COMPLEX MODEL OF A TRANSDISCIPLINARY ACTION-RESEARCH PROGRAM ON THE ENVIRONMENT, THROUGH INTERINSTITUTIONAL NETWORKS

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ABSTRACT

We propose a complex integral model of environmental transdisciplinary action-research processes through interinstitutional networks for the National Polytechnic Institute, NPI (Instituto Politecnico Nacional, lPN), a large and influential Mexican public university.

The great quantity of interrelated factors which characterize turbulent socio-environmental phenomena in today's world, need to be observed and studied as processes of great complexity, from different worldviews as *cognitive phenomena* that require a transdisciplinary gaze. The program of the interinstitutional research network is being designed and implemented, through a gradual participative integral or systemic action-research or iterative cybernetic process.

Today, at the NPI, there are several research and action networks working on environmental problem situations. This program, links research networks with action networks through a systemic transdisciplinary process, in which a heterogeneous group of professors, students, authorities and administrators participate with research-action projects at different units within the institution. The results of the projects can also be applied in public, private and social organizations. The environmental action-research network program is comprehensive, it is oriented towards research, design, implementation, and diffusion of a series of integrated synergic technological solutions or ecotechniques, to solve water, energy food, waste, housing, education and health problems under a conscientious vision of integral and sustainable quality.

INTRODUCTION

In this article, we develop a complex model of a transdisciplinary action-research process oriented to address problem situations of environmental systems; it is organized as an interinstitutional network.

Confronted by the great turbulence of the contemporary social and environmental world, it is increasingly evident that specialized theoretical approaches fail to construct adequate solutions at the level of real world issues, and fall short when the solutions are implemented in practice, in the particular conditions of each context. This turmoil is characterized by a dynamic and complex relationship between economic globalization processes, political reorganization and cultural globalization. Furthermore, the growing importance of information and communication technologies in public and daily life only adds to this state of commotion. Thus, the quantity and variety of interrelated factors that characterize socio-environmental phenomena of reality need to be observed, understood, constructed, validated and shared as *cognitive dynamic complexes* that require a transdisciplinary outlook for their complex theoretical-practical integration

under a conscious ethical vision of lasting socio-environmental quality, or process of integral and sustainable quality.

Given the scenario, we are creating a transdisciplinary research-action program in the National Polithecnic Institute, NPI. In addition, two networks, one action-based, one research-based, have been created at the NPI to confront environmental problem situations at the institution. The environmental action network that covers all schools within the institution was created in 2007 under the name of Environmental School Committees, ESC. For each School there is a corresponding committee in which professors, students, administrators and authorities participate by jointly diagnosing the performance of the institute on environmental matters, as well as by designing and applying solutions at various work centers. The Environmental Interdisciplinary Research Network, EIRN, is one of four research networks created at the institute also in 2007; it is constituted by students and researchers from different IPN schools and it aims to develop interdisciplinary studies on environmental matters. For additional information, read the annex on the National Polithecnic Institute and its research and action networks working on environment issues.

The object of this complex model is to achieve collaboration under a transdisciplinary systems outlook in the form of an interinstitutional network, and to develop participative research-action processes to diagnose the environmental status of the institution with involvement of professors, students, administrators and authorities, with the aim of designing synergic solutions using ecotechniques. The proposed solutions that come out of each of the IPN units would ideally be expanded to the greater society, and particularly to the most vulnerable sectors at the national level. These solutions can be promoted in different confines, locally, regionally, nationally and globally. To this end, we emphasize a deep development in philosophy, theory and methodological tools of systems sciences to ensure integral solutions that include different fields of knowledge in environmental matters.

