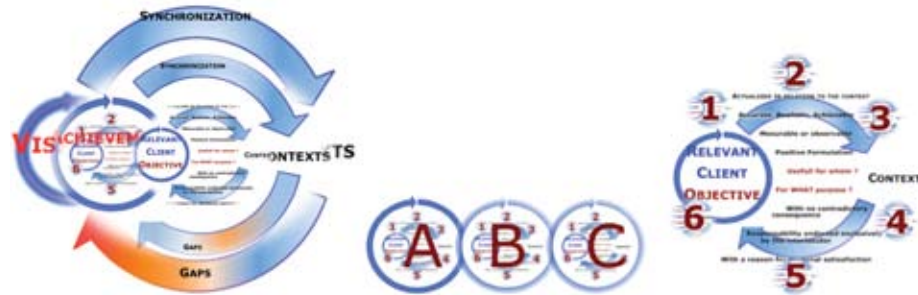


Figure 9.14: The vision clarifies itself through a project and objectives that divide and split themselves.



Figure 9.15: Relevant objective, project are interactional references.

- The issuer becomes simultaneously the receiver and the receiver becomes simultaneously the issuer, like in any couple of opposites;
- Causes and consequences are superimposed, until they merge. The chicken or the egg! What is the use of seeking the “ WHY of things” if all is contextual subjectivity?
- Every individual has the choice of placing the line that divides responsibilities and influence, at the level of what he accepts to take on in every interaction and in every professional role play (see Figure 9.17).
- The chosen and assumed responsibility-taking generates a useful and efficient influence.

9.2.2.7 Logic of Result: Solution-Orientated and Future-Orientated

Situation potential:



Figure 9.16: Superimposition of the interactional WEST-Issuer/EAST-Receiver.



Figure 9.17: Moving the line that divides responsibilities and influence/relevant objective.

- Tendencies
- Timely moment, included middle
- Influential individuals



Figure 9.18: A pragmatic attitude that invests the present in the realization and the strategic preparation. *It's the destination that leads to get on a train, not where it comes from! Preparing oneself to everything, even to what is unpredictable!*

- Context Resources
- The logic of result feeds on a pragmatic attitude that invests the present in the realization and the strategic preparation of the future in the direction of the project.
 - o Piloting the relationship comes under the “opportune opportunism”, from the appropriate adaptability to the variableness of the contexts, of the human emotions.
 - o Cultivating an “opportune opportunism”, the capacity of using the potential of contexts at the right moment.
 - o The relational usefulness and efficiency lie in the seeking of the new possibilities and of the new complementarities: the interlocutors can choose to adopt a tendency to renewal or to let the course of what happens supplant creativity (see Figure 9.18).
- Moving from the “Why?”, the seeking of the causes, to the “What happens, and how” and “How to deal with?”, the seeking of the solutions in action.
 - ⇒ *If it is sometimes useful to go through seeking the roots of a problem to make it solvable, such a step is indissociable to implementing a solution.*
- The dynamic of adaptation and permanent regulation in the service of progress.
 - o The gaps that are noticed all along the realization of the objective are precious resources and sources of progress, reciprocal incitements that have to be used to adapt the objective and the solutions.
- From the search for truth, to the choice of Responsibility, usefulness and efficiency in relation to a relevant third reference, initially shared. Since truth, objectivity and neutrality are subjective constructions.

- Acting as a thinking person and thinking as an acting person: Responsibility-Strategy-Action. Through strategic action, experiencing the world, confrontation to the tangible, to the limits, skills/competencies are acquired, through what is physically, sensorially and emotionally experienced, through adaptation. Being aware of the problem is not enough to let the change happen.

9.2.2.8 The Communication Packages and Opens the Relationship

- Language is the first media.
- Communication is a paradox that creates paradox!
- A useful and efficient communication allows opening dialog, deconstructing the paradoxes in communication and making the included middle emerge: “The solution is beside the problem!¹”
 - * Pragmatic questioning and validations
- Gathering information with perspicacity and precaution:
 - o Pragmatic questioning combined to validations neutralizes any personal spontaneous crushing projection and is the universal key for any Responsible, Useful and Efficient cooperation;
 - o Faced with the contextual emotional load and affectivity, questioning is a bet ;
- Any ambiguity, impropriety in the interlocutor’s languages, any paradox, must lead to dare asking one more question taking care of the form!
- Going beyond determinism: moving from the seeking of the causes, the “Why?”, to the seeking of the solutions in action (see above), the “How to do?”,

Since causes and consequences influence one another until they merge,
 Since identical causes can lead to different results,
 Since different causes can lead to identical results,
 Since causes always are many,
 Since observations vary according perspectives, everyone dividing the communication from his own point of view,
 Since the present conditions the vision of the past ...
- Pragmatic questioning aims at getting descriptions to make the tangible emerge in a transsubjective form, gaps instead of oppositions, working out the potential of the situation, identifying the influent persons, investigating the relational exchanges, the relative positions, the vision of the world – the position related to the context – and the interlocutors’ associations (see Figure 9.19).
- Questioning and rephrasing are indissociable. Getting validations (“Yes” sets).
 - * Inductive communication
- The communication packages and serves relational strategy:
 - o the attention showed is an essential implicit language;
 - o the form of communication, the mix of the 4 direct languages, the utilization of the medias, the way they are chosen, are at least as incentive a the information itself, since they give some details about the intention aimed at in the relationship (see Figure 9.20).

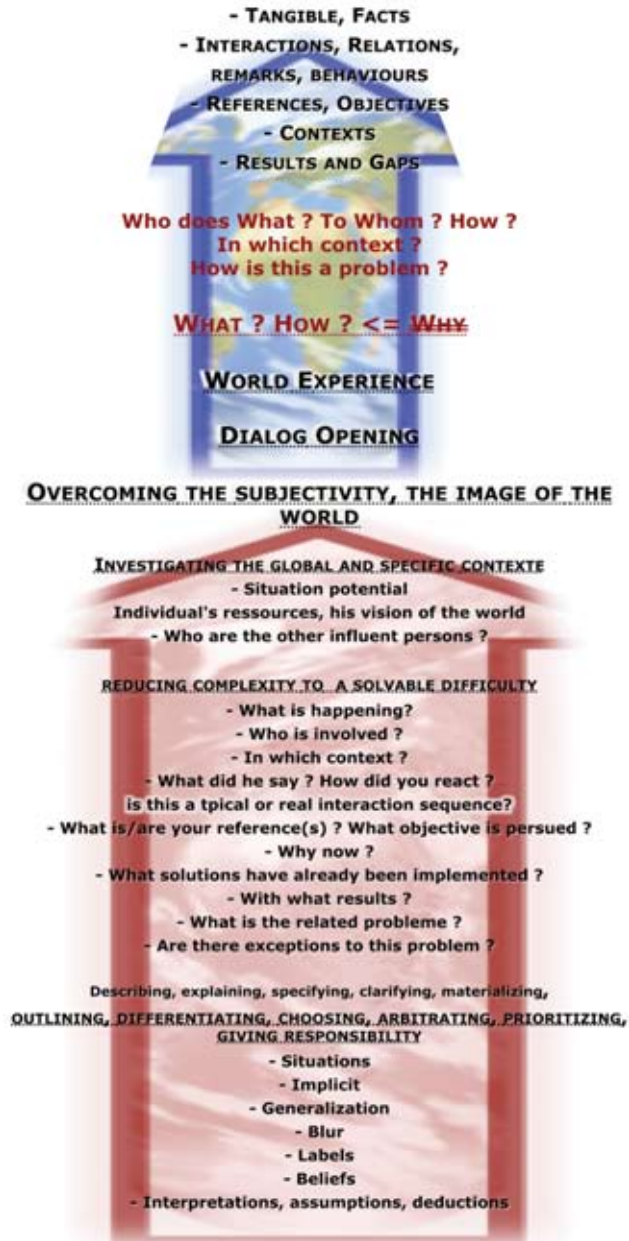


Figure 9.19: Questioning with perspicacity and precaution.

- a close vigilance (listening + observation) must be granted to the congruence of the languages used by the interlocutor and to their consistence (paradoxes);
- the emotional states arise and fill the communication.
- The communication in change relies on the interlocutor’s communication, it uses it pour make constantly narrative and inductive rephrasings: paraphrases, analogies (as if ...), aphorisms, metaphors, anecdotes, interrogative formulations, illusory alternatives, humor, confusion, multiple negations, sprinkling, indirect suggestions, assumptions ... promote the emergence beyond the emotional obstacles.
- The most is made of all opportunities to open, enlarge and reframe at the same time, to influence perceptions, emotions, to create new logical links, etc, bring together the points of view ... relativize the difficulties, make the aptitudes and skills/competencies emerge.
- To be inductive, every request, injunction or “prescription” has to be slow, repetitive, focused on the interlocutor and punctuated with validations (series of YES sets).
- A dematerialized communication, even if it is interactive, is not an interaction, it is an “extrapersonal” communication. Since it suppresses an encounter, it skips part of the interpersonal languages, transforms the emotions, wanes the empathy capacities (see Figure 9.20).

Universal Keys to Constructive Dialog

- Pragmatic empathy
- Questioning and rephrasing, validations
- Strategy, perspicacity, content and form: relevant objective, caution in language, doubt, reframing, mobility, agility, flexibility
- A third (Middle) always exists, between the two poles of a contradiction on another reality level

9.2.3 Letting Change Happen

From Auto-Regulation to the Choice of Change

- Every relational movement is or consists of an adaptation at least, a change at the most.
- When the adaptation to the reference frame doesn’t allow anymore to preserve an acceptable equilibrium on one reality level, synchronization to the context places the system if front of the choice to let a solution emerge on another reality level, in a new reference frame, therefore with another regulation and adaptation logic (see Figure 9.21).
- Change is an identity-related process because it comes under the free will of the individual, because it gives rise to renunciations sometimes experienced as denials, because it generates discomfort, most of the time.
- Asking a self-regulated system to change is a paradox! Change still remains to be obtained.

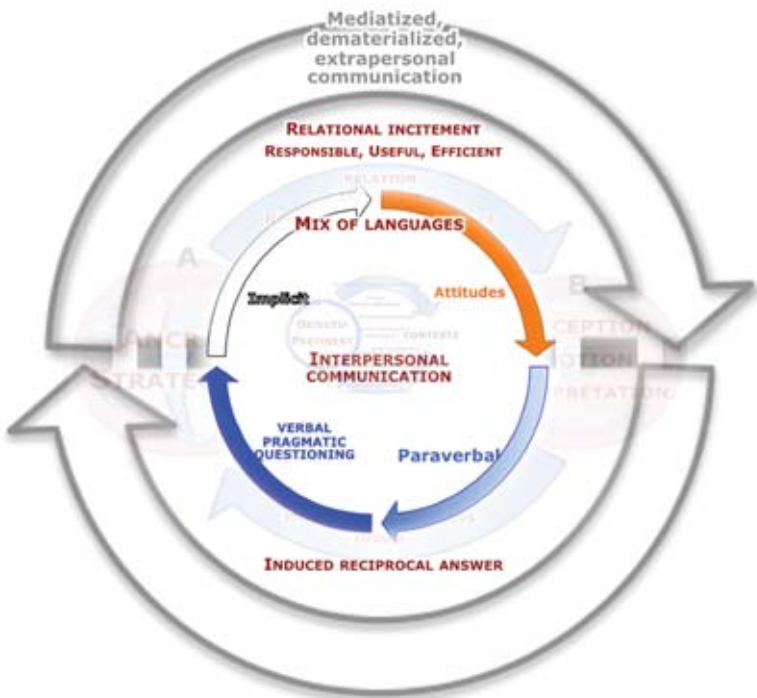


Figure 9.20: The inductive communication packages and serves relational strategy.

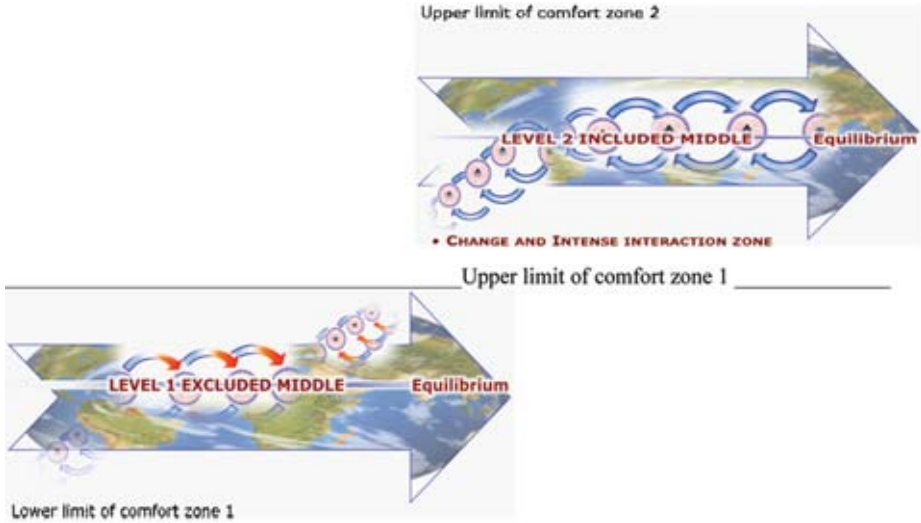


Figure 9.21: Change, is a change of reality level.

- Change requires a close, specific and identified relational support, and a communication that induces the movement.

