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INVITED PAPER

Rethinking research management in Colombia

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Abstract

Purpose – This paper seeks to present a proposal to change the form in which knowledge is produced in Colombia.

Design/methodology/approach – Discusses the key issue – to transform the way in which the production of knowledge is currently taking place at the university level.

Findings – To be able to increase the production of knowledge in this country there is a need to create bonds among industrial, governmental, and academic institutions. It is believed that this can be done by the development of a system capable of continuously forming researchers at a doctoral level.

Originality/value – The paper puts forward a proposal for the construction of such a system based on the developments of organizational cybernetics. The proposal is based on the concept of autonomy which is crucial to solve this problem.

Keywords Organizational planning, Cybernetics, Research work, Colombia

Paper type Conceptual paper



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1. Introduction

The construction of the knowledge society (Drucker, 1994) produces changes that can be seen in new developments in science & technology, in the emergence of new schemes for tertiary education, and in the evolution of a culture that swings from modernity to post-modernity (Lyotard, 1984).

Within the knowledge society the organization of graduate and postgraduate education experienced unexpected transformations. The USA is the current leader in new knowledge production (*The Economist*, 2005). With a coverage of 52.5 percent in tertiary education (United States Census Bureau, 2003) and having 17 of the 20 best universities in the world (*The Economist*, 2005). The United States of America has integrated the tertiary system to technological research and development (R&D) (*The Economist*, 1997).

In this paper, we intend to make explicit the need to re-construct the moral, intellectual, and organizational autonomy of the tertiary education in the Colombian context. Such re-construction is based on the interpretation of research as the cohesive factor of all university functions. In this sense, research is the articulating agent of teaching and social projection.

The basic thesis of this work is that we consider the university as the social organization in charge of the upbringing of autonomous citizens in the production of knowledge. The professor-student relationship is the invariant structure that conforms this institution. This structure has its origin in the *universitas magistrorum et scholarium* as from the twelfth century (Clark and Neave, 1992). Throughout history this relationships has been organized in different ways. In order to explore this ontogeny (Maturana and Varela, 2004), the following questions are valid: how to re-construct the Colombian context of the tertiary education system? What are the changes in the function of the university? How has the habitat of the institution been modified? How can we organize Colombian tertiary education to increase the production of new knowledge?

The paper is organized in five sections. In each section we address each of the questions previously stated.

Since, the basic concept on this paper is research, we want to state how we interpret it. We understand research as a systematic process towards the production of new knowledge. The task of the university is to construct the autonomy of a citizen with respect to her abilities to produce new knowledge. This new knowledge can be subjective, social, or universal. This means that a person with a professional university degree is an autonomous citizen in the production of any new subjective (Foucault, 1990) knowledge in the discipline in which he has been educated. We understand that a person is a subject in the sense that she is subjected by a greater system.

A master's degree should imply a citizen autonomous in the production of any new social knowledge from her discipline. A citizen with a doctoral degree is autonomous in the production of new universal knowledge in her discipline. These later citizens become the "stewards of the discipline" (Golde and Walker, 2006) in the context on which they produce new knowledge.

The concept of autonomous citizens is presented in this paper not as an abstract description but as a way of solving a problem in Colombia. This means that, we are not interested in discussions regarding methodologies or theories. Our disposition is directed at changing the system, we feel that systems science should focus its effort in

resolving or dissolving fundamental problems of peripheral countries, in the world system, like Colombia. We have stated in previous works (Zarama *et al.*, 2004). In this case we are taking into account that Colombia is far behind the leaders of the production of knowledge in the world. To illustrate this we can recall that in 2004 Colombia graduated 44 doctoral students, while the USA graduated over 58,000 students (*EL_TIEMPO*, 2006).

Following these thoughts, the concern that we address in this paper is: how to manage the research system in a developing country, in such a way that it will help us close the gap between us and world leaders in knowledge production?