CONTEXT

Transdisciplinarity makes conciliation necessary between the internal universe and the external universe, between experience and theory, between the subject and the object

Basarab Nicolescu

Given the enormous complexity of the contemporary world, characterized by a dynamic interrelation between processes of economic globalization, political reorganization, cultural integration and environmental degradation, we find it necessary to design collective inquiry processes of participative action-research. Advances acquired through information and communication technologies support these processes, and their application within the different realms of daily life, such as the familiar, educational and productive realms. Therefore, the incapability of theoretical and exclusively disciplinary approaches for constructing adequate and knowledgeable responses at the level of the relevant problems is increasingly becoming evident. Thus, the quantity of interrelated factors that characterize current social phenomena need to be observed studied and constructed in a participative manner as *complex cognitive models*.

THEORETICAL FRAMEWORK

"If I find someone capable of being reality in its diversity and, at the same time in its unity, that is the man who I search as a god"

Plato

"Knowledge imparted in fragments does not bring any interest and is not a source of meaning in general"

Edgar Morin

We use as theoretical framework four relevant concepts:

- *The ecosystemic metaphor*
- *Transdisciplinarity*
- *Cybernetic process*
- *Network organizational process*

Ecosystemic metaphor

The use of the ecosystemic metaphor serves as an image, as a guide for the design process of the Transdisciplinary Action-Research Program (TARP) or (Programa de Investigacion-Accion Transdisciplinario, PIAT, in Spanish). Some of the themes applied in this metaphor are:

- Territoriality
- Unity in diversity
- Equilibrium and sustainability

Ecosystems exist in geographical territories in which there is interplay of natural and human factors characteristic of each region. In each territory exists an ensemble of non-living, living and conscious systems that interact through processes of unity in diversity, which generate synergic effects. Permanence or sustainability of the ecosystems is based on processes of dynamic equilibrium.

Ecosystems are high quality natural product and process, resulting from a long co-evolutionary process of continuous improvement in an evolutionary medium towards dynamic equilibrium and sustainability. They are part of the biosphere, of Gaia, as a great cybernetic process of living and non-living systems on Earth. They are linked to the Solar system and the cosmos. Ecosystems are territorial, since each one emerges from specific conditions of space, time and culture of each region of the planet. They are the result of a unity in diversity process. In each space-time, where an evolutionary process has happened, there is an emergence of complexity and conscience due to increasing evolutionary knowledge.

Transdisciplinarity

"In the transdisciplinary neither the one nor the other predominates"

Gregory Bateson

"Transdisciplinarity is a generalized transgression that opens up a limitless space of freedom, knowledge, tolerance and love"

Basarab Nicolescu

Building a transdisciplinary thought allows one to overcome attachments, overcoming limited and partial interpretations. The great problems of risk-prone societies are transversal, transnational, multiple, multidimensional, transdisciplinary and planetary

Motta

In the fragmented world of disciplinary knowledge, two specialists in the same discipline must make a serious effort in order to understand their respective results. Today there are hundreds of disciplines. The tower of Babel is the metaphor that describes the lack of communication, which takes place in disciplinary science.

This process of "Babelization" cannot continue without putting our own existence in danger because a decision-maker becomes increasingly more incompetent regardless of his or her intention. Without exception, each of the major challenges of our era -- for example, the challenge of formulating an ethics adapted to the contemporary world -- require more and more competencies. However, it is obvious that even a group comprised of the best specialists from all the various disciplines would only be able to develop one generalized incompetence, for the simple reason that the sum total of competencies is not competence. Now, what is a decision maker, individual or collective worth, if it is not capable of taking into account all the givens of the problem being examined?

Disciplinary research concerns, at most, one single level of reality; moreover, in most cases, it only concerns fragments of one level of reality. The indispensable need for *bridges* between the different disciplines is attested to by the emergence of pluridisciplinarity and interdisciplinarity during the middle of the 20th century. *Pluridisciplinarity concerns studying a research topic not in only one discipline but in several at the same time*. Interdisciplinarity has a different goal from multidisciplinarity. *It concerns the transfer of methods from one discipline to another*.