There is No Change Without Any Resistance Phase

The Most Frequent Inappropriate Answers Given to Get a Change

- Persisting in implementing common sense solutions that don't work in the considered context
- Not aiming at a relevant objective, staying in one's illusions, utopias, "great ideas"
- Simplifying or denying a difficulty, thinking positive, going around without any strategy, procrastinating
- Analyzing, becoming aware, pondering, asking questions that have no answers, and not acting
- Denying the interlocutor's position and his vision of the world, "projecting oneself in his place", trying to persuade, giving some advice Trying to impose one's ideas rather than implementing a Responsible, Useful and Efficient strategy
- Wasting one's efforts to solve problems in searching their causes
- Criticizing, blaming, disparaging, depreciating, belittling, making a person lose face
- ASKING FOR A CHANGE! Trying to control what is a matter of free will and of spontaneous behavior: trying to dominate the interlocutor's emotions, or what is a strong question of identity.

A Protocol to Go Beyond the Resistance or Blocking Phases

9.2.3.1 Have All Dispositions of Precaution and Experience That Are Known to be of Common Sense Been Implemented?

Listing all actions that have been implemented,

- Are the aimed at objectives relevant?
- Has the team been synchronized in project mode (risk review), upstream and downstream with the other entities of the organization?
- Has a specific mode of regulation been adopted?
- Have inductive relation et communication been deployed (relational empathetic anchoring, pragmatic questioning, inductive communication and rephrasings)?
- Have the resources coming from previous experiences and/or possible exceptions to the problem been exploited?
- Has the potential of the context been used opportunely? (See Figure 9.22).

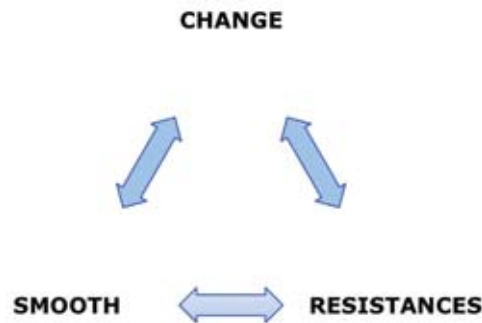


Figure 9.22: There is no change without any resistance phase.

9.2.3.2 Going Beyond a Resistance or Blocking Phase: When Common Sense Doesn't Go in the Right Sense, One Must Take the Other Way Round

A chronic problem is a difficulty that is dealt with inappropriately and repeatedly relatively to a given context: this initial paradox is a contextual logic error that we are going to fix using a paradoxical action.

⇒ A. IDENTIFYING THE PROBLEM THAT HAS TO BE OVERTAKEN

- What is happening (Who - Does what - To whom)?
- For whom is this a problem?
- How is this a problem in this context?

⇒ B. DESCRIBING THE INAPPROPRIATE AND REPEATED ANSWER THAT HAS ENCOURAGED, CREATED AND MADE THE PROBLEM GO WORSE UNTIL NOW?

⇒ C**. ADOPTING A STRATEGY THAT CONSTITUTES AN OPPOSITE INCITEMENT AT -180°- FROM THE ONE DESCRIBED PREVIOUSLY (or at least radically different)?

= USING THE PROBLEM, ACTUALIZING THE PROBLEM

- Aiming at an objective of change that is relevant and minimal.

⇒ D. TAKING A STRATEGIC REGULATING ACTION THAT WILL BLOCK THE PREVIOUS SOLUTIONS AND cause the emotion of change.

- Consolidating: considering a relapse, slowing down ...

****⇒ C. USING THE PROBLEM, ACTUALIZING THE PROBLEM**

The initial solution E implemented and actualized A(E) to solve the problem potentializes the resistance = P(non (E)) up to a blocking point.

Actualizing the potentialized resistance, the tension gives up and frees the Included Middle on another reality level.

In other words, using resistance according to modalities appropriate to the context, one uses the need for contradiction that values free will, and one changes the reality level, converting a problem into an opportunity for both parties.

9.3 Occurrences of Complexity and Relational Strategy

Using the Universal Keys to Constructive Dialog in Any Occurrences of Complexity

- Pragmatic empathy
- Questioning and rephrasing, validations
- Strategy, perspicacity, content and form: caution in language, doubt, reframing, mobility, agility, flexibility
- A third (Middle) always exists, between the two poles of a contradiction on another reality level

Nine Occurrences of Complexity and Relational Strategy to Be Implemented

From occurrence of complexity, to its expression in any situation... the relational strategy, the means and resources to be implemented.

9.3.1 Multiple Expression

- Person, character, situations, role plays, the individual is contextual, plural, different according to the various occurrences of his life
- The individual doesn't see himself acting: he dreams of himself the way he would like to be seen, he deludes and avoids himself

- An emotion can always hide another
- A point of view can always hide another
- An illusion can always hide another
- Multicausality, multifinality, variableness are the ingredients of the infinite combinatorics of the living
- Any context is the result of an infinite number of factors
- There cannot be two identical situations

Relational Strategy

- Being curious, perceptive, AND careful
- Sorting, eliminating, prioritizing, dividing: CHOOSING
- Practicing flexibility, mobility of the relational positions, agility on several reality levels, as a creative resource for reframing and for seeking a conciliatory solution
- The transpositions “other things being equal” are inappropriate to a complex environment, since no situation never occurs identically
- Moving from the “WHY?” to the “HOW TO DO?”: seeking THE cause can never solve a complex problem, since many causes gave rise to it; seeking the cause is endless, constantly renewed by the ever changing way the present is looked at
- Considering several solutions

9.3.2 Several Reality Levels

Expression

- A reality level is “a set of systems invariant under the action of a number of general laws”. From a reality level to another, “there is a breaking of the laws and a breaking of the fundamental concepts” (Cf Basarab Nicolescu). For instance, in the professional relationship area:
 - valuing the doubt as a resource / wanting to be right despite all opposition;
 - trying to be useful and efficient / seeking objectivity, neutrality, truth;
- Trying to be useful and efficient / seeking objectivity, neutrality, truth, is a change in the reality level referring to new logical references. A change in organization is not a change of reality level.

Relational Strategy

- Practicing the relational agility, learning how to detect the reality levels, and how to move from one to another in order to open the sphere of possibilities, at every step of the dialog.

Sample Founding Changes in the Reality**Level** ⇒

- shaping the strategic relationship / relying on the uncertainties of the contextual variations;
- making complementary what is contradictory / fighting against, conflicting, creating dilemmas;
- valuing the doubt as a resource / wanting to be right despite all opposition;
- dealing with the vagueness, the uncertainty and the unpredictable / acting only when there is no doubt;
- trying to be useful and efficient / seeking objectivity, neutrality, truth;
- choosing one's responsibility / being subject and executing;
- using gaps as a support for constant adaptation / pointing mistakes and sanctioning them;
- being future- and solution-oriented / seeking the causes;
- aiming at minimal relevant objectives / aiming at excellence at all costs;
- adopting the efficient relational-action strategy in order to change a behavior / figuring out the “why” of a behavior;
- combining reflection and action / becoming aware without taking action;
- replaying an unsatisfactory interaction / what is done is done.

9.3.3 Contradiction**Expression**

- Each element constitutes one of the two poles of a contradiction
- Variety, difference, gap are inherent to complexity
- The universe is governed by the dynamics of contradiction: “What is not alike contrasts, what contrasts prompts the other part reciprocally” (Cf François Jullien)
- Subject and Object make up the supreme couple of contradictories

Relational Strategy

- An accepted and legitimate difference is a recognition that opens the dialog: “dealing with, instead of fighting against”, seeking the interlocutor's point of view
- The antagonism of the two poles of a contradiction leads to the doubt, to a maximum tension, from which can emerge, on another reality level, the conciliatory choice, in favor of continuity
- Moving from “OR” one or the other, to “AND”, together, at the same time, on another reality level, is like moving from 2D to 3D
- Changing the reality level changes the logic: moving from a reality level that makes from an error a failure, to one that makes from differences and gaps contextual information that prompts to adaptation and progress.

- The period of change in the reality level requires a relationship that is especially attentive and an intense inductive communication
- The relational strategy leads to take the initiative of a conciliatory action

9.3.4 Fate, Unpredictable, Impermanence

Expression

- Like every complex system, the human is a black box: contextual, changing, unpredictable, etc.
- The sensitivity, emotional and affective potential of the human, his memorizing, association, reflection abilities are additional complexity factors
- An encounter is an emotional confrontation that can trigger an ego reaction radiating an unsuspected amount of energy
- The complexity of the interlocutor is a mystery that is experienced very emotionally, since it is unpredictable and singular, therefore risky and potentially carrying the imaginary anxiety of the worst ... (opposition, disagreement, blame, highlighting errors, weaknesses, or personal traits which are carefully, sometimes unintentionally, avoided)

Relational Strategy

- Practicing the relationship like a risky activity:
 - escaping assertion
 - making assumptions and bets, acting “as if”
 - combining perspicacity, caution and precautions
 - progressing with the detected gaps, completing using constant checking, adaptation and regulation
- Confronting any intellectual construction to what is tangible: action, implementation, experience make gaps emerge
- Future is prepared in the present, being ready for anything, even for a confrontation to what is unpredictable: agility, adaptability, flexibility have to be practiced and looked after
- If one never knows what a situation will require, one knows what should not be done anymore and how not to do it anymore
- Detecting the relevant information, what is potential, latent, using probabilities
- Using risk as a solidarity factor
- Using emotions and affectivity rather than seeking to control them
- Giving up trying to control what is uncontrollable, crying for the moon, radically banishing the questions that have no answers

9.3.5 Non-Normativity

Expression

- Complexity is non-standard: too many norms destroy The Norm
- One cannot live without interpreting
- Every individual interprets the facts his own way and creates his own image of the world
- The meaning of things belongs to nobody, and to everybody
- Reality, truth, neutrality and objectivity are “points of view”
- Everyone is right from his point of view, and everyone has good reasons to adopt a point of view
- Every point of view is identity-related: fighting against is like denying a person’s existence
- The individuals interact from their interpretation of the world
- The human doesn’t see himself acting, he dreams of himself the way he would like to be seen, he deludes and avoids himself

Relational Strategy

- Without any opposable absolute norms, the initial co-creation consists, in every context, in the adoption of third, explicit and shared references/norms (Aim/project/objectives)
- The objective is third, mediator and catalyst in every relationship
- Choosing the Responsible, the Useful and the Efficient instead of truth, objectivity and neutrality
- Every Responsible, Useful and Efficient action is strategic in relation to the reference that is adopted in a given context
- Being accountable for the choice of one’s representations and points of view
- Relating every position and every responsibility to the target reference
- Agreeing, seeking the interlocutor’s point of view, systematically assigning to him the meaning of things, is the basis of a constructive exchange
- Aligning the dialog on the interlocutor’s answers
- Aim, project, relevant objective fit together and divide themselves
- The relevant, explicit and shared objective is central to the effectiveness
- Aiming at a minimum objective is part of an improvement process
- Every reference has to be adapted and synchronized with the evolution of the context
- Generalities, great ideas, values exist only in their relation to the context

9.3.6 Interdependence

Expression

- Exchanging is vital: The human is essentially dependent, relational, systemic

- Information makes relationship
- There is no information without answer: they jointly and reciprocally make up both movements of the interaction loop
- The sequence of interaction loops makes the relationship
- The individual is only through his relationships, he is contextual
- The smallest entity under study: the individual in relation to the context
- The relationship makes foreseeable what is unpredictable and limits at the same time
- Influence is unavoidable, inherent to the person and to the character he/she plays in a given context
- The relationship to the context is a resource: the individuals, the right moment, what is potential, latent, the renewal of things
- Information, communication and relation are totally interlinked: the communication packages and opens the relationship
- The relationship makes the system, and the system controls the relationship to maintain an acceptable equilibrium
- The complex, open, self-regulated systems are inevitably interacting with their environment
- Every element of a system is in relationship with a number of other elements within this same system
- Every individual is an element from many systems at the same time
- The cause-consequence relationship is of a “many-to-many” and contextual type: an event can have several causes, and one cause can produce several results
- The smallest change in a relationship between two elements has consequences on the whole system
- A complex, open, self-regulated system tends to maintain its acceptable level of equilibrium
- The grouping of individuals in a complex system, develops some singular features

Relational Strategy

- Piloting an organized complex system, requires a regulation process that uses the logic of complexity
- Relationship can be practiced and piloted just like other activities
- Relationship exists only through encounter: dematerialization and the use of medias cannot be considered as full substitutes
- Relationship feeds on and spreads out in its opening to the variety, to the logic of complexity, to the use of the potential of the context
- The realization systematically associates reflection and action
- Adopting a training approach: experiencing, renewing, entering dynamic learnings
- Using the gaps, limits, constraints of the system, as resources

- Aiming at a minimal action to get an optimal change
- The communication has to be practiced with the relationship
- The communication packages and serves the relationship: the mix of the 4 languages
- The inductive communication relies on the interlocutor's communication, it even uses it
- Reframing and injunctions are influence tools
- Relationship and communication serve the strategic influence
- Moving from the “WHY?” to the “HOW TO DO?” Seeking THE cause can never solve a complex problem, since many causes gave rise to it; seeking the cause is endless, constantly renewed by the ever changing way the present looks at the past, varying depending the “geographic” point of view
- Locating and describing the relational sequences is more useful for the implementation of a solution than seeking the roots of a problem
- The transposition “other things being equal” is impossible

9.3.7 Circularity, Alternation, Constant Renewal

Expression

- An information and the answer to it follow different thought progressions: the interaction forms a loop
- The sequence of interaction loops makes the relationship
- In the interaction loops sequence, the poles of a contradiction overlap, mix up, change roles and are superimposed beyond a certain stage: Subject/Object; Beginning/End; Causes/consequences... relative positions, are matters of opinion about the relationship in a given context
- A result is achieved through future-oriented iteration, adaptation, renewal, and synchronization
- The progress lies in the way one makes use of gaps

Relational Strategy

- Circularity is to the relationship and to communication, to the course of the events what the wheel is to mechanics and to moving: speed, reduction ratio, conversion, crossing of obstacles, change in the reality level, renewal, continuity
- The dynamics of permanent adaptation and regulation induces the calling into question, the risk taking.
- The progression through iteration loops combines itself to the progression towards the future: the orientation towards the seeking of a solution, carries innovation, experimentation, evolution and change
- The superimposition of the opposites in the sequence and progression of the interaction loops opens the space for representations and choice opportunities: information-answer, beginning-end, initiator-follower, responsible-endured, can be an endless debate, or the choice of a representation in a given context, etc.