2. Current knowledge production in Colombia

In Figure 1 we show the total expense in R&D as a percentage of the gross national product (GNP) for the year 2003 in comparison with other countries. The bar-chart indicates that Colombia is far behind in investment on R&D. Figure 2 shows the differences of people dedicated to R&D in different countries.

Various characteristics regarding research in Colombia can be seen on Figures 1 and 2. In this paper, we are interested in observing research from the point of view of universities. Two aspects that help to understand the participation of tertiary education in research are the coverage and the number of publications. The coverage of higher education in Colombia was less than 1 percent up to 1950. This coverage increased to 12.25 percent in 1993, to 16.5 percent in 2003, however, this is far behind the average (25.7 percent) of Latin American countries and (54 percent) of the OECD countries (DNP, 2005). In terms of publications it is observed that the number of publications per 1,000 persons, taking into account the population of the country (CIA, 2006), indicates that the publications from 1997 to 2001 of some countries (King, 2004) and Colombian publications of that same period in ISI Thompson registered by Colciencias shows that Switzerland had an index of 8.87, Sweden had 8.09, UK in the

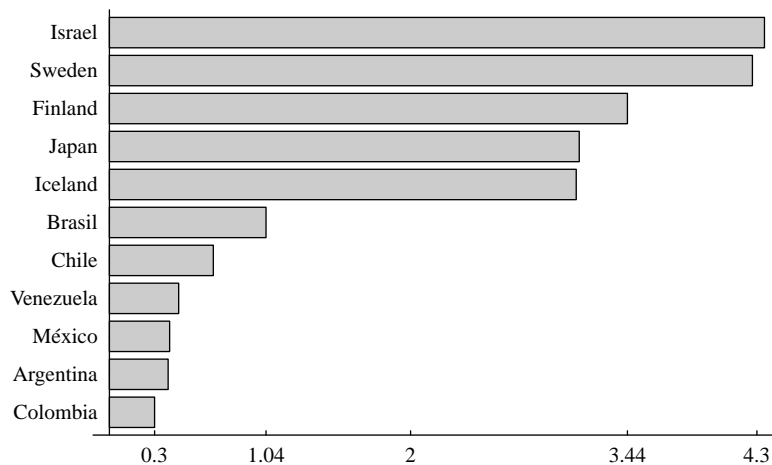
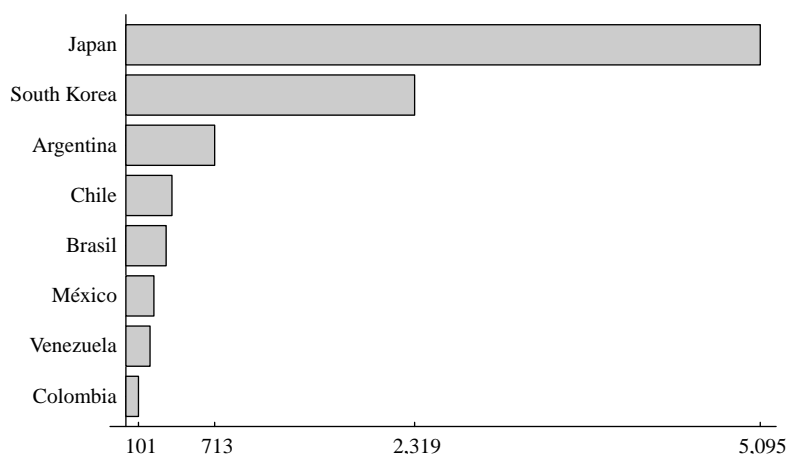


Figure 1.
Total expense in research and development as a percentage of the GNP, year 2003

Source: DNP (2005)



Source: DNP (2005)

Figure 2.
Researchers per million
population, year 2000

sixth place had 5.65, the USA in the eleventh place had 4.24, China had 0.09 and Colombia 0.08.