Transdisciplinarity is nevertheless radically distinct from multidisciplinarity and interdisciplinarity because of its goal, the understanding of the present world, which cannot be accomplished in the framework of disciplinary research. The goal of multidisciplinarity and interdisciplinarity always remains within the framework of disciplinary research. *Disciplinarity, multidisciplinarity, interdisciplinarity and transdisciplinarity are not unlike four arrows shot from a single bow: the bow of knowledge*.

Within the last two decades a new form of knowledge has arisen, transdisciplinary systemic knowledge, which integrates and harmonizes in a systemic manner, the diverse forms of knowledge that have emerged in different stages of recent cultural evolution

On the contrary to other forms of knowledge, *transdisciplinarity concerns the dynamics engendered by the action of several levels of Reality at once*. The discovery of these dynamics necessarily passes through disciplinary knowledge. As the prefix "trans" indicates, *transdisciplinarity* concerns that which *is* at once *between* the disciplines, *across* the different disciplines, and *beyond* all discipline. Its goal is *the understanding of the present world* , of which one of the imperatives is the unity of knowledge.

The deep frame of reference of transdisciplinary knowledge has an ethical character, it has a philosophical base, it is the dimension of greater profundity of knowledge of all complex systems, it is the dimension that achieves integral sustainable processes of quality by linking complexity and knowledge.

Transdisciplinarity is a broad means of acquiring knowledge to answer the state of planetary human crisis. This form of systemic knowledge is meant to transcend the limits of different areas of disciplinary learning, of the subjects and objects they encompass. It is a form of knowledge oriented towards transforming reality systems in a more complete and integrated way through which human beings, in their process of inquiry about themselves and their world, observe themselves, and they observe, dialogue, encounter, and better understand their reality.

The integration of different disciplines or the meeting of experts in a multidisciplinary manner signifies transcending beyond academic wisdom, being and feeling the global ambience in which we live. It makes us aware of our role and our responsibility as human beings on the planet and it uncovers the need for the enrichment of the truth through integral or systemic reflexive dialogue. It is linked to sustainability of the planet and all its forms of life and culture. Transdisciplinarity is a path to be followed by researchers and by all who are searching for learning toward wisdom, toward recovery of their own equilibrium. (Table 1).

Rigor, *openness*, and *tolerance* are the fundamental characteristics of the transdisciplinary attitude and vision. *Rigor* in argument, taking into account all existing data, is the best defense against possible distortions. *Openness* involves an acceptance of the unknown, the unexpected and the unforeseeable. *Tolerance* implies acknowledging the right to ideas and truths opposed to our own.

Table 1.
Comparison between multidisciplinarity (multi and pluri) and transdisciplinarity

DISCIPLINARITY/ MULTI OR PLURI	**TRANSDISCIPLINARITY**
Theoretical knowledge produced on a desk or/and in the lab, *in vitro*, on subjects isolated by specialty, through use of analytical intelligence (left hemisphere of the developed brain). It is based on Aristotelian logic, with a disciplinary scientific attitude.	Theoretical-practical knowledge, produced *in vivo*, which relates subject and object. New intelligence (left and right hemisphere). Results from harmony between the physical body and feelings. Transdisciplinary education revalues the role of intuition, imagination, sensibility and the body in the transmission of knowledge. Recognition of the existence of different levels of reality governed by different types of logic is inherent in the transdisciplinary attitude.