- The choice of responsibility is a question of position in relation to the context and to the adopted reference: changing the rules of the game
- The superimposition of the opposites in the sequence and progression of the interaction loops opens the space for paradoxical intervention: preliminary paradox /counter-paradox
- Choosing to take on a responsibility brings credibility and influence
- Everything can always be played again, more or less: as long as the end of a relational sequence has not been pronounced, one can always go back over an interaction that doesn't seem satisfactory
- The action's references obey to the same dynamics of regulation and adaptation

9.3.8 Reciprocity

Expression

- One cannot live without communicating: there is no information without answer
- One cannot live without adapting: dependence implies adaptation
- One cannot live without influencing: influence is inherent to the person and to the characters he/she plays
- The information and the answer are the two indissociable and reciprocal movements in an interaction
- Information and answer carry the image of the world of each of the interlocutors
- The line that divides responsibilities and influence appears between the information and the answer
- The incitement contained in the information creates the interpretation and the answer that follows
- The meaning of things belongs to the interlocutor
- The choice of the level and nature of the responsibility is a relative position-taking that influences its opposite

Relational Strategy

- Every interaction is an exchange in which both parties are respectively fully responsible of one of the two movements The line that divides responsibilities and influence just waits for a move: the context, like the adopted reference, endlessly lay down and re-shuffle the cards of the reciprocal responsibilities
- Giving substance to the relationship encourages to a constructive reciprocity: the expression space belongs to the interlocutor
- Pragmatic empathy is practiced through the rephrasing to the interlocutor; it avoids projection
- In the interaction loop, the tone is given by the interlocutor's answer
- Being accountable for a part of the responsibility in the relationship encourages the reciprocal responsibility-taking
- The choice of the position in the relationship is contextual

9.3.9 Change

Expression

- Change is part of the progression
- From auto-regulation to the choice of change, changing the reality level, the logical level to come back to an acceptable equilibrium
- Change is a process of calling into question that triggers an emotional “release”, or even more if it is accompanied by some renunciation; it then becomes an identity claim
- There is no change without any resistance or blocking phase
- Asking for a change is a paradox, the decision of changing is an expression of the free will of the individual and of what he/she can claim in terms of freedom

Relational Strategy

- The maximum tension, the conflict between the two poles of the contradiction is the expression of the right moment from which the Included Middle can emerge
- Every change requires the implementation of minimal precaution and experience measures
- Since change is a project, it must be piloted as a project
- Dealing with what is, instead of fighting against
- Calling for resistances and problems
- Converting the energy of resistance into the energy of action and realization
- The element that resists has to be placed in a situation of realization
- A paradox is resolved using another paradox that leads to a change in the reality level ; actualizing the potentialized resistance, the tension gives up and frees the Included Middle on another reality level. In other words, using resistance according to modalities appropriate to the context, one uses the need for contradiction that values free will, and one changes the reality level, converting a problem into an opportunity for both parties.
- Going beyond a resistance or blocking phase: when common sense doesn’t go in the change direction, one must take the other way round: preliminary paradox /counter-paradox
- Change is a very emotional process that requires a specific support
- At first sight, the solution, the Included Middle do not exist, it only emerges from the questioning in the relationship, and through the interlocutor’s voice

9.4 Universal Keys to Constructive Dialog and Piloting References in the Professional Relationship

9.4.1 Universal Keys to Constructive Dialog

- Pragmatic empathy

- Adoption of a shared, explicit, and relevant reference
- Strategy and action serving the targeted action reference
- Perspicacity and caution, content and form: language precautions, doubt, questioning-rephrasing, reframing
- Mobility, agility, flexibility: reality level, relative position in the relationship
- Reflection-action indissociable tandem
- Using contradiction as a reactional projection basis towards the Included Middle

9.4.2 Piloting References in the Professional Relationship

Responsibility is a Chosen Option Beyond What Is Imposed and Resists to Our Experiences

⇒ Sample Founding Changes in the Reality Level

- the constraints in life refer to several reality levels / linear conception;
- shaping the strategic relationship / relying on “determinism” and on the uncertainties of the contextual variations;
- making complementary what is contradictory / fighting against, conflicting, creating dilemmas;
- valuing the doubt as a resource / wanting to be right despite all opposition;
- dealing with the vagueness, the uncertainty and the unpredictable / acting only when there is no doubt;
- trying to be useful and efficient / seeking objectivity, neutrality, truth;
- choosing one’s responsibility / being subject and executing;
- aiming at minimal relevant objectives / aiming at excellence at all costs;
- using gaps as a support for constant adaptation / pointing mistakes and sanctioning them;
- describing the facts, being future- and solution-oriented / seeking the causes;
- adopting the efficient relational strategy-action in order to change a behavior / figuring out the “why” of a behavior;
- combining reflection and action / becoming aware without taking action;
- “things change” an unsatisfactory interaction can be played again / what is done is done.

The Responsible, Useful and Efficient Professional Relationship

⇒ Aiming at a Responsible Useful and Efficient Relationship

- practicing pragmatic empathy, inducing useful and efficient reciprocity;
- focusing on the interlocutor, seeking his/her logic, aligning his/her answers in order to pilot the dialog;

- agreeing explicitly on action references that are relevant in the context, aiming at minimal objectives;
- putting relational strategy in the service of the result, using the potential of the context;
- looking after one’s communication: mix of languages, perceptive and careful questioning, and inductive rephrasing and communication;
- practicing flexibility, mobility and relational agility: chosen and assumed responsibility, relative position, reality level;
- adopting the iterative dynamics of constant adaptation and regulation;
- combining reflection and action.

Every Relational Movement Is or Consists of an Adaptation at Least, if Not a Change

⇒ Inducing and Driving Change

- asking for a change is a paradox, change is yet to be obtained;
- ensuring that all dispositions of precaution, experience and common sense have been implemented;
- the initial risk review is the founding act of every change;
- establishing a close, specific and identified support process;
- inductive relationship and communication lead to change: deconstructing, de-framing, re-framing, provoking, and calming down;
- when common sense doesn’t go in the right sense, one must take the other way round;
- awareness doesn’t make change, action is needed.

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CHAPTER 10

Epistemological Awareness and Transdisciplinary Attitude: Experiencing the Embodied Being

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Epistemological-ontological fundamentals and their application in the Community of Learning at the Eco-Dialogue Center is the principal topic in this chapter. The reflections are based on recognizing that wisdom and knowledge cannot be attained in the absence of the body, since the latter provides the stage for the physical-emotional-mental-spiritual articulation for our being and knowing. Through transdisciplinary re-learning based on the development of emotional-cognitive abilities, personal, communitary and planetary sustainability becomes possible.

10.1 Introduction

The present text attempts to reflect a vision of what constitutes the fundamentals of the theory of knowledge or epistemology and their praxis corresponding to our Learning Community (a group of students, academics and people from the surrounding communities) at the Eco-Dialogue Center of the University of Veracruz. The experience of constantly becoming aware of thinking and experience processes resulting from being in community, and from a connection with what happens in the life is what we call “Epistemological Awareness”. This does not refer to a doctrine, a body of theoretical concepts, but to an attitude that can be expressed as *living-is-knowing*, suggesting that there is no separation between my knowledge and my process of being alive which means a way of being present and becoming in the world we have been co-creating together for the past ten years.

Our Learning Community, formally, is an academic program dedicated to promoting life long and formal education for sustainability. It has its place within a public state University whose objective is the formation of professional human beings at the service of Veracruz and Mexican Society, in order to collaborate in the co-construction of a Mexico with equity and a satisfactory and sustainable quality of life.

Because we gather and work in this academic center with the vision of collaborating in education for sustainability and care of the community and the environment, it has behooved us to create reflective settings, dialogs and concepts that appropriately reflect these principles through the programs, projects and academic products that we share with our University community, as well as with the society of Veracruz and Mexico in general.

Under these premises, we will attempt to express simply the articulation of notions and concepts that constitute the center of what we might call our epistemological and ethical fundamentals in work and in life.

10.2 Epistemological and Ontological Basis of Our Proposal

The wisdom and knowledge for a return to the living and present world benefits from an inclusion of a bodily perspective, as noted by Merleau-Ponty for instance; such a perspective is required for the comprehension and articulation (physical-emotional-mental-spiritual) of our being and knowing (we call this the “embodied mind”). In the academic practice of our Center, we propose the study and practice of Embodied Being as it becomes and develops in its community and its world, and thus builds itself through its being and doing in its territory (a pedagogy of place) and its life. It is in the Embodied Being where the mind and the emotions, reflection, poetry and the cognizance of our history and experience in life take place. The recognition of this internal-external ecology (the self and the environmental aspects of our mental processes) of our mind, constitutes the fundamental element for the “ecologizing of knowledge” on a personal and planetary level. It is in this setting where the generation of epistemological awareness as the operative basis for the methodology of knowledge, goes beyond the limits of disciplinarity and interdisciplinarity. We call this proces “transdisciplinary re-learning”. We believe that this academic theory and practice is the very basis to co-create means of sustainable living, which are produced and experienced from one instant to the next, from my individuality that at the same time is community and place.

10.3 Origins of Our Mind-body Separation in the Western Tradition

In most of the world, and very particularly in our Mexico and our America, life under the post-modern, globalized cosmovision builds and reiterates itself constantly during our coexistence through an obstreperous omnipresence of the still dominant rationalistic-mechanistic vision of the world. We swim and live in the sea of modernity and post-modernity to the extent that we never notice it, nor does it move us to conscious reflection; we simply construct our world in its midst. It is so crushing and it has entered our lives so unceasingly that most of the time we are no longer aware that we exist, think, consume, love and die in it...

If we aspire to reconstruct our being such as to create a more sustainable world, we must become conscious and re-appropriate our modern forms of thinking and living in order to reunite them with ancestral forms in a constant retro-progressive

(taking what is meaningful from the past and what can create a possible humanity for the future), co-creative act of new sustainable life.

The great paradigm of the West, which erects a way of life founded upon certain forms of thinking is sustained by rationalistic Cartesian thought which has conceived reality – the world- as an object that is independent of whoever observes it and “knows” it (Berman [1]; Capra [2]). This marks a separation between two entities: one that analyzes studies and ultimately prescribes or emits a judgment, and the other that is analyzed, studied and exposed to scrutiny. The reflection of this deterministic manner of conceiving reality is perceptible in the universalistic derivations resulting from the human break with nature, which occurred in the Occident at the dawn of modernity; its roots can be found in the Greece of Plato and Aristotle, in the confines of patriarchal society, Eisler [3], and it expresses itself clearly in the Platonic and Cartesian separation of mind and body, Griffin [4]. Rene Descartes (1596-1650), in his Discourse of Method, Descartes [5], divides the human being into a thinking part – the mind, the soul-, contrasted with the material part – the body-. He considers mentality as the essential part, since its existence does not depend on anything material. The body, which is where the emotions, the passions and instinctive life are expressed, is placed in a subordinate position and its activity is canalized by the thinking part. As Morris Berman states:

For Descartes, the identification of human existence with pure reasoning, the idea that man can know everything that he is given to know by means of his reasoning, included the supposition that mind and body, subject and object, were radically unmatched entities. Apparently, thinking separates me from the world confronting me. I perceive my body and its functions, but ‘I’ am not my body, **Berman [1]:270.**

In this way, the subject has been separated from its surroundings, thereby conceiving the existence of a universe out there which functions according to mechanical laws that need to be discovered, known and, if possible, controlled. Thus has the essence of the modern human being been constructed: an individuality resting upon an entity “I”) that perceives, is informed, conceives, thinks and transforms reality, including the body in the very first place.

This has given rise to the “reflexive I” and the blossoming of the platonic vision in which the ‘truth’ is purely abstract... Life, then, no longer resides at the horizon, on the rocks, in the air, Vasquez Rengifo [6]. Magic is dead. So now we find ourselves free to plunder the earth, Abram [7]. Consequently knowing is conceived as a rational, logical and mechanical act, carried out by an abstract and aseptic mind, which operates independently of the whole body (Keleman [8]; Damasio [9]).

We can realize an experience of self-inquiry so as to give more life to this reflection. Let us close our eyes and feel the presence of “our body”, of our breathing... let us pause there for at least a minute, at the same time perceiving and contemplating our being-breathing, our bodily weight, on being seated on a chair, on the ground, on our Earth. Let us keep our attention simultaneously on these two aspects of our being and becoming for at least a minute— now let us ask ourselves: What is our body? To whom does our right hand belong? Who is naming and “thinking” of my hand? Something tells me that my hand belongs to my mind and I tend to “think” that this mind has a place, which happens to be my head... Immediately I think of my brain. However, the very act of saying “I tend to think” or “my brain” suddenly shows that this quality of thinking also “perceives and is conscious” of “my brain”.

Then we notice that seemingly this “mind” lives outside at a higher level or different from all of my body, including my brain. At this point I can no longer distinguish whether I “think” because in this way I have learned to conceive of myself since childhood, because in this way I tend “to think of myself” as a modern human being, or whether there are other ways of perceiving myself.

