

Desenvolvimento sustentável, interdisciplinaridade e Ciências Ambientais

Sustainable Development, Interdisciplinarity and Environmental Sciences

Desarrollo sostenible, interdisciplinaridad y Ciencias Ambientales

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Resumo

O tema deste artigo insere-se no debate sobre interdisciplinaridade na pesquisa e na pós-graduação, com foco nas ciências ambientais. Tem por objetivo apresentar discussão acerca da institucionalização da interdisciplinaridade e das Ciências Ambientais na pós-graduação brasileira, a partir da vivência dos autores, de análise documental e pesquisa bibliográfica. A partir dos dados da evolução da pós-graduação brasileira, apresenta-se a institucionalização e discute-se a prática interdisciplinar na pesquisa de pós-graduação em Ciências Ambientais, evidenciando caminhos e desafios para um futuro próximo.

Palavras-chave: Desenvolvimento Sustentável. Interdisciplinaridade. Ciências Ambientais. Pós-Graduação. Pesquisa Integrada.

Abstract

This article addresses the debate on interdisciplinarity in research as well as in postgraduate studies in Brazil, with a focus on Environmental Sciences. It aims at presenting a discussion about the institutionalization of interdisciplinarity and of postgraduate studies in Environmental Sciences in Brazilian postgraduate studies, based on the experience of the authors, documental analyses and bibliography evaluation. In light of the data about the evolution of postgraduate education in Brazil, institutionalization is presented, and the interdisciplinary practice is discussed in postgraduate research in Environmental Sciences, highlighting pathways and challenges for the near future.

Keywords: Sustainable Development. Interdisciplinarity. Environmental Sciences. Postgraduate Study. Integrated Research.

Resumen

El tema de este artículo es parte del debate sobre la interdisciplinariedad en la investigación y el posgrado, con un enfoque en las Ciencias Ambientales. Tiene como objetivo presentar las discusiones acerca de la institucionalización de la interdisciplinariedad y de las Ciencias Ambientales en cursos de posgrado brasileños, teniendo en cuenta la experiencia de los autores, el análisis documental y la revisión de la literatura. Con base en los datos de la evolución del posgrado brasileño, se presenta la institucionalización y se discute la práctica interdisciplinaria en la investigación del posgrado en Ciencias Ambientales, mostrando caminos y desafíos para el futuro próximo.

Palabras clave: Desarrollo Sostenible. Interdisciplinariedad. Ciencias Ambientales. Posgrado. Investigación Integrada.

Introduction: Environmental issues and sustainable development

The concern with sustainable development evolved when society noticed that natural resources are finite; such a perception was accentuated in the 1970s with the oil crises, which until then was seen by many as abundant and inexhaustible. The crisis ultimately triggered serious economic damage, causing recession, inflation and unemployment in many countries, and raised questions about the development models adopted.

Growing reflections about the environmental accidents that occurred and the need to review current paradigms encouraged countries and the international community to develop joint actions. The United Nations Conference on Environment and Development, known as Rio 92, was a landmark in the universalization of the environmental theme which established people's right to live in an environment with the quality that allows living with dignity and well-being (PNUMA, 2002).

The concept of 'sustainable development' was consolidated at Rio 92 as a process of change in which the exploitation of resources, the

direction of investments, the orientation of technological development, and institutional change are harmonized, in order to meet present and future human needs and aspirations (CMMAD, 1991).

The emergence of the term 'sustainable development' is related both to human awakening and to the limits of the natural resources available on Earth, ensuring access to basic health and education conditions and respect for customs, traditions and the legitimacy of institutions, all this within a perspective of interconnection in networks of local, regional, national and international character.

International movements of recent decades have gradually brought to light the issue of sustainable development and have also recognized that the solution of social and environmental problems necessarily implies profound changes to the organization of knowledge. Such wide proposal presupposes reorganizing research and teaching formats, which require a systemic vision of reality and actions and methods of an interdisciplinary character. Such changes are already present in academic centres and research institutes, as well as in the daily practice of several governmental and non-governmental sectors.

Along the same lines, another aspect of the complexity inherent in this theme is that the development paradigm leads to a double ethical imperative: synchronous solidarity with the current generation and diachronic solidarity with future generations (SACHS, 2002). Thus, cultural aspects emerge from the social field with a distinct and integrative role in sustainable development, in which culture is broadly defined as the complex of spiritual, material, intellectual and emotional issues that characterize a society or a social group. It includes not only the arts and literature, but also ways of life, fundamental human rights, value systems, traditions and beliefs (UNESCO, 1995). Thus, the sustainability of the development demands recognizing and protecting this cultural capital, built upon the protection of ecosystems and natural resources.