Aims to rationally know, prove and explain with certainty, disciplinary aspects of reality's systems. Disciplinary experts do the inquiry with scientific rigor, based on proof and control.	Aside from knowing and explaining, one understands, feels, applies, gets feedback, reflects and shares. It is considered as the affective dimension that appears in participative processes of research-action. It is based on the included third logic, the dialectic to join opposites and the plurality in the forms of knowledge or transdisciplinarity. Tolerance is practiced between the different styles and ways of acquiring knowledge.
It focuses on the study object, forgetting on most occasions, the richness of the natural and cultural environment. There is little tolerance for experts from different disciplines and for other forms of knowledge.	Aside from observation of the study object, it requires self-examination by the observer. It does not lose integral sight of the human and his or her environment or context. It has an open approach to knowledge that goes beyond the field of the exact sciences Transdisciplinarity does not exclude a trans-historical horizon. It teaches contextual, concrete and global approaches. The transdisciplinary approach is inherently trans-cultural
Knowledge is separated by discipline, with little awareness over its relationships and the unity of the different forms of knowledge.	Transdisciplinarity complements disciplinary approaches. It causes the emergence of new data and new interactions out of the encounter between disciplines. Transdisciplinarity does not strive for mastery of several disciplines but aims to open all disciplines to that which they share and to that which lies beyond them. In comparison with interdisciplinarity and multidisciplinarity, transdisciplinarity is multireferential and multidimensional. Its keystone is the semantic and practical unification of the meanings that *traverse* and *lay beyond* different disciplines, and demands their dialogue and their reconciliation with the humanities and the social sciences, as well as with art, literature, poetry and spiritual experience.
En muchos casos no se consideran valores, ni ética, ni el para quien, el por qué y el para qué It does not consider, in many cases, values or ethics. It does not answer why, what or for whom.	Oriented to service to others or the other, taking values into account, it implies a re-education process to do transdisciplinary systemic science. Shared knowledge should lead to a shared understanding based on an absolute *respect* for the collective and individual Otherness, united by our common life on Earth.

Cybernetic process

"Action-Research and Critical Systems Thinking are two icons carved out of the same log"

M. Levin

Critical Systems Heuristics, CSH, and Participatory Action Research PAR as M. Levin says are two icons carved out of the same log. They are two cousins living in different parts of the world under specific multicultural contexts. Each one has a wide body of knowledge and experiences, but little contact with each other. The strength of PAR is the design of an empowerment process from the grass roots, it addresses the basic and fundamental issue of fairness in a polarized world, in PAR the main decision makers are the communities affected by a systemic method of change. A critical

approach to system design means planners making transparent to themselves an others the normative content of designs. Each methodological design has qualities and limitations including CSH.

We need a heuristic cybernetic method to link the design with the real conditions of the world. Concepts are heuristically necessary if, only by making them explicit, it becomes possible critically to reflect upon the presuppositions entering into planning and social systems design and action. Critically heuristic categories are established around fundamental distinction between those involved in any planning decision (client, decision maker, planner) and those affected, but not involved (witnesses). There is a methodological link between the formal and practical experts, the planners and the witness. A radical participatory process erases some of these boundaries. PAR is a product of third world struggles and radical change processes and social science from the grassroots. It has more than thirty years o worldwide experience in the application of an emancipatory process of empowerment with the underprivileged. CSH has a deep theoretical background of systems and social science.

The cybernetic process is the basis for the design of the systemic methods of research-action, which include two important processes, one of concrete action, or praxis in the real world, and one of modeling as a result of the research process. Action and research are linked through processes of closed iterative cycles of permanent feedback and learning. Cybernetic processes are intelligent; they compare the result of each action with a referenced design model. When the feedback process occurs, the virtual design is compared to its application in a complex evolutionary context and thus, knowledge is generated. This learning experience is of great use in achieving evolution, continuous improvement and innovation of models and applications, adapting them to the changing context of the real world and generating changes in itself, through creative action of the designers who use the additional information of the feedback process.

The second order cybernetic approach is a theoretical and practical outlook, with feedback and feedforward reflexive loops. It is a continuous, intelligent, heuristic, learning and transformation process toward sustainable dynamic equilibrium as an open and reflexive process, it is a profound feedback loop under the guidance of metaphors as a framework toward a coherent behavior in the long term.

Network organizational process

Recently, network forms have been adopted for inter and transdisciplinary processes of research and action. Complex open processes are handled, they are non linearly redundant, dynamic and horizontal in the shape of a network, ideal for the linkage of researchers from different specialties, professional experiences and with diverse worldviews. Through these organizational processes, joint researches take place on complex reality systems, under a transdisciplinary manner that links different types of knowledge. Networks, as complex and dynamic processes, facilitate horizontal linkage of the different forms of knowledge of the people involved in participative processes of research-action as open systems. In the systems that undergo intervention, it is necessary to simultaneously consider the dynamic internal and external inter-relationships, which are generated by communication processes between members of the network and between them and their cultural medium, where internal and external clients interact through participative and interactive processes of research-action, with feedback, as a permanent cyclic process.