At the same time, if I keep the question open and become aware again on my breathing... and on my bodily weight... and more still if I expand my attention to the skin and muscles of my right hand, maybe I can perceive that consciousness also exists there, that also I-am-hand... Can I feel more than just an object-hand, a part of my being that also has the quality of being present, maybe of biomechanical, sensorial or immunological intelligence? Is this feeling the beginning of an expansion and embodiment of my mind returning to its place of being in my body? What do the cognitive sciences, the studies of consciousness, quantum physics, neurobiology, the perception of art and the traditional systems of knowledge have to say in this respect? Is this vision of a separation of mind and body sustainable?

I am-think-hand-body...

Let us keep this question and self-inquiry open...

Let us continue with our story of returning to a Being-Mind-Body-that-lives-on-the-Earth...

From this dualism, the “body” operates as a source of metabolic and operative “resources” for a “thinking” brain that computes the mental processes (a metaphor which perfectly matches that of the brain as machine); therefore body and mind are thought as separate entities in the process of knowing. Thus, the act of knowing is an exclusive, characteristic of reason, disembodied, that is devoid of any subjective and affective component (Damasio [9]; Maturana [10]; Maturana and Varela [11]). Thus separated from experience, the creation of knowledge based on abstract theoretical systems, mechanical and deterministic models that provide but little insight to the complexity of reality, takes place. That is how we construct and live in the abstract, rational world that we experience as the system of ideas and concepts on which our thinking is based. Much as we try to dissuade ourselves, we are unable to break away from this experience that informs us of a mind computing and ordering, according to concepts, the “world out there” of which the body with its senses informs us.

As far as we know, Plato was the first to propose clearly the separation of the sphere of ideas from the rest of human existence, particularly from corporality (subsistence and sexuality), Griffin [4]. Since in Greek society the woman was associated with domestic reproduction and with carnal and reproductive sexuality (as opposed to the erotic love with a young man idealized by Plato, or a “platonic love”), it appears that she was not considered as a part of rational and significant humanity, separated from and rising above nature. That it is that patriarchal society idealizes and privileges the notions of rationality, liberty, and transcendence over nature. Both nature and woman are perceived as chaotic and disorderly entities to be dominated and put in order through reason, Plato’s “logos” (not necessarily the only possible acceptance of this notion!). Another important characteristic associated with woman and nature by mechanistic rationalism is the absence of intelligence and her constant and limiting passivity and receptivity. Nature is only an inane source of matter and energy (the *Res Extensa* of Descartes); it is the rational man with his logos that imbues her with sense and intelligence, attributes that have to be watched over and rectified constantly. The logos, then, must be superior to that which it

governs and dominates. Francis Bacon explained this patriarchal position toward nature in operational and technological terms: nature must be tortured, cornered and compelled by means of meticulous rational and mechanical procedures to reveal her secrets to us, Berman [1]. Patriarchal Christianity incorporated these central elements of separation between body and soul, carnality and divinity into its cosmogony. Nevertheless, the material world can never be eradicated (just like sin); consequently said materiality has to be repressed by the logos, individually and in society as well as in the interaction between humanity and nature.

This cosmogony was founded in Greece in a society based on war for the conquest and domination of other peoples. The individual, nature and life, then, are without intrinsic and sacred value, since it is by imposing death and domination that the state and the powerful classes perpetuate themselves. Susan Griffin confirms the existence of a psychological pattern common to all forms of oppression; said pattern insists on identifying emotion, the body and nature with the feminine gender, these attributes being considered as inferior to reason, the mind and culture, which are identified with masculinity, Griffin [4].

From the eco-psychological viewpoint, this process of establishing patriarchy also produces an equally devastating catastrophe: our being is separated from the world and from the intimacy of our humors, secretions, rhythms and animalities; almost all of our profound connections with nature and the archetypical forms of perceiving them are cut off and declared unrighteous, Glendinning [12]. This should enable us to understand how, in modern society, we humans spend more than 99% of our lives in a state of indifference to the wild natural world. We become beings whose relationship with nature is constantly influenced by a multitude of ideas and preconceptions, by machines and an artificial way of life, Cohen [13].

At the same time and in a complementary manner, scientific knowledge has developed fragmentarily since the 16th century, thereby resulting in an ever-growing specialization of disciplines that divides and departmentalizes the knowledge generated in the different areas of specialization; this creates a type of knowledge that advances by fragmenting, separating, observing, analyzing, abstracting and controlling. By experiencing modernity in our everyday lives, we realize that this way of confronting the world provides us with comfort, predictability, health and material technological wellbeing. But we are also aware of living in an uncontrolled avalanche of destruction and exhaustion (devastation of the earth, its bio-diversity and cultural diversity, violence, addictions, polarization, etc.) which no one can even conceive, much less contain and convert into something human and sustainable.

10.4 Reincarnating Our Living and Knowing in the World

On the academic level, we now realize that this form of rationalistic-reductionist thinking and transforming the world conforms the disciplinary structure of the universities, which generates forms of knowledge that are closed and incapable of contending with the uncertainty and hyper-complexity of the real world. It is clear that we need knowledge capable of creating pertinent, systemic, sustainable and participative alternatives to meet the crisis which faces the civilized world of today (Morin [14]; Leff [15]; Gadotti [16]; Nicolescu [17]).

Gregory Bateson, Edgar Morin and Basarab Nicolescu have reflected upon the

roads that have led us into this entanglement of the reductionism and dualism that prevail in modern thought, particularly in the academic research of universities (Morin [18]; Bateson and Bateson [19]; Nicolescu [17]). These thinkers pose the necessity of a reform in thought that places the human being, the being-that-knows, in the center of knowledge. At the same time, Latin American thinkers such as Leonardo Boff, Humberto Maturana and Paulo Freire emphasize the pertinence of human life to an Embodied Being, a Community Being and an Earthly Being. This impels us toward an internal ecology of the thinking subject co-determined and existing within the living ecology of an articulated, organic, non-mechanical world (the auto and the eco posed by Edgar Morin). What is required is to re-edify and co-edify a Human Being-in-the-World that is aware and conscious of the suppositions involved in her or his thoughts and actions, and in his or her experience of knowing.

In agreement with what has been discussed in the present text, this cannot occur through reasoning; rather, it must take place within the totality of our emotional being, within the Reflective and Thinking Embodied Being rooted in a community and in the world in which it lives, articulated and co-determined. According to our experience, is impossible to enter the ambit of complexity by means of just rational thought, even this article which attempts to de-construct rationality, is no more than a representation, a map of ideas about a multiphonic reality inaccessible to the isolated rational mind (Griffin [4]; La Chapelle [20]; Gadotti [16]). One way of escaping from this vicious circle is by opening oneself and experiencing transformation through an awareness that articulates sensations, sentiments, personal experiences, including ritual and wildness (occurring from within an oikos, a community and a world) setting in which we can reconstruct our psyche in a sentient and thinking embodied being, La Chapelle [20].

The experience of constant becoming aware of thinking process resulting from my being in community and from a connection with what happens and is the product of my living in the world is what we call “Epistemological awareness”. The Batesons use the word Epistemology with a capital “E” so as to think of it as the systemic “ecology of the mind”, Bateson and Bateson [19], implying that every process of the world that is “a difference that produces a difference” is a mental process, and consequently participates co-creating a web of communication and transformation processes. Based on this, we can perceive the world and the human participation in it as constant flow of interacting meanings, an “Epistemology,” life in a world in constant computation, Morin [14].

But what are the significance and implications of this work and this epistemological awareness? We wish to make a pause here to describe some aspects of the matter.

We consider that in academic knowledge, and in education and modern life in general, the corporal and emotional cognitive implications involved in this need for an epistemological and cosmological change in regard to complex thought and the transdisciplinary attitude, are commonly subestimated. However, this embodiment of knowledge cannot be realized through the rational and aseptic discourse as a divorce between mind and body. Emotion, pleasure, pain, the capacity to perceive beauty, but above all to create it by articulating our body-mind-spirit, cannot be simulated: it must be exercised and experienced.

Although we can emit a discourse from our chair, it continues to be just that; a discourse disconnected from our body and our reality. It is necessary to reconstruct our personal history, to give it new meaning through our Biology of Knowing

(Maturana and Varela [11]; Varela et al. [21]), of our total body, being aware of our dualistic rationalizations.

The articulating and inclusive origin of ecological wisdom makes no distinction among art, science, technology, religion, pleasure, or ritual. Unfortunately, even if we become empathic and perceive the pertinence of this vision of the world, transforming rationalistic words and customs into actions, to a life directed by intuitive intelligence, is a leap that can be perceived and embodied only in praxis, by letting the body live in a different, articulated and sacred manner. This participative co-construction of the knowledge filled with experience-based requires a “spelling out of sensations,” a complex (which means interconnected and distributed) learning and thinking process that propitiates the articulation of experiences and knowing styles where participative and planetary knowledge originates - inquiry in the first-person of plural-, Heron [22].

10.5 Transdisciplinary Re-Learning for Personal, Community and Planetary Sustainability

In this way, it is possible to cultivate emotional-cognoscitive abilities by elaborating a setting for a dialogue of knowing styles, work with Mother Earth (eco-formative horticulture), rituals and myths, participative processes (community politics for a solidary society). This will facilitate a blending of sensations in which odors, touch, sounds, sight and taste, stories, family knowledge styles, the encounter of community and personal experiences through cyber-space, etc., are contrasted within a complex framework (complexus) which takes place in our Learning Community at the Eco-Dialogue Center and beyond, in our Bio-Region and the Planet Earth, which is our living space.

Obviously, we cannot converse peaceably and creatively with someone we desire to dominate and conquer (be it a body, my emotionality, an “object of study” or a human being with whom I live). A conqueror has never been able to know and enjoy the delicious pleasures and secrets that make up the subtle story of the “dominated” peoples. It is logical, then, for our techno-scientific acts to be so coarse, ugly, and inefficient on both local and planetary levels. We perform them behind nature’s back, without listening to her subtle whispers, without time to lose, and always thinking of the next conquest to be achieved. For this reason we require a constant process of experiencing a return to the world, of knowing it by conversing with it. That is the personal, communitarian and global experience we create and re-create constantly at the EcoDialogue Center and which, from the academic point of view, we call Transdisciplinary Re-Learning.

In this respect Transdisciplinary Re-Learning sets out from problematization of complexity. It reevaluates the role of intuition, imagination, sensitivity and the body in the processes of generating and acquiring knowledge. Transdisciplinary Re-Learning is a form of learning for the purpose of multiplying and diversifying knowledge through dialogue, for self-transformation, self- knowledge, and for producing “a new art of living”, Falconar [23]. All of these qualities make up a set of abilities appropriate for an ecologized knowledge, having epistemological and practical sensitivity for acquiring pertinent social and planetary knowledge. It is designed to open the levels of perception towards the multiple dimensions of Reality, to mobilize the emergence of *general intelligence*: curiosity, creativity, and reflection (Morin [14])

and [24], Morin et al. [25]), and in this respect, to generate processes of social self-organization destined to guide the evolution of consciousness toward the construction of *world citizenship*, Morin [24].

The central praxis in this process is built starting from the Biology (or Life) of Knowing (Maturana and Bloch [26]; Maturana and Nisis [27]; Maturana and Verden-Zoller [28]); this proposal starts out from the notion that the process of learning through care (care of my knowing process, care of my body, of my emotions, of my community, of the world) is the essence of the biological-social-spiritual nature of human beings and of all living things. Knowing-is-being, living-is-knowing-what-it-is-to-be. And given that our being has come forth from a unique cognitive-corporal experience (our ontogenetic self-organizing path), our knowing is unique, so we can co-create a world by knowing it. This can be applied to the separation of being and knowing, an idea that arose through Cartesian rationalism. Diverse studies have shown that if the “information” perceived by our organism is not processed and interpreted with all of the body besides the brain (the skin, internal organs, muscles, bones, etc.), the process of “thinking” is meaningless to our being. The emotional environment represented structurally by the “limbic brain” is fundamental and without a substitute in the formation of consciousness (Berman [1]; Damasio [9]). This helps us to realize that ancient expressions such as “feeling butterflies in the stomach”, “a broken heart”, “think with the stomach”, etc., express something more than mere “images”; they are representations profoundly related to the nature of our thinking in our whole being.

Knowing, then, is keeping a “world at hand” (Maturana and Varela [11]; Varela et al. [21]), this in reference to the multidimensional experience of living through the bio-psych-social-spiritual dimensions in the process of knowing, the “whole person learning” process, Heron [22]. In other words, the cognitive process unfolds through the articulating integrity of the EXPERIENCE of our Embodied Being (Damasio [9]; Maturana and Varela [11]; Varela et al. [21]). The Spanish philosopher Xavier Zubiri called this process “sentient intelligence”, Zubiri [29]; correspondingly, the pedagogues, Candida Moraes and Saturnino de la Torre come up with a notion they name *sentipensar* (feel-think), Torre and Moraes [30]. Indeed, our emotional system constitutes an element that is essential for our knowing to exist and to be meaningful (Damasio [9]; Maturana [10]; Maturana and Varela [11]; Varela et al. [21]).

Thus, in the EcoDialogue Center we place special importance on the personal and collective processes of caring for the emotional world and its correlation with the transformation of reality, not through therapeutic processes but through participative settings in which the Circle of the Word, the process of co-learning (learning as a collective participative process) and the spaces of deep dialogue, Bohm [31], operate as participative processes for healing and for personal and communitarian re-learning. In the flow of our emotions, of that story and those doings that we shall now call *emotioning* of our experience, in the here and now of the present moment, is where we synthesize our evolutionary history as a specie (in the evolutionary chain of which we are part, phylogenetic self-organizing path) and, at the same time, as individuals living in a specific historical space and time (ontogenic self-organizing path), Maturana and Varela [11]. But our everyday experience of knowing what we are living and experiencing is what constructs us cerebrally and corporally as living, cognizant being. In other words, we co-produce what we are and what we know, whereas that which we co-produce and the world in which we live (our time-space environment) produce us (Morin [14], Nicolescu [17]).