Such broad understanding of the environmental theme and its multiple interfaces with the dimensions of sustainability have boosted important movements, laws and institutional arrangements in the second half of

the last century in order to address and implement the new relationships of this emerging scenario.

The National Environmental Policy, established by Federal Law No. 6938/1981, defines environment as “the set of conditions, laws, influences and interactions of physical, chemical and biological order, which allows, shelters, and governs life in all forms.” This is an indefinite legal concept and, as such, its content is very broad. The implementation of this policy requires government actions that ensure the management of environmental resources, construed as the act of managing, directing or governing the ecosystems in which mankind is, individually and socially inserted, in a process of interaction between the activities that it performs, seeking the protection of natural resources and of the essential characteristics of its surroundings, according to quality standards (PHILIPPI JR.; ROMÉRO; BRUNA, 2004).

One of the significant instruments established by the National Environment Policy is the Environmental Impact Assessment, which has been contributing to solve or minimize conflicts between economic development and environmental conservation. These are instruments that involve multiple disciplines, from different areas of knowledge (exact, human, biological and health sciences), which must be necessarily integrated, in an interdisciplinary manner, towards a common goal, which is to analyze the environmental viability of policies, plans, programs and projects of significantly impacting developments, be they public or private in nature, allowing for the minimization of ensuing impacts and establishing mitigating and compensatory measures.

An insertion of the environmental dimension is also noticed in several spheres, such as the construction of a broad institutional apparatus and extensive legal framework. An example is the treatment of cross-cutting subjects in environmental education and the proposition of the Environmental Education National System (Sisnea), which aims at providing consistency to the set of environmental education actions in Brazil, related to other management systems.

In the field of higher education and of science and technology, the environmental theme has also aroused interest from an early stage.

Several disciplines have started addressing the environmental theme, studying its technical, technological, behavioural, planning, management, and education aspects associated to several different issues, such as the treatment and prevention of the effects of polluting activities, planning and use of natural resources, waste disposal, use and occupation of soil, use and conservation of water, atmospheric pollution, among so many other aspects – ample or specific – that started being part of research agendas (RAYNAUT; ZANONI, 2011).

According to Jollivet and Pavé (2000, p. 56), throughout the world “research on the environment emerged from a double perspective: one having a scientific origin and the other having a social origin”. The scientific origin, which is older, arises from the effort to apprehend nature while the more recent social origin arises as a problem of cross-cutting research to the disciplinary model. Such a cross-cutting character refers to two fundamental issues: one related to the object and the other, as a consequence of the former, to the epistemological and methodological nature of the study of the object. The one referring to the object addresses what we understand as environment and, in face of the impacts generated by the anthropogenic activities in such an environment, what we understand as environmental issues. The ones grounded on epistemological and methodological matters refer to the way the object is dealt with, whether it is comprehensible only by means of isolated disciplinary studies or necessarily refers to a specific multidisciplinary field that involves the analysis of interdisciplinary nature. Having these two questions as a starting point, it is possible to become aware of how difficult it is to understand the environment and, consequently, the problem that involves the anthropogenic impacts and the conservation and destruction of nature in face of social dynamics, as a scientific object, mainly from its origin and context of social and economic development (BERKES, 2005).

With regard to the environment and the environmental theme, recovering recent history, one may say that such a theme emerged in the 1960s with the awareness of environmental issues, when such issues started to be noticed because we had to face some practical daily problems of small and large proportions, and because of the environmental rhetoric.

The first questions about environmental degradation, which linked it to increases in population, the economy and production systems, were based on the report entitled *The Limits to Growth* (1968), published by the Club of Rome, which highlighted the dangers of unlimited growth¹.

With the events at the beginning of the 1970s, such as the oil crises mentioned above, which announced an eminent collapse of both energy and natural resources, the perception about environmental issues grew notably. The discussion surpassed the scope of environmentalists and became a topic increasingly debated by society, as well as by official institutions such as the United Nations and its international conferences.