Two network types are handled as a bifocal network process of personal and institutional networks. Personal networks are the foundation of the organizational

dynamics, they are based on relationships of trust between people who have known each other for decades. In personal networks, there is a central nucleus composed of a few individuals, perhaps three or more, and a wider group of personal relationships, which surround the nucleus. The persons in the central core have a collection of personal relationships inside the research network and with other people with similar interests. At the same time, several network participants are members or leaders of related institutions and organizational processes that may become associated formally or not. The essential elements are the relationships, mainly those in the nucleus, which maintain group unity in time, despite the environment's changing conditions, which generate continuous adaptive changes in the open network processes.

TARP PROGRAM DESIGN

Design of the Transdisciplinary Action-Research Program (TARP) includes defining the following:

- **General and Specific Objectives**
- **Design of the organizational process in the form of an open network**
- **Participants**
- **Organizational development strategies**
- **Implementation at the NPI as a case study**

A Transdisciplinary Action-Research Program (TARP) or (PIAT in Spanish), is being designed at the (Posgrado en Ingeniería de Sistemas, PIS), of the (Seccion de Estudios de Posgrado e Investigacion, SEPI), of the (Escuela Superior de Ingenieria Mecanica y Electrica, Unidad Zacatenco, ESIME Z), at the)Instituto Politecnico Nacional, IPN) (consult the annex on the IPN and its environmental research and action networks). The TARP is being developed to give an integral response to complex contemporary socio-environmental phenomena, rooted in the past and which may have great impact on life in all its different manifestations.

Development of the TARP, has involved an emergent process in the form of a network for transdisciplinary solution of problem situations affecting, Mexican, Latin American and worldwide societies at a local, regional, national and global level. An assembly of high-level human resources, from diverse areas of expertise and experience is being convoked. In parallel, the necessary infrastructure is being designed and assembled in order to develop the program, at the different stages of development. The first stage of the action research process will take place at the different campuses of the IPN, starting within the main campus, the Unidad Adolfo Lopez Mateos on the north side of Mexico City. Different technical socio-environmental projects will be implemented on campus facilities to integrally solve environmental concerns of the educational institution.

Transdisciplinary vision and participative cybernetic process of research-action

Objectives

General

To generate a capacity for participative transdisciplinary research-action

This capacity has the following characteristics:

- From an **interinstitutional space** that encompasses al regions of Mexico starting from the central campus of the NPI, it aims to concentrate efforts and resources from the NPI and the country.
- With an integral, technical and humanistic education that allows for the design, definition, planning, realization and sharing of results of the participative processes of systemic transdisciplinary action-research on relevant problematic situations of the real world.
- From a transdisciplinary perspective that links academicians and users of different educational levels and with different professional and practical experiences.

Specific

- The transdisciplinary research programs, which are designed in the form of an open network, have an educational objective for the NPI and for participating individuals and academic and non academic institutions
- It strengthens the creation of a critical mass of transdisciplinary systemic researchers.
- It serves as an extension toward economic, political, and social sectors looking for integral answers to complex environmental situations in each of the country's regions and in other countries.

Design of the TARP organizational process in the form of an open network

The design form of the open research-action network is innovative. There are research networks like the one at the NPI, particularly the Environmental Research Network, ERN, of interdisciplinary academic character; however, these networks are not linked to other networks oriented to the application of knowledge, such as the Academic School Councils, ASC of the NPI. These councils aim to resolve in an operative manner the environmental issues at the institution's facilities, and generate a participation process of many persons who work in the NPI. That is the reason for linking them, since they are complementary to interdisciplinary research and to theoretical-practical actions of continuous improvement. They are similar to a TARP, which bridges research and its application in different instances including that of the educational institution. The association between both networks and with other organizations and people at the NPI and of other organisms occurs through a bifocal network process. They are like two interlacing networks, that of personal relationships between people with shared objectives and that of institutions through people with memberships in NPI organizations like the EIRN and the ASC (See Figure 1).