The main strategy that Colombia designed to increment its number of publications within a strategy of R&D is the “Sistema Nacional de Ciencia y Tecnología” (National Science & Technology System, SNCyT). A basic unit of this system is the research group. The research group is organized to satisfy the necessary organizational autonomy with the possibility of institutional and national recognition. This structuration process (Giddens, 1986) originally presented in 1990, has been tested, studied, and modified in such a way that today Colombia is held as a pioneer in Latin America (Villaveces, 2002). In Figure 3 we show the evolution in the number of research groups in Colombia in recent years.

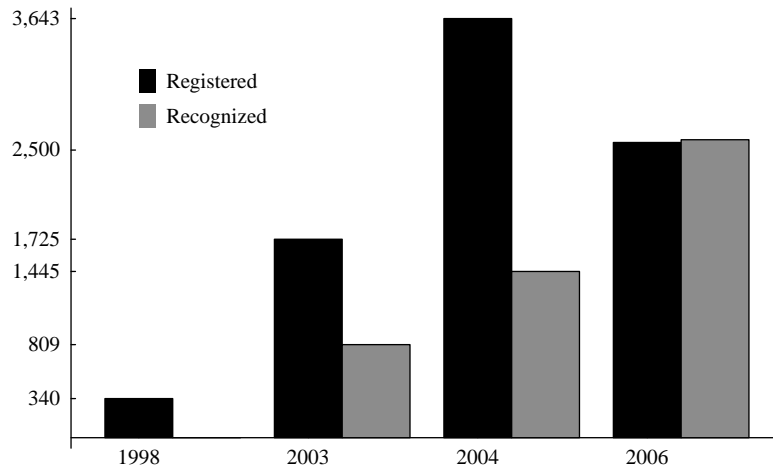
Our main statement is to organize the research groups around and within research centers like the ones we propose in Section 5. We have designed, proposed, and constituted one of these centers that is called CeiBA-Complexity (Dyner *et al.*, 2006).

3. The role of the university in the knowledge society

Our proposal is to structure the centers mentioned at the end of the previous section for the education of PhD students working around strategic problems of the country. For that reason the main partners of the centers should be different universities. Therefore, we are going to indicate, in this section, how we see the role that the university institution is playing.

The way in which knowledge has been produced in universities has had different influences. These influences can go back to Aristotle’s reflections on the nature of theoretical and practical knowledge and the acquisition of technical abilities. The most recent reflections appear to answer to the so-called postmodern condition (Lyotard, 1984) that indicates the state of culture after the transformations that have affected the rules of engagement of science, literature, and arts from the nineteenth century. Within

Figure 3.
Number of registered and
recognized research
groups in Colombia for
1998, 2003, 2004 and 2006



Source: DNP (2005)

these reflections there is an argument that questions the division of tasks in a university.

The evolution of those reflections has influenced changes in the functions of the universities. To observe such, we should go back to the origins of the University of Bologna around the twelfth century. In that university, students enjoyed a high level of autonomy to select the courses they wanted to attend. We call this kind of organizational form a *universitas scholarium*. A few years after the foundation of that institution a new type emerged with the foundation of the University of Paris. This university focused education as a process to discipline students. This kind of organizational form is called *universitas magistrorum*. Other centers were created in Europe through the following centuries in which schemes and instruction themes were copied mainly by religious orders (Clark and Neave, 1992).

The organization of the university, however, experienced a fundamental change in the nineteenth century. The French University was reformed by Napoleon in 1808. His purpose was to establish a teaching body to obtain the means to direct the political opinions and morals (Tünnermann, 1997). In the French system the research was left to the academies. In this sense academies and universities were different institutions.

In 1809, Wilhem von Humboldt founded the University of Berlin. Since, then von Humboldt's thesis has become the main characteristic of universities. His orientation is based on the integration of teaching, research, and an interest to tackle human problems and difficulties (Clark and Neave, 1992). von Humboldt's paradigm, unlike the traditional model that focused on disciplined learning, paved the way for a reorientation of higher education institutions, implementing educational models that allowed research processes and explorations aimed at improving human conditions.