Nevertheless, the discussion was not limited to official organisations. Several parallel forums, Global Forums and, more recently, World Social Forums) have been carried out, so the discussion has extrapolated the official scope and reached organized civil society, at the same time that it has gone beyond the environmental discourse. The environmental theme appears as an expression of a much worse crisis that permeates all aspects of society. Forums – mainly the Global Forum in Rio in 1992 – began to provide room for discussion, in which one can present and verify the multidimensionality of the crises stirred up by the environmental theme. Social, cultural, political, economic, gender and ethnic-related issues have been included in the discussion in search for solutions. More recently, as expressed in the opening address of the World Social Forum in Porto Alegre (2003), forums are aimed at being open spaces for reflection, whose goal is the democratic debate on ideas, the preparation of proposals, the free exchange of experiences and the articulation of actions of civil society's entities and movements.

The environmental issue emerged then as a social and political phenomenon in the diversity of representations in the context of the first conferences and forums (HOGAN; VIEIRA, 1992; VIEIRA; BERKES; SIEXAS, 2005), at the same time that conferences and forums were the first ones to legitimize and fuel the topic, making the environment and the environmental issue a field for research. Therefore, it is a research field that was born from the emergence of an empiric reality at a global level, which has been gaining ground in the institutions of several

¹ This report is also known as the Meadows Report. It was commissioned by the Club of Rome in 1968, and prepared by technical staff of the MIT (Massachusetts Institute of Technology), under the coordination of Donella Meadows, Jorgen Randers and Denis Meadows.

countries. The environmental theme emerges as a social, political and institutional reality propelled by scientific research, the international context, supranational institutions and the social and environmental movements that appeared as of the 1960s.

After almost a century has elapsed since the emergence of the socio-environmental theme, one may say, aligned with Vieira (2001), that, on the one hand, it has been addressed as a collateral effect or nuisance to be circumvented:

After almost three decades since the Stockholm Conference, in 1972, it is not an overstatement to say that we are still facing a socio-environmental crisis as if it were only an untimely disturbance, some type of background noise to be treated in a reactive and fragmented way [...]. We must admit that, in the plan of behavioural effective changes, the socio-environmental crisis is still a marginal item in the agenda of every day concerns of most of the planet's population (p. 9).

On the other hand, in view of the risks of its simplification, brought about chiefly by dividing subject matters into too many compartments, a group of opinion makers has been growing that insist on the interdependent nature of the intersection of social and environmental problems, as well as their pluralism and views. To this effect, Vieira (2001) states that “first of all, the crucial challenge lies in a drastic rupture of all representations of the environmental theme that inherited the economic reductionism and bureaucratic technoscience” (p. 9). That is, he suggests that the complexity of the environmental issue is not restricted to the destruction of nature. A view that is shared by other researchers such as Morin (2010), Serres (1990), Berkes (2005), Sachs (1986), Leff (2001), and Dansereau (1999), who point to such interdependence.

From such a perspective, the concept of environmental issue, as a portrait of a broad spectrum that encompasses from local problems, such as the pollution of a river by effluents of a company up to the insalubrious and destitute conditions of the large urban centres (GARCÍA, 1994), emerges as a socio-environmental problem, which is the result of how society, in its several sectors, relates with nature (FERNANDES; SAMPAIO, 2008). It

appears as an economic, technological, social, institutional and cultural issue (LEIS, 1999; VIEIRA, 2009).

To the same effect, as Leff confirms (2001, p. 111), the concept of environmental theme is, consequently, a concept directly linked to social activities: “The environmental theme is a problem of an eminently social nature: it was generated and is trespassed by a set of social processes”. It further emerges, Leff continues, “as a social development problem, which proposes the need to normalize a set of production and consumption processes that, subject to the market’s economic rationality, degrades the environment and the quality of life” (Ibidem, p. 130). The entire range of processes of ecological destruction is not disconnected from socio-environmental degradation, which goes from the loss of soil fertilization to social marginalization (GARCÍA, 1994).

According to Leff (2001), the socio-environmental problems only exist due to the way of appropriation of the world and of nature based on social and power relations, which are materialized by economic, political, scientific, and religious means, among others. The challenge nowadays is to understand the complexity embedded in the dynamics of socio-environmental systems and of its articulation with the biosphere (VIEIRA, 2001).

And it is due to the foregoing that said writers (VIEIRA, 1992; LEFF, 2001; SACHS, 1993) adopt the socio-environmental problem favouring a view of interdependence between society and nature, which, according to Davidson-Hunt and Berkes (2003), gets away from the nature versus society dichotomy to focus on processes that link nature and society, on different spatial and time scales. It is an eminently interdisciplinary strategy that focuses on the relationship of human beings both between them and with the environment. It is an environmental problem that arises out of social and ecological problems from a perspective that seeks to integrate mankind and nature and overcome dichotomies by favouring a systemic and complex view; therefore, it is a discussion about the environment understood from the relations between cultural/society and natural/nature processes.