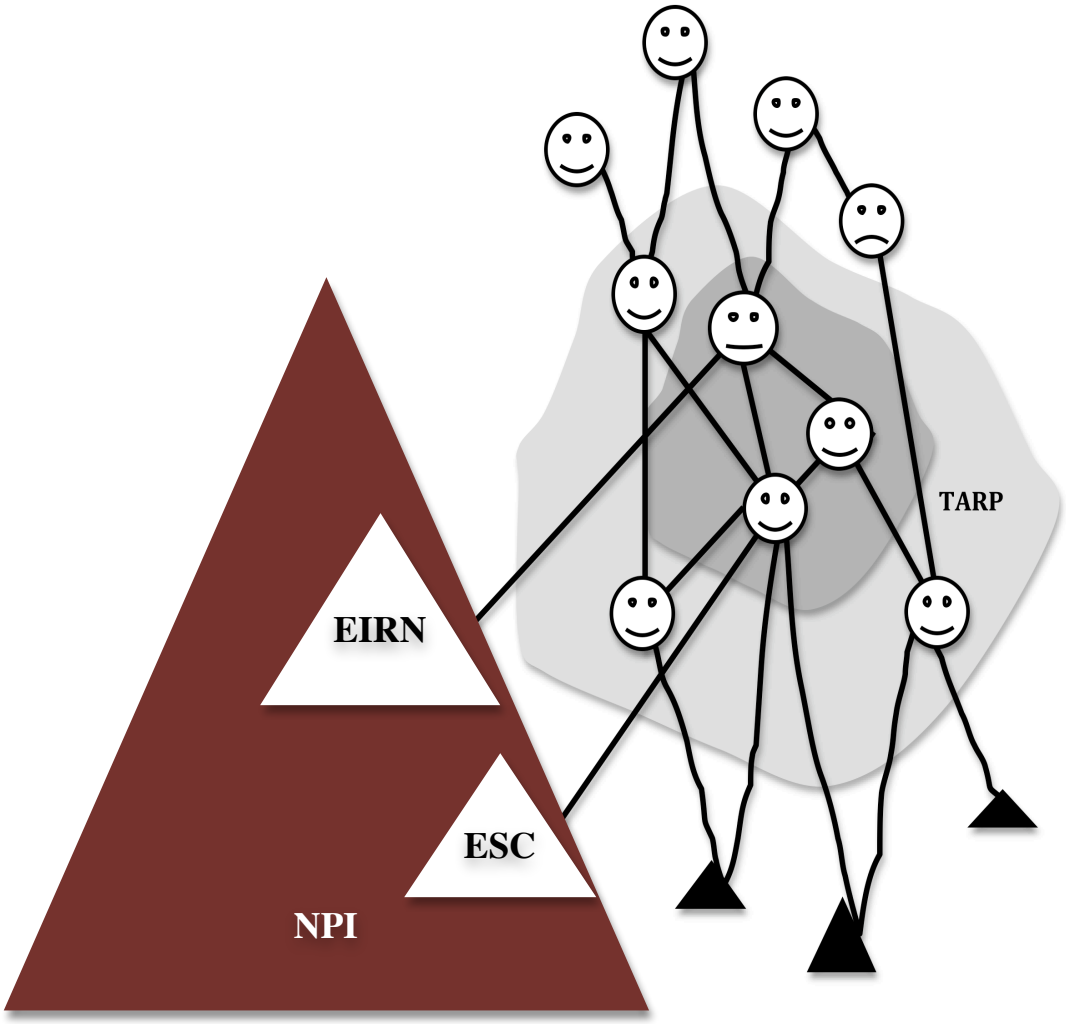

Figure 1. Bifocal network of persons and organizations from the Transdisciplinary Action-Research Network (TARP), and its links with the Environmental Interdisciplinary Research Network (EIRN), and the Environmental School Committee (ESC) of the National Polytechnic Institute (NPI).