The USA followed the German proposal. Such model, in that particular context, characterized by high demands that mass production stressed on new technologies. This demand promoted both the development of huge public and private universities

and community colleges. Processes that developed massive access to tertiary education that increased the index of coverage. Today, this model is recognized as the best model for the massive construction of new knowledge (*The Economist*, 1997, 2005).

On the other hand Latin America followed the Napoleonic model. This can be an explanation for the main differences between the two models (United States and Latin America). In the case of Colombia the Napoleonic model adapted had not even achieved a 1 percent of coverage in 1950 and hardly any doctoral education.

To push Colombia towards a massive production of new knowledge we propose two main policies. The first one is to develop a financial system to guarantee to every citizen that finishes secondary education has a place in post secondary education. Our proposal would be to use the credit system that Colombia has established since 1950 (ICETEX, 1997). To increase the PhD students we propose that the government develops a system in which private industry pays the expenses of the education of a doctoral student. The system would develop ways to discount the money invested in education through a discount of taxes. For example, an industry that finances the cost of a student would receive a discount of 125 percent of the money invested from the value added tax. The research centers could offer the government and industry sectors a way to concentrate research efforts on answering basic questions that they propose. The financial aspects of these proposals are developed in another paper (Zarama and Giraldo, 2007).

Our second proposal is a re-organization of the university system by promoting the constitution of research centers aimed at doctoral research. Based on the data shown on Figure 2, we estimate the number of doctors Colombia should have to compete with Argentina would be 40,000. If we want to compare ourselves to Japan that would imply 200,000 doctorates. If we expect the research centers we are proposing could graduate 60 percent of these numbers and that these should be achieved in a horizon of ten years, then the centers should graduate 4,000-20,000 doctors per year. If each center graduates 100 doctors per year, then we would need 24-120 centers to reach these goals. That is why our proposal would be to organize higher education around at least 50 centers as the one we will describe in Section 5.

The center that we have proposed was approved by Colciencias at the begging of 2006. The purpose of the administration of the center is to raise enough funding to achieve the standard proposed in the previous paragraph.

4. The habitat for knowledge production

Until now we have described the situation of research in Colombia and the role that universities should play. We recognize that the habitat in which knowledge is produced has changed through history. The habitat now is not the same one from 100 years ago. In this section we are going to describe the characteristics of this habitat for the production of knowledge in the present moment of history. The purpose of describing these characteristics is to indicate the way in which the centers proposed by us should construct this habitat. We say this because scientific work mutates from one epoch to another. This has been pointed out by historians like Koyré (1985) and Kuhn (1962).

The mutations of the habitat indicate the transformation of social practices. We understand social practices as the technologies that emerge on every historic moment (Heidegger, 1962). In such sense technology refers to the social practices that

use scientific developments. To isolate technology from the domains of the emerging sciences on a particular time and of its corresponding practices is to strip each of these three aspects of their important complements.

Given the perspective synthesized in the previous paragraphs, the main purpose of the centers is to forge the university habitat for the production of new knowledge. In the present moment of history the habitat is characterized by the virtualization of the space for discussion as the theoretical battlefield for the structuration of the research communities (Derrida, 2002).

In that habitat we are observing an acceleration of the production of knowledge. For example, each year more than 100,000 new mathematical theorems are made public (Clark and Neave, 1992), also internationally published scientific knowledge took 1,750 years to duplicate since the beginning of the Christian era, then it took 150, 50 and 5 years to duplicate it again and it is estimated that by the year 2020 it will duplicate every 73 days (Infante, 1999, citing Appleberry, J).