Such an approach is different from other theories that have a Cartesian, positivist, illuminist and pragmatist cut, which have kept the separation between nature and society, although having provided sophisticated models of how nature and society are articulated together and influence each other. It is about providing support for an interdisciplinary approach, emphasizing that systems are typified by non-linear processes and by multiple balances (MORIN, 2010). Instead of stability, there is unpredictability in connection with changes to the system (PRIGOGINE; STENGERS, 1984). Moreover, it is a perspective that includes man as a part of nature instead of the dichotomy man versus nature (DAVIDSON-HUNT & BERKES, 2003).

From such a perspective, the research on socio-environmental problems is fundamentally the acknowledgment of the interdependent relation between society and nature.

Consequently, it is by definition a study that requires an interdisciplinary focus on the relationship between mankind and nature. Environmental issues emerge from the interaction of social and ecological processes and may be examined within the context of social and environmental parameters, as well as spatial and time ones. This problem is a research field that agglutinates numberless subjects, implying the need for interdisciplinary research. Environmental research is not shown as a new topic, but rather as an agglutination of old topics that have already been addressed on a large scale by specialized subjects, involving the analysis of, among others, biological, physical, chemical, hydrological processes that are related to the economic and social problems mediated by science and technology. It is new, though, because it implies – simultaneously – a totalizing and systemic approach, which encompasses subjects that already exist and implies articulating and redefining the exact same subjects (PHILIPPI JR.; TUCCI; HOGAN, 2000).

Its construction as an object of scientific research has demanded the coordination and integration of several fields of scientific knowledge (AÍMOLA, 2002). According to Leis's (1999) assertions, the complex interrelation of the environmental issues with economics, politics, and culture in general suggests that the environmental issue encompasses

a wide spectrum of levels of knowledge and practices that include natural and human sciences, technology, culture, and philosophy in its broad meaning. Such complexity makes scientists place their analysis in the context of a deep cultural transformation that makes natural and technological sciences converge with the social ones.

To the same effect, the environmental issue implies that the entire set of subjects – both in natural and technological sciences and in the social ones – should internalize environmental knowledge, in order for one to be able to effectively build knowledge able to “captivate the multi-causality and the interdependence of relations of the natural and social processes that regulate socio-environmental changes” (LEFF, 2001, p. 109). The internalization of such knowledge should result, in its turn, in a complex manner of thinking and a methodology for interdisciplinary research, as well as in an “epistemology able to lay the foundation of knowledge transformations, induced by the environmental issue” (Ibidem). It is the only way to make it possible to re-establish the connection between the social and the natural, which has historically been minimized by research and that, more recently, has limited to internalized ecological and technological rules into economic theories and policies, leaving aside the analysis of social conflict and the strategic ground of politics that traverses the environmental field (LEFF, 2001).

The intermediation of such a process is carried out especially by what Habermas (1994) considered in his “scientific rationality”, linked to the institutionalization of “scientific progress”, which is responsible for the changes in paradigm, according to Thomas Kuhn’s concept¹. To this effect, socio-environmental problems, in the environmental sciences construction (ABRAMOVAY, 2002), bring along an ample process of knowledge transformation and criticism of the models of scientific rationality, inducing the construction of a type of knowledge that has an interdisciplinary nature in opposition to the fragmentation and adjustment of the object to subjects’ dynamics; therefore, subjects must adjust to this new field, which demands integrated and interdisciplinary research.

Therefore, as a research field, the Environment implies the discussion about the fragmentation of knowledge and the need to break with the model divided into subjects for the sake of a more integrating model. According to Leff (2001), “environmental knowledge” is still under construction, and is neither finished nor homogeneous, since it completely depends on the ecological, socio-cultural and economic contexts, which, in turn, are in constant transformation. In the context of environmental sciences, it is therefore fundamental to practice interdisciplinarity. In view thereof, the purpose of this article is to discuss some aspects and ways of such a practice, guided by sustainability principles, particularly in view of the context of postgraduate programmes.