Participants

An assembly of high-level human resources, from diverse areas of expertise and experience is being convoked. The researchers have a rich combination of academic and professional expertise on technological development, economic analysis, educational and health systems, on sociology and environmental studies, on information and communication systems, on the design of mathematical models and they also have professional experience in the building industry, organic food and alternative energy production, on organizational development, etc.

Organizational development strategy

The first stage of the action research process will take place at the main campus on the NPI, the Unidad Adolfo Lopez Mateos, on the north side of Mexico City. The first

project is on the integral management of wastes in the ESIME Zacatenco Engineering School in the main campus of the NPI. Researchers of TARP are also leaders of Academic Environmental Council of ESIME Zacatenco, and also participate in the Interdisciplinary Research Network on the Environment. In the initial project teachers and students of the ESIME Engineering School are participating with administrators and authorities in an integral environmental action-research long term. Project.

Later on, in the next stage, similar integral projects on the environmental management of water, energy, food, and forestry programs will be designed and implemented. This project is a pilot program that is in touch with similar projects in different schools of the NPI at a national level through the environmental research and action networks on the environment. The main campus of the NPI is becoming a huge laboratory for action-research programs with the participation of different members of the community from its different schools. It is an inclusive critical transdisciplinary participative process.

In later stages, thorough the personal and institutional relationships of the members of TARP, and through the educative and diffusion infrastructure of the NPI, the results of the environmental projects will be extended to other educative, productive, governmental, and social organizations of the city, and the country. Its academic results will be published at the national and international congresses.

CONCLUSIONS

1. The Transdisciplinary Action-Research Program, TARP is a product of a long-term building of a network of persons with similar interests on the environment who are working on the National Polytechnic Institute, NPI, at a graduate program of Systems Engineering. The hearth and mind of TARP, is a small group of researchers who have worked together for a long time in different social and environmental research and action projects, each one has also other relationships with researchers, students and organizations working on environmental problem situations in the NPI and other academic and professional organizations, in different parts of the country. It is a bifocal dynamic open network of persons and institutions.
2. The NPI in the last two years has begun large programs on the environment. It now has an interdisciplinary high level research program, the EIRN from the different graduate programs of the institution, and also Environmental Schools Council, ESC, of the different technical, college, and graduate programs of the institution with a broad participation of teachers, students, administrators and authorities.
3. The design of TARP uses as a guideline the ecosystemic metaphor, in which the territory are the NPI facilities, the unity in diversity process is achieved through the selection of an appropriate group of people with an environmental vocation who have different types of complementary knowledge, experiences and visions, who can work together in harmony. This group has the common vision of working toward sustainability through a transdisciplinary action-research participative process.
4. TARP is now at its initial stage of development in the NPI, in its next stages of organizational development it will extend its process of transdisciplinary action-research in social and environmental problem situations in Mexico City, and other parts of the country. It will also participate in national and international

congresses with articles on the main results of this systemic transdisciplinary program on relevant environmental problem situations.

5. The TARP program, has the vision of becoming a seed of environmental concience for the members of the important Mexican public education institution, the National Polytechnic Institute, NPI, and its thousands of students, teachers and laborers. The NPI is an influential educational system in Mexico with international presence.