10.6 Tenderness, Incarnated Knowing Styles and Sustainability

This space-time “world” is strongly marked by the relationship between the external space of effectivity and the internal space of affectivity, and vice versa. By effectivity we understand the open and communicative process in which the person participates in the life processes, while at the same time being aware of the constraints, the necessities and restrictions of a co-created reality. When this participation is carried on in a sustainable way, i.e. the whole system is improved or at least maintained for a long term, we call this intervention effective. By affectivity, we understand that the participative process expresses and cares about the emotional essence and necessities of the person and her or his community (values, traditions, tenderness, love, beauty, etcetera). The paradigms of the Western world favor efficiency (sort term and mechanistic) over affectivity (and effectivity too), since affectivity has no mercantile or apparently useful value and is therefore neglected and ignored. The reflection of this imbalance is perceptible in the overvaluing of the masculine by the patriarchal, which is understood as being associated with efficiency and the depreciation of the feminine associated with affectivity. It should be made clear that the gender of human beings is no directly connected with worldly masculinity or femininity, but the need for equilibrium leads us to a marriage between the femininity and the masculinity of the world, and within each person, Nicolescu [17]. Achieving this dynamic equilibrium requires a social femininity that can create social ties among human beings, as well as to re-create the sort of wisdom capable of building sustainable futures.

Faced by this situation, what this hyper-modern society immersed in a planetary crisis needs is a profound restatement of our relationship concerning feminization on one hand, and the reconstruction of what is masculine on the other (affective and effective masculine). This relational transformation involves our body, genders and, in the center, our relationship with nature.

This re-enchantment permits us to delve more deeply into our techno-scientific work so as to conduce it toward wisdom that does not classify and dissect nature or social and community processes, but lives and moves as one more of the beings it has created and reared, Vasquez Grimaldo [6]. In this involved and compassionate *good deed* it is possible to rediscover alternative and complementary principles, for example, the line, the dot and the circle, which are the central ancestral elements of mechanical, linear and rational engineering (Bartholomew [32]; Zajonc [33]), in order to apply them in promoting a dialogue of knowing styles, indispensable for sustainable knowledge and designs. A human observer re-inserted into nature, dialoguing through natural processes, can experience forms of organization, proportions and dynamics that are more complex and articulating, more sensitive to the multiple levels of reality than those we presently assume to be the only valid ones, in accord with modern science. The Chinese, with their Taoist and Buddhist science and technology, have produced an almost infinite repertoire of techno-scientific creations that are not based on empirical and rationalistic methodologies, and this tells us of a pluri-epistemology, Needham [34]. In many ways we can point to this style of knowledge as co-creating together with nature through a “feminine” techno-science, in which intuition, empathy and spelling out sensations play a fundamental role in the process of thinking. It is, then, through this kind of re-enchanted and eco-poetic (embedded in community and planet) kind of work that we can redirect our civi-

lization toward a life in communities where people live together and with nature, co-creating the ritual of the “art of proportionality”, Illich [35].

The process of self-organization and self-creation (the so-called auto-poiesis), Maturana and Varela [11], from our experience have shown to be the foundation for the biological and social processes of life, and consequently of our Transdisciplinary Re-Learning Community. It is this cognitive, epistemic, systemic, bodily-mental, ecological and planetary reconstruction of the human being that constitutes the essence of transdisciplinary re-learning and the dialogue of knowing styles. Therefore, the constant creation and re-creation of knowing styles, based on epistemological awareness, constitutes the fundamental systemic competence in the process of teaching-learning at the EcoDialogue Center.

It is in this complex dynamic of the Embodied Being where the permanent process of *knowing our knowing*, of *the self*, of *acting* and of *living together*, takes place through the so-called Biology of Love, i.e., the epistemological awareness that operates within the wholly integrated Human Being (Maturana [10]; Maturana and Bloch [26]; Maturana and Nisis [27]; Maturana and Verden-Zoller [28]). This cognoscitive and conscious reconstruction at all the levels, becomes articulated with the creative cycle of personal-community-social transformation that constitutes our work.

Thus, by means of *complex thinking* and the *biology of knowing and loving*, we are pointing up the necessity of co-generating processes of Transdisciplinary Re-Learning and Eco-Literacy, whose four pillars are centered on the process of learning to know, learning to do, learning to live together and learning to be, Nicolescu [17]. All this implies a praxis of re-learning by which living is recognized as a learning process, one that takes place within the somatic process by personally experiencing self-eco healing. Healing through the reconstruction of communitarian creative capacity. It is a question of generating processes requiring active participation, in which research and learning are directed toward the communities with which we collaborate and toward society in general.

With this object in mind, we start from the methodological proposal to retake the notion of Evolutionary Learning Communities (ELC), systems of local and alternative learning that seek to catalyze the social transformation toward the creation of sustainable and evolutionary futures (Laszlo [36]; Atlee and Zubizarreta [37]). The ELC are places for re-evaluating all the spheres of knowledge accessible internally and externally to all those participating in the experience-workshop. In these spaces a profound systemic dialogue takes place (Bohm [31]; Checkland [38]) it starts out from the *seed proposal* of each educative experience, eventually moving toward the set of local learning elements available within the collectivity of teachers-students-invited participants: texts, videos, poetry, oral knowledge, field experience, student’s personal histories, introspection, Falconar [23], sensitive observation of the environment (Barab [39]; Bowers [40]; Clinebell [41]), vernacular research among the peasantry’ (Núñez [42]; Vasquez Rengifo [6]), systemic inquiry, Checkland [38], co-operative inquiry, Heron [22], etcetera.

In tune with Morin’s *Method* [18]: “...there is no path walker, the path is made by walking it”, Machado [43], the ELC do not reject error, doubt or contradiction; nor they consider the particularities of local knowing styles as impediments to knowledge. These settings for re-learning do consider the perturbations, problems and stories of each participant in the knowing process, or the conflicts within the community as factors of enrichment in the research-action process. Thus, from the systemic focus we see “the crisis as opportunity” or “the crisis as bifurcation”, Laszlo [36], [44];

Prigogine [45]; the imbalances of the general human ecology in its different levels (physiological, mental-emotional, family, economic, inter-generational, community, cultural pathology, etc.) become stages for co-creative work in the ELC (Laszlo [44]; Atlee and Zubizarreta [37]).

The design of the ELC implies the creation of settings where people can co-learn about the interconnected nature of our world, feel the ecological impact of our individual-collective elections and the satisfaction of finding significant ways of contributing to the emergence of sustainable and evolutionary futures. We call this the process of eco-literacy, that is, the awareness needed for re-inserting human processes into an ecosphere and a general ecology, including the ecology of mind(s), an ecologizing of the life of each person and of the community through the experience of crisis as a co-creative opportunity. These processes are implemented at the heart of a framework of re-education (the constant creation of nourishing settings in which to learn from and for life) of the community for its constant reconstruction.

Learning is to establish a conversation with what occurs in nature. This is accomplished under a premise agreed upon by our community in consensus: that of doing weekly work in our gardens with our Mother Earth, taking care of our cultivated plants and letting them take care of us (horticulture and eco-literacy).

By expanding beyond a teaching that only assumes a rational apprehension of information a data, in the sense of grasping something mentally (an action does not result from an order that operates from the brain to the senses), what can emerge is the dialogue of knowing styles, the space of conversation that is established between feeling and the world within a community of learning. From what has been said, the recreation of a practice done with others does not produce an exclusive relation with knowledge but rather with wisdom; thus, the activity resulting, is not derived from an individual volition but from community action, that is, from the reciprocal raising in which the educators become re-created through the action of cultivate.

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CHAPTER 11

Integrating Transdisciplinarity in Undergraduate Education

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This chapter is aimed at a wide audience of students in capstone design classes that cut across multiple fields. In keeping with the dynamic nature of complex problem solving, modern teaching curricula must be designed in ways that help students develop critical thinking and problem-solving skills in both core subjects and new technology-driven content. This chapter presents a new methodology in engineering education that is focused on teaching students transdisciplinary skills thereby allowing them to become creative and innovative engineers. This chapter also presents an alternative to conventional textbooks in the form of a free, internet-textbook (iText-Book) comprising transdisciplinary learning modules that cut across multiple disciplines. Main objectives of this chapter are: to reduce the educational cost burden on students, parents, states and governments, thus helping society; and to teach students innovation skills, educating them broadly and preparing them for an increasingly transdisciplinary, collaborative, and global job market.

11.1 Introduction

“Education should have two objects: first, to give definite knowledge-reading and writing, language and mathematics, and so on; secondly, to create those mental habits which will enable people to acquire knowledge and form sound judgments for themselves.”¹

“We begin to think about the university as a place of ideas, not as an organization of academic disciplines.”²

A specific area of study is known as a discipline provided that it has cohesive tools, techniques, and specific methods and a well-developed jargon. As shown in Figure 11.1-a, disciplines unsurprisingly develop into self-contained hard shells, which

¹The Bertrand Russell Dictionary of Mind, Matter, and Morals, Citadel Press, P. 56.

²S. Upham, The Aims of Graduate Education, Keynote Address, Workshop on Global Transdisciplinary Education, and Research, SDPS, Pasadena, CA, June 2001.

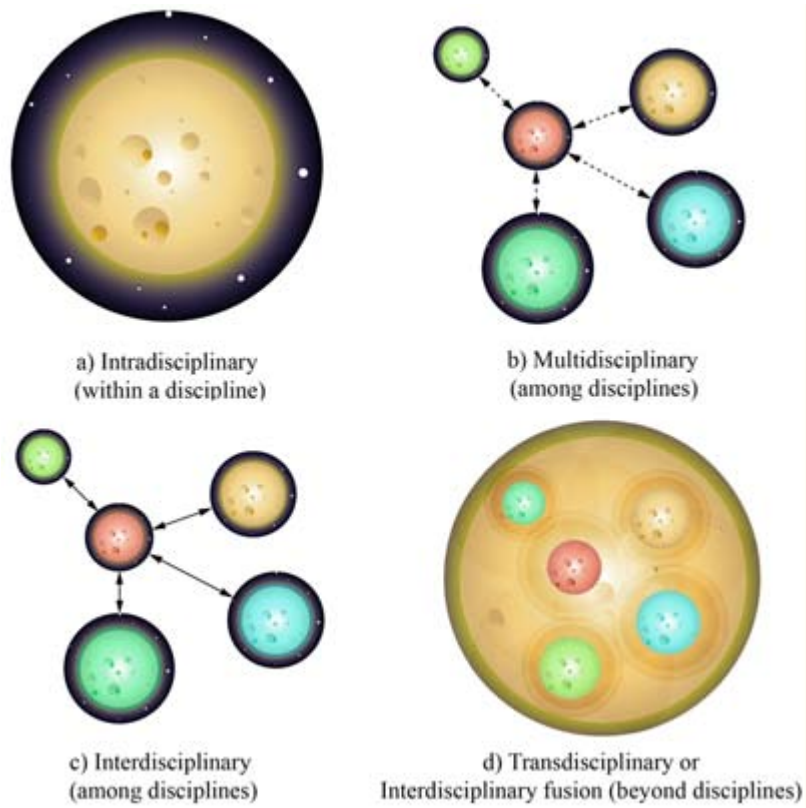


Figure 11.1: From disciplinarity to transdisciplinarity.

lean to minimize interaction with outside units or other disciplines. The longer a discipline evolves, the thicker and tougher its shell becomes. General practitioners of these disciplines develop an effective level of intra-disciplinary communication and collaboration due to their well-developed disciplinary jargon. However, the rigid disciplinary shell and the precision of the disciplinary jargon lean to minimize the communication and collaboration among the researchers from diverse disciplines. Thus, from the social sciences point-of-view disciplines develop territories that are intensely defended. Evidently, these territories and disciplinary shells are not in-sync with the move toward the current integration of technology. Today's problems are not obviously restricted to artificial discipline-oriented boundaries. Times have changed; a massive communication and collaboration infrastructure has helped to tackle on complex problems using larger groups of researchers from multiple disciplines.

Multidisciplinary teams and programs have been developed to address common problems that extend across several traditional disciplines. Multidisciplinary activities involve researchers from more than a few disciplines working basically independently, each from their own discipline specific perspective, to solve a common problem. Inadequate and weak communication combined with the territorial concerns limit the effectiveness of multidisciplinary efforts. As shown in Figure 11.1-b, multidisciplinary teams do cross discipline boundaries; however, they remain limited to the framework of disciplinary research.

In Interdisciplinary activities, researchers from various disciplines work jointly on common problems by exchanging methods, tools, concepts and processes among them to find integrated solutions. As shown in Figure 11.1-c, interdisciplinary activities also overflow discipline boundaries with strong link between them.

As shown in Figure 11.1-d, in transdisciplinary approach, hard shell of disciplinary boundaries disappeared. Soft disciplinary boundaries intersect each other for open communication and collaboration on a uniform platform that is common to all of them.

This chapter presents an alternative to conventional textbook design in an innovative approach to creating free, digital, internet-textbook (iTextBook) transdisciplinary learning modules crossing multiple disciplines, aimed at a wide audience of capstone design classes across fields. In keeping with the dynamic nature of complex problem solving, modern teaching curricula must be designed in ways that help students develop critical thinking and problem solving skills in both core subjects and new technology-driven contents and transdisciplinary contexts. This chapter also presents a new methodology in engineering education to teach students transdisciplinary skills to become creative and innovative engineers, integrated into a modular, participatory, and extensible publication format. Students need to be taught new skills for dynamically synthesizing new knowledge in response to new challenges.