In this new habitat, the possibility for a person to have a complete knowledge of all the produced knowledge on a particular domain is close to zero. It follows then that trust is the basic disposition we must aim to reconstruct. For instance, take the formal proof of Fermat's Last Theorem. Some mathematicians estimate that less than 10 percent of the specialists on number theory are capable of understanding the 150 pages of the proof. Furthermore, today Richard Taylor a Cambridge Lecturer who was one of the referees to verify the proof is recognized as a co-author of such proof. Taylor's contribution was to find a minor error in the original proof, but the mathematicians community trust Taylor's comment to the point of recognizing him as a co-author. Equally known is the proof of the problem of classifying the finite simple groups. This proof holds over 500 papers written by more than 100 mathematicians. The only person that understood the 15,000 pages of the proof was Daniel Gorenstein, who died in 1992 (Singh, 2002).

New processes become available thanks to technology. Staying in the mathematical domain, we recall the use of computers in the proofs of some theorems (Horgan, 1993). In this sense, the history of mathematics has been split in two. The two central examples of this process are the four color theorem (Appel and Haken, 1977) and the party problem solution. Both proofs require calculations that are very difficult to develop, or verify, by hand. This situation led to rethink the concept of truth. Today, we can talk about a computational proof that offers a plausible vision of truth. In this scope, all proofs are not the heroic product of solitary work.

This reflection may lead us to think of a "new kind of science" (Wolfram, 2002). This means that we may be living in a similar situation to the one that took place three centuries ago. Let's recall that at that time we thought that a way to describe the world was through the rules of mathematical models. This new kind of emerging science is based "on the much more general types of rules that can be embodied in simple computer programs" (Wolfram, 2002).

We consider that in this new habitat, with new forms to produce science, and with an increment of connections between disciplines it is crucial to develop scientific communities that are united by trust. Mathematicians trust that the proof of Fermat's Last Theorem is correct. They also accept the proof for the classification of finite groups, the proof of the four color theorem and the solution to the party problem.

Another characteristic of this new habitat is that the traditional frontiers between disciplines are vanishing. We are confronted with evidence that the traditional tripartite division between natural sciences, humanities, and social sciences is not as evident as it used to be. For example, social sciences have taken the role of a reconciliation space between the humanities and natural sciences (Wallerstein, 2004). This bridge implies a strategy that brings together, and does not fragment, knowledge.

The description in the last paragraph leads us to talk of the emergence of interdisciplinarity. In our opinion the best conceptualization of interdisciplinarity was proposed by Piaget on a seminar at the Université de Nice in 1970. Piaget distinguished two ways to relate different disciplines (Apostel, 1979):

- Multidisciplinarity “happens when it is necessary for the solution to a problem to obtain information from one or two sciences, and such are not changed or enriched.”
- Interdisciplinarity takes place when “cooperation between various disciplines or heterogeneous sectors of the same science lead to real interactions, this leads to mutual enrichment.”

In some of these new emergent domains the division between applied and theoretical sciences looks out of place. Examples of such domains are precisely biotechnology and nanotechnology.

The distinction points towards a different view of science & technology than the one accepted in the nineteenth century. It appears that today there is a compact symbiosis in which the developments of one discipline have repercussions on the others in a continuous way. Therefore, we talk about a fusion between science & technology that denies the possibility of observing them as separate entities and forces the development of innovative national systems rooted on their respective national production system (Lundvall, 1992). This operator (&) cannot be seen as a mere conjunction because it implies the fusion between both terms. A building of a semantic space is taking place in the actual context, emerging a new concept. We think that such concept is referred by the term science & technology.

5. Proposal for the management of the center

In this section, we will develop the main characteristics of the way in which we propose to manage a research center in Colombia. We expect the center to be organized as an autonomous organization and that its mechanisms promote the autonomy of its researchers. This proposal is based on the conviction that the “invention of autonomy,” to use the name of a well known book, is a significant breakthrough in the history of mankind (Schneewind, 1997). In the case of the universities, the concept of autonomy has always been an important issue. An example of this importance can be seen in the declaration of the IV conference of the International University Association held in Tokyo to define what should be understood as the autonomy of a university within the academic community.