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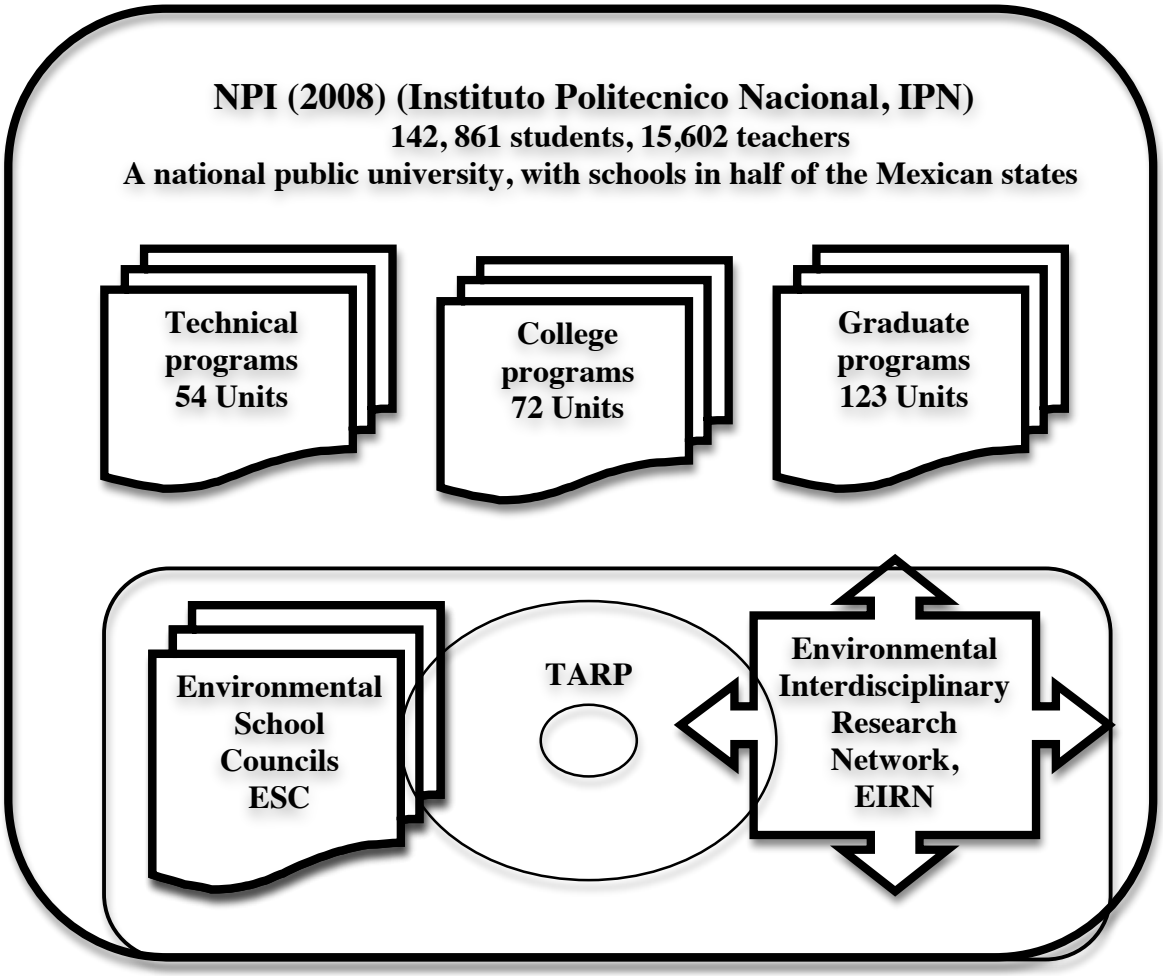
http://www.ipn.mx/wps/wcm/connect/ipn%2Bhome/IPN/Estructura%2Bprincipal/

ANNEX 1. The National Polytechnic Institute (NPI) and its environmental research and action networks



The Program on Transdisciplinary Action Research, TARP on the environment, is a research activity of the graduate program on Systems Engineering of the NPI. A group of researchers from this program participate in the Environmental School Councils, ESC, and in the Environmental Interdisciplinary Research Network, EIRN of the NPI. The members of this program of transdisciplinary action-research program have been active for decades in the systemic study of environmental problem situations and also in the social application of technical and social solutions in different parts of the country, they have also published articles in many national and national congresses.