Specific objectives of this study are four-fold: 1) to reduce the educational cost burden on students, parents, states and governments, thus helping society in general and in countries where the cost of print texts work against their adoption; 2) to provide students a deeper understanding of material from multiple domains of expertise; 3) to educate students with an ability to adapt to changes and to be able to work at the interface of different disciplines; 4) to teach students innovation skills, educating them broadly and preparing them for an increasingly transdisciplinary, collaborative, and global job market. Objective 1 can be accomplished by providing a free iTextBooks. Objectives 2, 3 and 4 will be accomplished by the inclusion of four core transdisciplinary modules, interactive homework problems, and module projects

in the iTextBook.

11.2 Transdiscipline

Over recent years, there has been growing interest among researchers and educators for organized collaboration on the national and international levels. The development of large scale collaborative efforts between researchers from disparate disciplines was spawned from the necessity to increase efficacy in solving complex problems that require knowledge from multiple disciplines. Realizing the benefits from collaborative research, numerous initiatives have been launched to develop transdisciplinary research groups and establish new or larger centers of excellence.

Definitions of transdisciplinary research go back to the early 1970s (Nicolescu, [1], Pohl [2]). Nicolescu (2005) stated that transdisciplinarity concerns that which is at once between the disciplines, across the different disciplines, and beyond all disciplines [3]. Klein (2004) distinguished between the terminology of multidisciplinary, interdisciplinary (ID) and transdisciplinary (TD) approaches as "Multidisciplinary approaches juxtapose disciplinary/professional perspectives, adding breadth and available knowledge, information, and methods. They speak as separate voices, in encyclopedic alignment...", "Interdisciplinary approaches integrate separate disciplinary data, methods, tools, concepts, and theories in order to create a holistic view or common understanding of complex issues, questions, or problem", and "Transdisciplinary approaches are comprehensive frameworks that transcend the narrow scope of disciplinary world views through an overarching synthesis... [T]he term also connotes a new structure of unity informed by the world view of complexity in science, a new mode of knowledge production that draws on expertise from a wider range of organizations, and collaborative partnerships for sustainability..." [4].

Stokols et al., defined transdisciplinary science as collaboration among scholars representing two or more disciplines in which the collaborative products reflect an integration of conceptual and/or methodological perspectives drawn from two or more fields [5]. Hadorn, H. G et al., stated that: "Transdisciplinary research is research that includes cooperation within the scientific community and a debate between research and the society at large. Transdisciplinary research therefore transgresses boundaries between scientific disciplines and between science and other societal fields and includes deliberation about facts, practices and values" [6]. Rosenfield defined Interdisciplinarity as a process in which researchers work jointly, but from each of their respective disciplinary perspectives, to address a common problem whereas transdisciplinarity is a process by which researchers work jointly to develop and use a shared conceptual framework that draws together discipline-specific theories, concepts, and methods to address a common problem [7].

Gehlert stated that "Transdisciplinary education that combines exposure to a range of disciplinary knowledge and methods with effective instruction in processes for working on teams to transform knowledge and methods into solutions for complex social problems is the gold standard" [8].

Cronin stated that "There is a need for transdisciplinary research (TR) when knowledge about a societally relevant problem field is uncertain, when the concrete nature of problems is disputed, and when there is a great deal at stake for those concerned by problems and involved in dealing with them. TR deals with problem fields in such a way that it can: a) grasp the complexity of problems, b) take into

account the diversity of life world and scientific perceptions of problems, c) link abstract and case specific knowledge and d) constitute knowledge and practices that promote what is conceived to be the common good." [9].

In summary, interdisciplinary and transdisciplinary research they both give integrated solution to a problem in question. Transdisciplinary research includes the key components of interdisciplinarity, along with the incorporation of external non-academic knowledge, applied to solve practical problems. Transdisciplinary research leads to a creation of new paradigms and provides pathways to new frontiers.

Engineering must play a vital role in advancing transdisciplinary efforts, and conversely transdisciplinary efforts will further advance engineering, technology, and science. The prospect of transdisciplinary research is exciting. New networks of researchers can be created in a short time, and other non-traditional participants can become involved in solving the world's problems.

The common threads of all disciplines are notions of design, process and systems (Tanik, et al.,1995) [9]. Design, process and systems (DPS) provide the patterns, the insight, and the judgment necessary to apply knowledge and skills to unstructured problems.

Herb Simon, in the section Holism and Reductionism of his most well-known book *The Sciences of the Artificial* [10] eludes the establishment of crucial balance between holistic thinking and mechanistic thinking. There is a clear parallel between disciplinary/ transdisciplinary thinking and reductionism/holism. In the effort of searching for solutions to this dichotomy a realistic approach has been suggested. Noticing the difficulties faced, Simon said, "We are learning that we need a science of complex systems, and we are beginning to construct it" [11]. In *The Science of Design* chapter of *The Sciences of the Artificial* [10] he says "The proper study of mankind is the science of design, not only as the professional component of a technical education but as a core discipline for every liberally educated person." Following Simon's lead, we believe that notions and patterns of *design, process and systems* are so fundamental that they cut across all disciplines. There is something in these concepts that introduces a *greater logical economy* in dealing with everyday concrete processes involving engineering activities and business relationships [12, 13]. The better logical economy is required more these days than any other time in the history of mankind. The reason is apparent in light of the vast expansion of mankind's knowledge base and the speed of introduction of new and exciting technological artifacts. Noticing this extraordinary knowledge expansion we should keep in mind that techniques and methods of the past is needed but not sufficient. A transdisciplinary way of acquiring knowledge means that education, research, development, production, and training are intertwined to produce a better picture and a higher level of abstraction [13].

From the realistic point of view, the systematic study of DPS for their own sake has the likely of providing the essential thinking to maintain intellectual control over the ever increasing information growth; therefore, developing into a scientific discipline. Future engineers or systems integrators, in this framework of integration, will develop functional artifacts and services by considering economical, environmental, social and ethical aspects of human awareness. The transdisciplinary nature of DPS utilization will prove important in improving largely research quality, productivity, and the education of students to build, sustain, and manage the next generation of enterprises as well as their products and services. The first step in achieving transdisciplinary education is to extract the common elements of DPS from existing

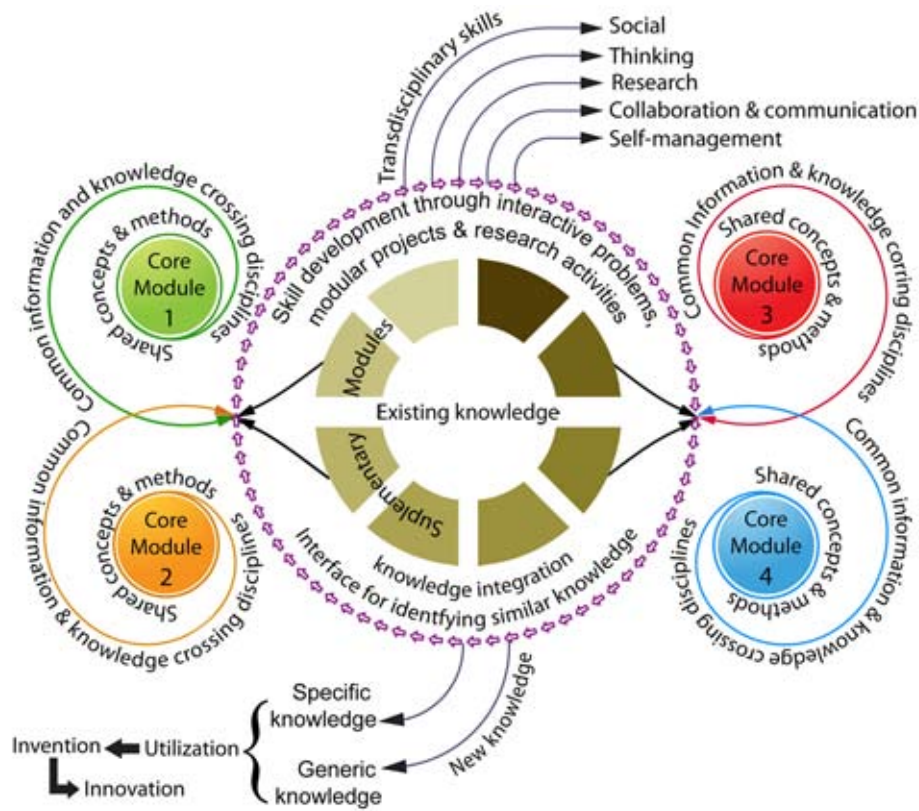


Figure 11.2: Transdisciplinary skills and new knowledge development process.

disciplines and synthesize them into the foundation of the transdiscipline. This extraction process can only be accomplished by broad study of the disciplines with an exclusive goal of identifying the truly common aspects. Once the universal aspects of DPS have been known, they must be woven into the fabric of the transdisciplinary educational model [12, 13].

11.3 Transdisciplinary Skills and Modules

As shown in Figure 11.2, four transdisciplinary core modules and twenty supplementary modules for a capstone design course is proposed. The content of the transdisciplinary core modules will include information and knowledge common to multiple disciplines. The core modules will also include appropriate shared concepts and methods. To provide students a deeper understanding of the material, there will be some content overlap between the core modules as seen from the figure. Students will progressively synthesize the modular information and knowledge as the mod-

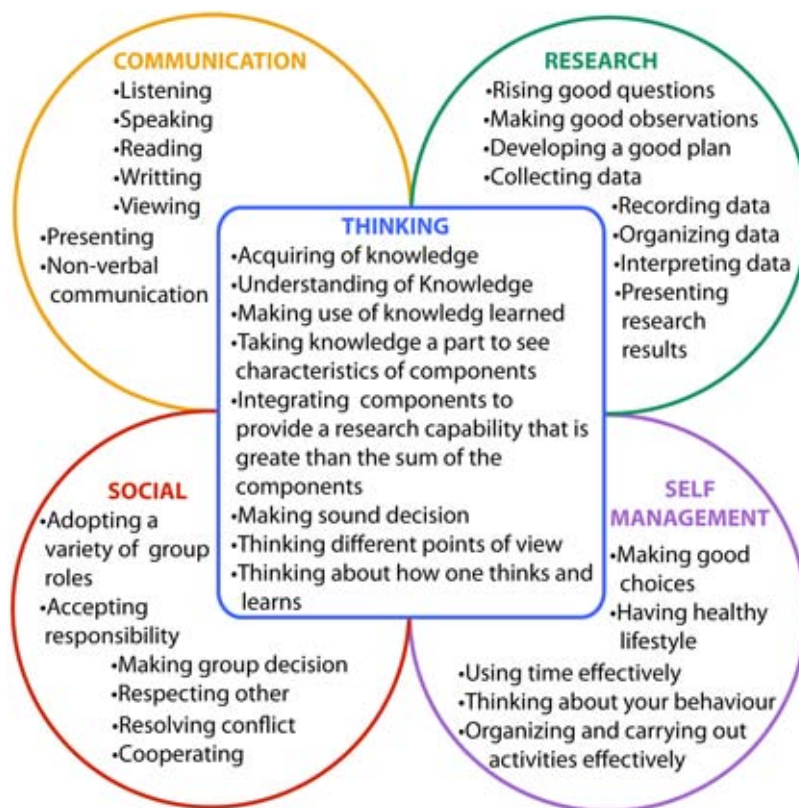


Figure 11.3: Transdisciplinary skills.

ules are covered to create a spiral of new knowledge and ideas. As shown in Figure 11.2, to produce new knowledge, the process of identifying similar knowledge and knowledge integration will take place at the interface of the core knowledge with the existing knowledge.

New knowledge should be generated by the student teams in order to solve a given research project. The existing knowledge that is available through supplementary modules along with the newly generated context specific knowledge can be applied to solve a specific problem. It should be noted that the solution of a context-specific problem may not be applicable for solving other problems of a similar kind. However, generic knowledge is applicable to solve similar kinds of problems. Generic knowledge enhances the body of knowledge in science and is applicable to solve societal problems [14]. Successful collaborative student teams will be able to bridge between knowledge and invention and ultimately results in innovation.

Students will also develop transdisciplinary skills (see Figure 11.2) progressively while working on interactive homework problems, performing their modular projects, and collaborating with students on research activities. They will learn, practice, and develop skills as defined in Figure 11.3 [15]. The success of the research team

depends on the team's ability to exploit their most valuable assets: knowledge, transdisciplinary skills, and creativity.

Although the past decade has seen growing interest and investment in transdisciplinary graduate education, undergraduate education remains predominantly dependent upon narrow, disciplinary foci. To prepare students to become transdisciplinary engineers and scientists, engineering programs must start integrating transdisciplinary courses into the undergraduate curriculum. Although researchers have become accustomed to working across disciplinary boundaries, the undergraduate classes offered by many universities have been the same for decades. Transdisciplinary thinking requires integrated broad knowledge from many disciplines which creates different types of talents to discover and solve unstructured problems (need transdisciplinary synergism) with creative and unusual but appropriate ways. Transdisciplinary skills in our students must be set in a rich soil so that the seed can germinate and in time grow into a "student of transdisciplinary." Undergraduate students should master transdisciplinary competencies before they go on to graduate studies or before they start working.