The concept of autonomy first appears in Greece. It refers to the capacity of certain regions to legislate and make decisions without authorization of a central government. Since, then this concept has been used in many fields. Within philosophy it refers to the individual capacity of auto-determination through reason, within social sciences it refers to the capacity of the individual to reside within society following global norms

and expressing certain level of conformity. Within jurisprudence it refers to freedom from external politics. Within pedagogy it refers to the decision-making capacity through reason. The different conceptions assume common characteristics such as auto-determination and the existence of an environment or a situation within the environment. From this point of view autonomy should not be confused with independence, since the former assumes the existence of a global system in which the individual is embedded, belongs to, and follow its norms (Pohlmann, 1971).

In organizational terms we implemented autonomy has been developed by organizational cybernetics (Beer, 1979; Espejo, 1989). We understand organizational autonomy as the capacity of an organization to create, regulate, and realize its mission activities (Espejo *et al.*, 1999). Our design implies that the center should empower its diverse units in such a way that each one reaches its own autonomy but preserving the global cohesion of the center (Dyner *et al.*, 2006). To achieve this we designed the center as a recursive system (Beer, 1979) (Figure 4).

The organizational dynamics of the center is directed towards the construction of autonomous researchers. For this the structure of the center aims to build trust. We expect that the relationship of two mechanisms develops this relation. The two mechanisms are the mechanism of cohesion, and the mechanism of adaptation (Espejo *et al.*, 1999).

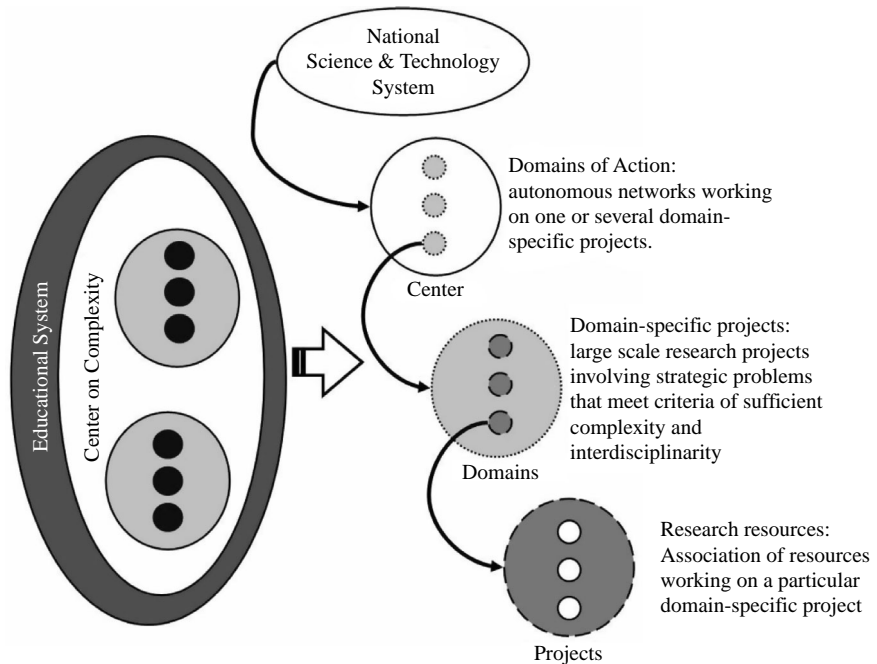


Figure 4.
Complexity unfolding
(Espejo, 1989) of the center

Notes: The center is embedded in the educational system. The center distinguishes different domains of action. Inside each domain, several domain-specific projects are developed by the interaction of different resources of the center (researchers, database, research groups, etc.)

The adaptation mechanism seeks to create new possibilities and to adapt to new situations observed in the national and international environment. The interaction of the two mechanisms allows the autonomous development of each unit, but maintaining the cohesion of the center around its identity. This is a structure for viability (Beer, 1979).