Dr. Dowling from Harvard University reports that by the year 2050 the average longevity of an American will be around 128 years. If we still retire at 65 years what do we do for the other half of our life time. Age decays our learning skills, particularly our memory and association skills which undergo steep decline. If we do not have these skills in later life, we spend half of our lifetime as useless vegetables. iTextBook process is not only mechanical. Aim of the process is to build skills. iTextBook creates curiosity in students which creates an interest and concentration so that students can absorb information. Consequently, they develop skills. It has been shown critical skills can be turned into habits which remain anchored in us for most of our lives. For example, old man can't find the kitchen in the house but when he is hungry because of the habit automatically goes to kitchen to eat. Therefore, a prerequisite to develop critical skills to help later professional updates and career migrations will be to enhance and reinforce these fading skills earlier in life through awareness, practice and most importantly education [16].

11.4 Textbook Costs

Government studies report a substantial increase in textbook costs. College textbooks can add thousands in cost to a student's education expenses. This is a tremendous financial burden for many students and their families and has a negative impact on federal and state government spending as financial aid providers. Textbook prices "represent a significant barrier to access and persistence." Textbook costs (in 2007) were found to range from \$700 to \$1000 per year; textbook prices have risen much faster than other commodities (more than 4 times the rate of inflation [17]); and college aid fails to cover textbook expenses (and many other college costs) [18].

Many faculty members select and assign textbook for their class with little concern to the cost of the textbooks. Often times, students try to find an inexpensive way of obtaining the required textbook—borrowing from friend or library, sharing with a roommate, renting, downloading an illegal version, or simply not buying the book. In one survey, 7 in 10 students reported skipped the purchase of a required textbook because of its high cost. Additional complaints about textbook publishing practices included frequent issuance of new editions that prevent use of used

textbooks, the packaging of textbooks with CDs, passcodes that expire, and custom editions created for their school [19].

Nevertheless, students recognize that they have to buy the books in order to do well in many classes. Lack of access to textbooks due to cost is even worse for disadvantaged students at historically disadvantaged colleges and universities. The high cost of textbooks has a negative impact on improving educational access in the USA.

Equal attention should be paid to the content and quality of textbooks. Modern teaching curricula must be designed in ways that help students develop critical thinking and problem solving skills in both core subjects and new technology driven contents. It is questionable whether today's traditional textbooks, in general, make a positive contribution to learning. How much and how fast can students absorb information from a voluminous (600 to 800 pages) textbook in a one-semester course? Just like loud noise is bad for one's ears, too much information overload is bad for one's brains. This results in developing a short attention span and harms the learning process associated with the science, technology, engineering, and math topics that require deep and sustained mental concentration.

11.4.1 Open Educational Resources

About a decade ago, MIT started free online learning by using the Internet to share the by-products of its campus teaching – including syllabi, lecture notes, assignments, and exams. This effort was initiated to improve learning worldwide, mainly through providing resources to educators, and also as a way to encourage other universities to share their intellectual assets rather than providing them only to those who could afford to pay [20].

Recently, Rice University received funding in the form of grants from the William and Flora Hewlett Foundation, the Bill & Melinda Gates Foundation, the 20 Million Minds Foundation and the Maxfield Foundation to offer free course materials. Using Rice's Connexions platform, OpenStax (a non-profit publisher) will offer free course materials for five common introductory classes. The grant money is used to hire experts to develop each textbook and to have their work peer reviewed. However, if an instructor decides to use supplementary material from a for-profit company, that would be an additional cost to students [21].

Students can download the OpenCourseWare materials for all the required classes for a four-year degree at Harvard Medical School. One can read all the course materials and take all the quizzes and tests. Moreover, students can even grade themselves. However, students cannot get a degree from Harvard – not unless they pay tuition. Similar arguments can be made for recent MIT and Stanford initiatives [22]. Obviously, if students are not seeking for a degree they have the potential for a huge benefit from a good OpenCourseWare program. For this proposed study, the goal is not only to provide free modular textbooks or courseware but more fundamentally to change the textbook content, design and development to improve student learning. Through the proposed study, professors and instructors will have the freedom to design and customize a textbook with respect to the needs of different students, such as majority, average, or disadvantaged students. The students will design and develop their own modular projects and will provide solution(s) collaboratively to produce new knowledge. The inclusion of transdisciplinary core modules will teach the students the conceptual foundations of transdisciplinarity. Ultimately, students



Figure 11.4: Process for creating iTextBooks.

will learn conceptual and methodological strategies designed to enhance the processes and outcomes of collaborative, team-based research to address important practical problems.

11.5 Creating iTextBook

As the pace of improvement of new technical systems has sustained to accelerate, the necessitate has shifted from interdisciplinary or multidisciplinary design teams to trans-organizational and transnational work. During the last decade, the number of complex problems facing engineers has exploded, and the technical knowledge and understanding in science and engineering required to strike these problems is speedily evolving. A few examples are the innovative advancements in semiconductor technologies, software technologies, the biosciences, and nanotechnology. The last two decades of designing large-scale science and engineering systems educated us that neither disciplinary, nor multidisciplinary or interdisciplinary approaches provide an environment that promotes the collaboration and synthesis necessary to extend beyond existing disciplinary boundaries [23].

As mentioned earlier, the essence of transdisciplinary engineering and science lies in the common ground built on the foundation of design fundamentals, process development, and systems design. The core of design, process, and systems knowledge is broad, incorporating concepts and methods from many different disciplines. A sound transdisciplinary engineering and science needs, of course, to incorporate knowledge from many different areas. Therefore, as shown in Figure 11.4, in the proposed process for the creation of iTextBook, the core of knowledge areas centered on design, process, and systems will be augmented with peer-reviewed supplementary modules. The modules will be clustered in the three categories; yet, these three categories are interconnected. In fact, some of the modules in them could be stored in two or three of the categories.

Modules will be designed to be stand-alone, and professors, instructors will be able to assemble custom and focused content for students. This focused approach will help students master the most pertinent and applicable subject matter. The process for creating iTextBooks, as shown in Figure 11.4 is creative, interactive, and dynamic. The iTextBook process is configured to present subject matter options for the creation of modules that are stored in a database. The module database can contain the newest and most common modules used across several disciplines. The modules selected for creating iTextBooks are dynamically revised to keep them up to date. iTextBook will have the characteristics of adaptability (make the module content flexible to meet the learning outcomes and learning style of different students), personalizability (each student is different—an iTextBook can be assembled for the majority of students, for average students, for disadvantaged students, or for individual students), and customizability (the iTextBook content can be customized for different disciplines). Modules that are not updated can be eliminated from the database or sent to the authors for revision at any time. The revision of one or more modules is far more efficient than revising an entire textbook and publishing a new edition.

Objectives 2, 3 and 4 will be accomplished by the inclusion of four core transdisciplinary modules, interactive homework problems, and module projects in the iTextBook as described below.

11.5.1 Modular Projects

The iTextBook, representative of textbooks of the future, will promote project-based-learning. Instead of assigning the students to solve already established homework problems to students, professors and instructors will assign modular projects to be conceived and developed by student groups to reinforce fundamental concepts and to generate innovating projects. This will shift students' efforts away from some of the homework problems at the end of traditional textbook chapters. As an alternative to traditional homework problems, students will be allowed to develop their own research-based, open-ended modular projects and propose solutions. Modular projects enhance the content. Besides teaching module content, the open-ended modular projects can teach students critical and creative thinking skills. By developing and solving modular projects, students can create things outside the box. Namely, students already know something, but instructors want them think beyond and above what they know to produce new knowledge. The process of developing modular project is not only rote. The aim of the process is to develop skills and habits to strengthen the students' abilities in terms of teamwork and leadership.

Requirements to Design Modular Projects

To complete each module, student project teams will be assigned a modular project, which will integrate most of the fundamental concepts of the module that students have learned. Since design, process, and systems are envisioned as the essence of the transdisciplinary concept, each module will have three following modular project requirements: 1. Design requirements, 2. Process requirements, and 3. System requirements. Students must follow the generic modular project requirements to design and develop their modular projects. Some examples are:

- Identify the important parameters affecting solution decisions;
- Investigate which parameters affect the solution most;
- Relate the modular project to human health, security, disasters (water crisis, food crises, earthquakes, tornadoes, tsunamis, and flood), economics, business, management, etc;
- Relate the modular project to sustainability (addressing environmental, economic, social aspects);
- Relate the modular project to complexity (natural, social, humanities, engineering);
- Consider functional requirements, ethical issues, safety issues, and contemporary issues;
- Evaluate and report the following transdisciplinary attributes [24]: project design, development, and implementation; knowledge integration/synthesis; new knowledge generation; collaboration (the interaction of social and cognitive factors in collaboration and teamwork); management and leadership, networking; creativity and Innovation; research and bibliometric measures (literature search, new findings, chapter publications, etc.).

If the modular project involves system thinking, that should be also clearly stated. Students must show each and every step of the solution process. Requirements will be clearly stated at the end of the module by the author of the module to guide students to design their modular projects.

It is important to note that the final modular project will be the cumulative result of the modular projects given previously. This process will provide a progressive approach for designing and developing modular projects and knowledge synthesis. Therefore, the modular approach to presenting the materials will provide a mechanism and opportunity for the students to combine knowledge from multiple modules and promote the skills of finding and integrating tools and methods from what have traditionally been separate knowledge areas.

11.5.2 Introducing Interactive Homework Problems

To facilitate a deeper understanding of the material, besides traditional homework problems, interactive homework problems will also be included in the appropriate modules. Interactive problems will help students develop problem-solving strategies that are based on conceptual understanding, rather than equation manipulation. These interactive problems can be manipulated by the students to explore the effects of parametric changes on the problem. Interactive process promotes more fundamental and generalizable understanding of the material, as opposed to “cook book”

approaches that instill pattern matching between chapter examples and homework or exam problems.

11.5.3 Implementation

The scope of possible module subjects spans the curriculum and encompasses the sciences (physical, social, and biological), engineering, medicine and health, philosophy, technology, mathematics, arts and the humanities. Examples of some generic module topics include, but are not limited to social systems, natural systems, life-support systems (atmosphere, water and food), ecology, life processes, process science, cognitive process, mental process, process modeling, process ontology, design process, engineering design, science and design, healthcare design, bio-design, energy, safety, sustainability, environment, economy, business, management, complexity, education, ethics, collaboration, communication and many others.

However, for this study, transdisciplinary iTextBooks for the first part of the capstone engineering design course will be proposed to be used by all the engineering disciplines as well as those from other scientific disciplines such as environmental science, economics, and business. Capstone design courses integrate knowledge, concepts, and skills associated with the whole sequence of study in a program. Although the idea of including a capstone course in a degree program is not new, the format of capstone design courses changes considerably among different disciplines [25, 26]. The two-semester sequence of capstone design courses at the Texas Tech University in the Mechanical Engineering Department has the objective to better prepare graduates for engineering practice. In the first semester of the capstone design sequence (ME 4370, Design I), design problems characteristic of engineering are used to introduce students to the engineering design process. Topics covered and associated exercises include problem formulation, design requirements and specifications, project management, concept synthesis, decision making approaches, analytical considerations of cost, design optimization, codes and standards, engineering communication, ethics, environmental considerations, and sustainability. In the following semester, the second part of the capstone design sequence (ME 4371, Design II) utilizes industry-level team projects to prepare students with important design, implementation, communication, and presentation experience. The following twenty-four modules that cut across engineering disciplines for the first part of the capstone design course are proposed.

Transdisciplinary Core Modules

- *Transdisciplinarity and Complexity (1)*: A practical foundation for complexity is presented that enables an engineering system's complexity to be evaluated against its functions and qualitative factors, such as social mores and human values. The course covers a) definitions and characteristics of complexity; b) modeling of complex systems; c) tools and methods for managing complex systems; d) strategies for reducing complexity; and e) transdisciplinary applications of complexity theory.
- *Transdisciplinary Sustainable Design and Development (2)*: Transdisciplinary methodologies to guide research, policy and action towards sustainability will be covered. Students will learn broad research skills and knowledge in strategies for sustainable integration, sustainable resource use and management, en-

environmental conflict resolution, policy formulation and decision-making. Using case studies, interconnectivity of environment, economy and society will also be discussed.

- *Transdisciplinary Training and Research Process (3)*: The focus of this course is to enable the students working jointly with others representing diverse disciplines. This course covers: generic design; collaborative activities, conflict resolution; practice and research ethics, transdisciplinary research process using a system of systems approach; impact of social issues on design; generic activity-based transdisciplinary research process framework; the role of experts in transdisciplinary research processes and transdisciplinary case studies.
- *Transdisciplinary System and Product Development (4)*: System/product development involves product planning, technology planning, requirements engineering, concept development and selection, design elaboration, process design, implementation and testing as well as management of various resources. This module teaches transdisciplinary system and product development methods, techniques and tools so that engineers can have a big picture view of the whole system/product life and use systematic approaches to design and development of products and systems.

Supplementary Modules

- *Design Category*: Design Analysis for Materials Selection (5), Prevention through Design (6), Environmental Psychology (7), Environmental Design (8), Bio-Design (9), Nano-Tech Design (10), Healthcare Design (11), Modeling and Simulation (12), Reliability and Safety (13), Optimization (14), Innovation and Creativity (15), Engineering Ethics (16), Project Financial Modeling & Management (17).
- *Process Category*: Statistical Decision Making Process (18), Risk Analysis and Assessment Process (19), Entrepreneurship (20).
- *Systems Category*: Systems theory and thinking (21), Social Systems Design (22), Systems of Systems (23), Collaboration, Communication, and Teamwork (24).

Figure 11.5 shows the network of twenty-four modules and their relationships. From the network given in Figure 11.5, instructors can create several different kinds of iTextBooks for different students from different disciplines for capstone design courses. The inclusion of core modules will teach students the transdisciplinary skills required to identify, frame, and address important practical problems that cut across disciplinary boundaries. Because the transdisciplinary core modules are focused and independent, they can also be mixed and matched with other courses or integrated into the redesign of an entire curriculum.