To implement the mechanisms mentioned the operation of the center is based on an overall functional framework in which the center serves as a facilitating agent for the synergetic integration of research efforts in strategic domains with complex systems themes and methodologies. This basic framework is represented schematically through a “guiding matrix” shown in Figure 5. The central area of the matrix depicts a common interaction space among domains, themes and methodologies (Dyner *et al.*, 2006).

A domain is represented by a row in the matrix. A domain is conceived as an autonomous collaboration network. Each domain works on one or several large-scale research projects. A project deals with problems that meet criteria of sufficient complexity and interdisciplinarity. This conception allows for the formulation of well-defined domain objectives around the specific goals of the research projects. The five domains are: Nanos (natural and artificial nanosystems), Techne (technology and industrial processes), Bios (biological systems, ecosystems and biologically-inspired systems), Gaia (terrestrial, atmospheric and oceanic processes in interaction with ecosystems), and Oikos (socio-economic systems). The columns of the matrix represent key aspects of complex systems themes and methodologies. These themes and methodologies include:

- modeling such as model conceptualization, data acquisition, time-series analysis, visualization, uncertainty assessment, and model assessment;
- simulation such as quantum methods, dynamical systems, stochastic methods, networks, multi agent methods, games and experimentation, non-quantitative methods; and
- abstraction such as emergence, resilience, structure and function, adaptation and evolution, design and control (Dyner *et al.*, 2006).

The thematic component of the center concentrates on conceptual and methodological aspects of complexity and interacts with the domains. The thematic component has the purpose of providing expertise as well as distilling complex systems knowledge.

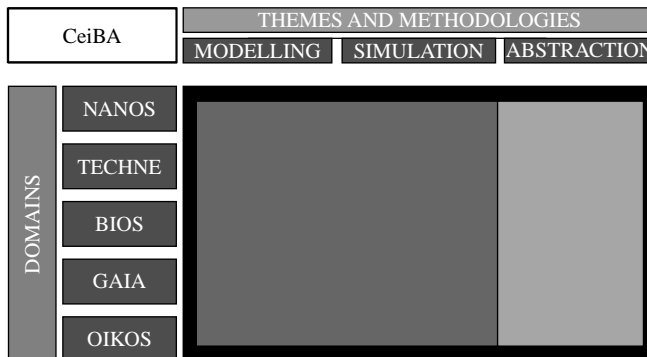


Figure 5.
Guiding Matrix for the
CISC (CeIBA) center
operational framework

The instruments facilitating this interaction are thematic actions and fall under the responsibility of the thematic component (Dyner *et al.*, 2006).

Thematic actions include the organization of seminars and workshops, and coordinating and advising in the use of resources for modeling and simulation. Finally, in a later stage of the center (represented in the matrix by the gray block), thematic actions will include research projects involving theoretical aspects of complexity (Dyner *et al.*, 2006).

Domain-specific projects and thematic actions are the primary activities associated with the center and constitute the backbone of the operational framework. This is shown in Figure 6. Each falls under the responsibility of a well-defined group of researchers associated with the center and aims at fulfilling a specific mission. The goal of these projects aim at proposing complex systems solutions to strategic applications. The goal of thematic actions aim at advancing the state-of-the-art in complex systems research. In turn, the formative aspect of the mission is implemented through a set of derived activities, represented in the figure by narrow arrows stemming from the projects and thematic actions. Derived activities include:

- PhD students and postdoctoral researchers involved in theoretical and applied research projects;
- workshops involving decision makers in both private and public sectors;
- university courses and theses undergraduate and/or graduate courses in complexity at the participating universities including undergraduate and master theses; and
- conferences and publications on complexity for the public-at-large (Dyner *et al.*, 2006).