11.6 Expected Learning Outcomes

The expected learning outcomes that will result from this project will be:

1. to provide students a deeper understanding of the material,

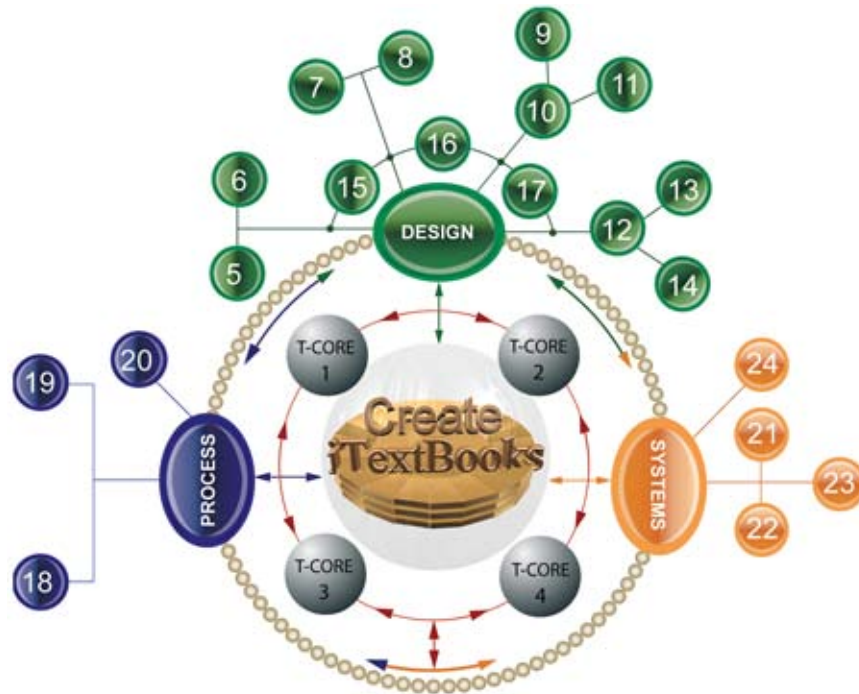


Figure 11.5: Network of modules.

2. to educate students with an ability to adapt to changes and to be able to work at the interface of different disciplines,
3. to teach students innovation skills,
4. to educate the students broadly and to prepare them for an increasingly trans-disciplinary, collaborative, and global job market, and
5. to teach transdisciplinary skills to identify, frame, and address important practical problems that cut across disciplinary boundaries.

11.7 Assessment and Evaluation Plan

The process for defining, assessing and evaluating learning outcomes is shown in Figure 11.6.

11.7.1 Formative Assessment

Formative assessment will be conducted: by goal setting to create clear expectations, by observations to verify student understanding, by questioning to give opportunity to students demonstrate what they have learned, by given very short essay question to project teams which will demonstrate collaborative activities, and by student

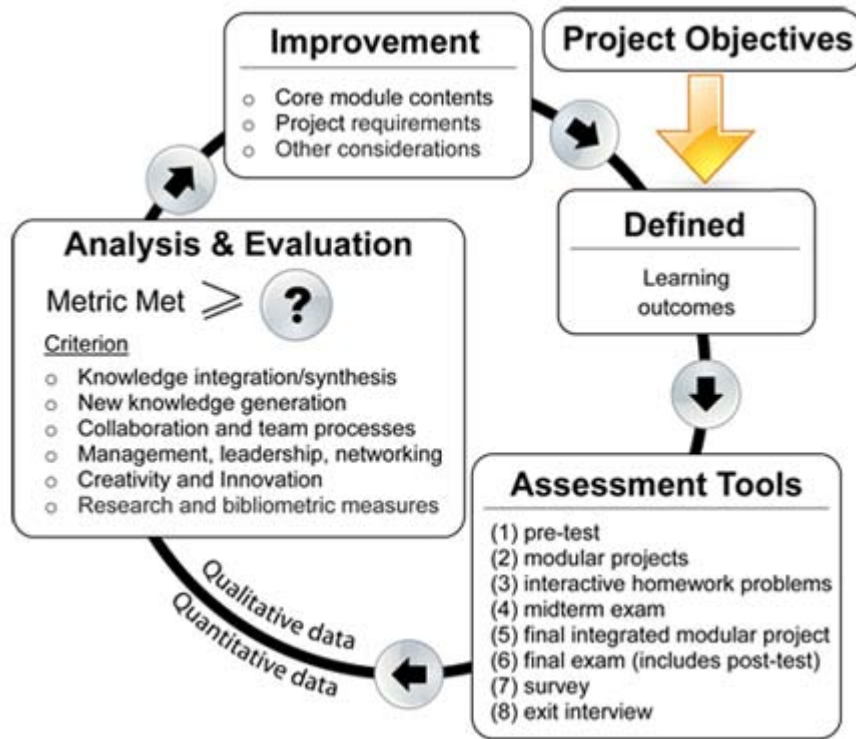


Figure 11.6: Process of assessment/evaluation.

record keeping to help students better understand their own work [27, 28]. Since formative assessment will provide feedback to students, it may not be used as an evaluation tool.

11.7.2 Summative Assessment

Summative assessment process will be conducted at the beginning, at the midterm, and also at the end of the class in order to judge student's overall performance and to determine whether long-term learning goals have been met. This process will include continuous assessment tasks during the entire one semester class period. Summative assessments tools will include:

1. pre-test,
2. modular projects,
3. interactive homework problems,
4. midterm exam,
5. final integrated modular project,
6. final exam (includes post-test), and

7. survey, and
8. exit interview.

Evaluation will be a collaborative activity between teachers and students. Students will assume an active role in evaluation so they can begin to develop individual responsibilities for development and self-monitoring. To accomplish this goal, a survey will be developed to assess student opinions about the usefulness of the proposed concept and to collect standardized information through structured questionnaires to generate quantitative data.

Survey questions will be developed using the learning outcomes (defined previously) and also using the main factor requirements stated as follows: Five treatments (main factors) to be compared in the analysis are: (1) Introducing transdisciplinary core modules (treatment A), (2) Introducing modular projects (treatment B), (3) Introducing interactive problems (treatment C), (4) Introducing transdisciplinary project collaboration (treatment D), and (5) Introducing the process of integrative teamwork (treatment E).

11.7.3 Statistical Approach for Survey Data Analysis

One Way ANOVA will be used to test hypotheses regarding the equality of the main factors (treatments) [29]. The basis of ANOVA is the partitioning of the sum of squares into between-treatments sum of squares, $SS_{between}$ and within-treatments sum of squares, SS_{within} . This will facilitate comparisons of observations simultaneously rather than individually. In this analysis, we will assume that samples are normally distributed. F test defined by Equation (1) will be used to evaluate the null hypothesis.

$$F = \frac{MS_{between}}{MS_{within}} \quad (11.1)$$

Since there are more than two treatments (in this case, 5) of independent variables, statistical analysis will be carried out in two steps:

Step 1. Perform the F test to determine if any significant differences exist among any of the means. If the F test value shows statistically significant, then carry out the second step.

Step 2. In the second step, a post-hoc analysis will be performed to determine where the inequalities are. A post-hoc test is used when there are three or more means to compare. This test provides us the critical difference between all possible two means. For this study, Fisher's Protected t-test will be used. The formula is given by:

$$F_{compare} = \frac{(M_i - M_j)^2}{MS_{within}(\frac{1}{n_i} + \frac{1}{n_j})} \quad (11.2)$$

Where i and j are the treatments being compared, and n and M are the number of observations and the mean of treatment, respectively. The test statistics will be performed for each pair of means by using the values of $F_{compare}$ and F_{cr} . The critical value of F_{cr} is determined from statistical tables using the degree of freedom between treatments and the degree of freedom within the treatments' values. The calculation of the values of $F_{compare}$ and F_{cr} will guide us to make a decision whether question #1 is statistically significant and which treatment is the less or most dominant factor to provide students a deeper understanding of the material.

Development of Survey Questions

Now, consider the learning outcomes defined in Section 6 and the main factors (treatments A, B, C, D and E) for the ANOVA analysis. For example, Question #1 corresponds to the first learning outcomes with 5 treatments defined previously. Then, survey question #1 should read as:

Which treatment is significant *to provide students a deeper understanding of the material*. Place a 1 next to the item that is least important and place a 5 next to the item that is most important.

- Introducing transdisciplinary core modules (treatment A)
- Introducing modular projects (treatment B)
- Introducing interactive examples (treatment C)
- Introducing transdisciplinary project collaboration (treatment D)
- Introducing the process of integrative teamwork (treatment E)

Pre-Test and Post-Test

At the beginning of the class, students will be randomly assigned to modular project teams to eliminate selection bias. This process will allow one to measure not only differential gains between groups, but also absolute gains in skills and knowledge. Each student will take a conceptual design project as a pre-test upon entry into the capstone design course. This special conceptual design project will be developed in a way that the solution(s) will require all the transdisciplinary characteristics, skills, and tools for innovative design solutions. The same conceptual design project will be given as a post-test as a part of the final exam. The comparison of pre-test and post-test will provide concrete data that could be scored and analyzed to see whether there is a gain in student learning pertaining to transdisciplinarity.

The results of the modular and final integrated modular projects can be compared for each student team to determine average gains in student learning in transdisciplinary skills. Interactive homework problems, midterm and final exam questions can be analyzed to determine the students understanding of the fundamental concepts. This analysis can be conducted by using rubrics similar to the one used to analyze the modular and the final integrated modular projects results. Moreover, a group of students can be interviewed after the course is over to understand their preconceptions and misconceptions about the material covered in transdisciplinary core modules.

Table 1 shows criteria for determining transdisciplinarity. Although means for evaluating transdisciplinary processes are a big challenge due to their multidimensional character, Table 11.1 can provide reasonable conceptual framework measures for transdisciplinary evaluation [24, 30, 31].

11.8 Conclusions

With the challenges discussed above in mind, consider the future of U.S. higher education. One need is for customizable content. With modular textbooks, professors or students can dynamically assemble suitable content that is most up-to-date.

The high price of textbooks is a tremendous financial burden for many students (especially economically disadvantaged students in U.S., students at the historically

Table 11.1: Criteria for determining transdisciplinarity.

Indicators to Measure Transdisciplinarity	Degree of Indication
Deeper understanding of the material	Check: midterm and final exams; interactive problem solutions to what degree and how correctly methods and fundamental concepts are used.
Transdisciplinary skills	Check: social, thinking, research, communication, and self-management skills.
knowledge integration	Check: whether the content of the research outcomes reflect knowledge integration; diversity of knowledge sources; sharing from different sources; how many of the integrative steps set out and how well the steps were carried out [31].
Generation of new knowledge that transcends disciplinary boundaries	Check: content of the research outcome; what kind of existing data and information are used to transform them into a new knowledge; knowledge assets such as intellectual capital; value of new knowledge (technical, economic and social).
Collaboration and team processes	Check: practice of collaboration of the project teams with different disciplines; interaction of social and cognitive factors in collaboration and team work; transdisciplinary behavioral patterns of project team members; use of external experts.
Innovation	Check: capture of new physical phenomena; bootstrapping of existing technologies; use of disruptive technology; patent system.
Creativity	Check: number of concepts generated (fluency); diversity of concepts generated (flexibility); originality of concepts generated (originality); check amount of detail of concepts (elaboration).

Table 11.1: Criteria for determining transdisciplinarity (continued).

Indicators to Measure Transdisciplinarity	Degree of Indication
Management, leadership and networking	Check: how well the organizational structure fosters communication; networking among group members and project teams; joint work activities and shared decision making; leadership tasks (cognitive tasks, structural tasks, and process tasks).
Research and bibliometric indicators	Check: literature search, diversity and the co-authorship of the references publications used, content of the research outcome, possible paper resulted from the modular project; research benefit to society.

disadvantaged colleges in U.S. and in non-industrial nations) and their families and has a negative impact on federal and state government spending as financial aid providers. One of the key aims of this proposal is making a contribution to the community and society as well as making an impact in education. It is believed that the curriculum improvements that will result from this project will have significant impacts on undergraduate engineering education. iTextBooks will have the characteristics of adaptability (make the module content flexible) to meet the learning outcomes and learning style of different students), personalizability (each student is different) and an iTextBook can be assembled for the majority of students, for average students, for disadvantaged students, or for an individual student and customizability (the iTextBook content can be customized for different disciplines).

The biggest impact of the project will be seen when iTextBooks are made freely available to the world academic community and trans-sector organizations in the public and private sphere (the target is approximately 70,000 engineering seniors in the U.S. as well as those from other scientific disciplines such as environmental science, economics, business and in countries where the cost of print texts work against their adoption).

The digital nature of these texts allows for the incorporation of interactive homework problems in each module. These problems can be manipulated by the students to explore the effects of parametric changes on the problem. This promotes a more fundamental, generalizable understanding of the material, as opposed to “cook book” approaches that consist of pattern matching between examples and homework or exam problems.

The text books of the future will promote project-based learning. Students will work on projects that apply the concepts learned in each module to real-world problems. Students will be motivated to learn the material because they can immediately see the importance of the concept for dealing with real-world context and situations. Moreover, the projects will promote a deeper understanding of the material of each module through requiring the students to synthesize new knowledge in the form of implementations of the concepts and tools.

Finally the modular approach to presenting the materials will provide a mechanism and opportunities for the students to combine knowledge from multiple modules and promote the skills of finding and integrating tools and methods from what have traditionally been separate knowledge areas.

The Academy of Transdisciplinary Learning and Advanced Studies (TheATLAS) will work together with many international distinguished scientists and engineers to accomplish this important project.

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