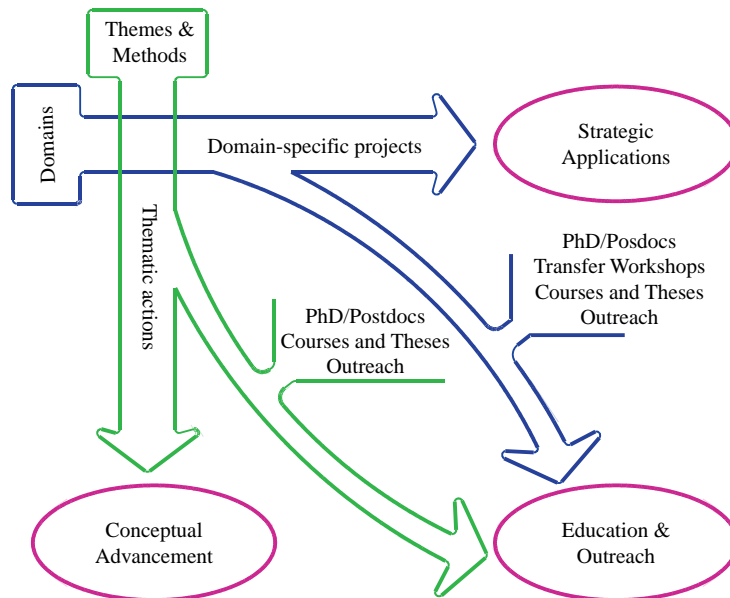


Figure 6.
CISC operational
framework

In addition to the primary and derived activities, the center operation includes supporting activities related to logistics. This support is mainly in terms of access to computational facilities and databases managed by the center or its affiliates, administrative assistance, support for the organization of events, and a limited amount of support for travel-related purposes (Dyner *et al.*, 2006).

We distinguish among all activities an annual center meeting. This meeting pertains to thematic activities. We envision a major event, gathering center researchers, experts in the field, and international participants. Furthermore, the event will serve as the primary integrating venue of the center. This event will include both thematic and domain-specific workshops and seminars, special activities geared at interacting with selected groups of policy-makers and heads of industry, and outreach activities (Dyner *et al.*, 2006).

6. Conclusions

We must point out that in 2003, 8.2 percent of the Colombian population lived with \$1 or less a day. The poorest 20 percent of the population had access to 2.7 percent of the total income, while the richest 20 percent benefited from the 61.8 percent of that total (DNP, 2005). This has led to a knowledge gap between Colombia and developed countries. This gap is highly responsible of the low economic development of the country. In 1994 the Science, Education and Development Mission located “Colombia [at] the verge of an opportunity” (Colciencias, 1995). We feel that a key factor to reduce that inequality is to promote a radical transformation of the relationships of knowledge production, by recognizing the autonomy of researchers, projects and centers, but bound to address fundamental and relevant problems for Colombia. For this we have proposed the constitution of research centers in the transformation of universities based in the concept of autonomy. This implies the capacity to run the risk of forming whole generations of researchers.

If we are able to gather through the coming years in research centers a significant number of young people who can stand on equal footing with their peers at other world-class centers, we are certain that they will constitute a critical mass that, in the country and its surrounding region, will look for explanations and forms to dissolve some of our most critical problems. That dissolution, based on state-of-the-art advances in their respective domains of application, constitutes for Colombia the most genuine manifestation of the promise of a knowledge-based society.

We believe our proposal is a correct step towards this goal. CeIBA-Complexity will begin to fully operate by January of 2007. The center will congregate 20 research groups, 101 professors with a doctoral degree, nearly US \$3 million in resources (they do not include the salaries of researchers) and bringing together four of the top universities in the country. The center expects to graduate 50 doctoral students each year after the fifth year.

A good management during the first years will allow research centers to become international speakers and a primordial referent for non G-10 countries. Early and adequate positioning can become the most serious possibility for allowing different actors – government, industrial and social – to fund doctoral students for research projects. This vision will make sustainable research centers enhancing knowledge production within the country.

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