Creation of the field of Environmental Sciences in the Brazilian Postgraduate System

According to the data provided by Capes and CNPq, Brazil has 65 researchers for each 100 thousand inhabitants while in Europe there are 1670, in the USA 1270, in Japan 740, and 665 in China. Such figures show that Brazil still lacks critical mass, in comparison with such countries. Furthermore, the same sources reveal that over 10 thousand doctors postgraduate per year in Brazil, and although such data mean a 600% increase from the 1990s, in developed countries, such a figure ranges from 30 thousand to 45 thousand doctors. Therefore, the discrepancy is not only in relation to large world centres but also to the demands faced by Brazil, considering the several different crises that overrun communities.

It should also be mentioned that in 2011 Brazil had 3,397 postgraduate programmes in charge of 5,080 courses. Out of them, 2,925 pursued a master’s degree and 1,738 a doctor’s degree, and 417 attended professional masters’ courses. The number of students enrolled in such programmes in 2010 was approximately 173 thousand, out of which over one third (approximately 67 thousand) had grants from the Capes and CNPq systems – 41 thousand for academic masters’ [courses] and 26 thousand for doctorate programmes. There were 57,270 professors linked to postgraduate programmes in 2009. In the context of the

Brazilian Postgraduate System, which maintains a system to follow up, evaluate and accredit programmes developed by Capes, in 2012 there were 48 fields of knowledge that evaluated the total amount of masters' or doctorate courses in Brazil (CAPES, 2011b; 2011c).

Due to its characteristics, Capes created an Interdisciplinary Field that in 2010 had 249 accredited programmes, with 312 courses, distributed in four groups: (i) Environment and Agrarian; (ii) Applied Social Sciences and Humanities; (iii) Engineering, Technology and Management; and (iv) Biological Sciences and Health. The Interdisciplinary Field is also one of Capes's fields with the highest demand for proposals, which, associated to the strict evaluation criteria of the field, makes it more difficult for any course to be approved. In addition to the criteria that usually typify a good proposal in the disciplinary fields, in such a field it is mandatory to take into account the interdisciplinary character established for the development of the research and training of people. The training of people and the production of knowledge must reflect the concept and method of interdisciplinary work (CAPES, 2011b; 2011c).

Such figures and criteria show effervescent interdisciplinary activity in the academic community, and not only in Brazil. It is safe to say that the complexity of the questions that need answer in the contemporary world have led researchers to realize that such issues cannot be addressed only within the scope of one single subject. The knowledge of several different fields is necessary in order to obtain answers that may be more effective and last longer.

The effervescence of interdisciplinarity naturally arises from this, as a concept, a process and a form of producing knowledge, impelled by the need to connect types of knowledge and amplify technical-scientific cooperation. This is something that both the teaching staff and researchers that work in an interdisciplinary fashion start incorporating into their practices. Sharing information becomes inherent in the process as there can be no progress without sharing it with the different approaches of several subjects, which are the ground elements for the existence of interdisciplinarity.

The institutionalization of Environmental Sciences in Brazil

In the core of interdisciplinary effervescence, in 2011 Capes created the CACiAmb (Environmental Sciences Coordination Field), as the field to accredit postgraduate programmes (Ordinance 81, of June 6, 2011). According to the Document of Environmental Sciences Field (CAPES, 2011a) such a field was initially composed of postgraduate courses connected to the environmental set of themes existing at the CAInter (Interdisciplinary Field Coordination), therefore, with a research background, since CAInter completed 10 years in 2010. The emergence of such a set of themes, as a research field and a knowledge field, is part of the process of institutionalization of the environmental issue in society as a whole.

According to Capes (2011a), the Environmental Sciences Field has 2011 as its symbolic creation date, the Environment Day, June 5, which was the result of a proposal discussed and formulated by a work group created for such a mission, composed of members and consultants of the Interdisciplinary Field.

The creation of the CACiAmb in the context of the Brazilian System of Postgraduate Evaluation of Capes arises from the need to become aware of the complexity of environmental issues from a multidisciplinary point of view, due to the connection between the anthropic and natural systems that emerge in the contemporary world that are often brought about by the very advance of scientific and technological knowledge based on the building of knowledge conspicuously divided into subjects (CAPES, 2011a).

The CACiAmb is currently composed of 67 programmes, which encompass 84 courses. Ten new postgraduate programmes to be added have already been approved by the Higher Technical-Scientific Education Council (Conselho Técnico Científico da Educação Superior) of Capes (CTC-ES), encompassing 13 courses, planned to start in 2013.

The distribution of courses according to their grades is 46% with grade three, 38% with grade four, 13% with grade five, and 2% with grade six.

When one divides grades by courses, grade three prevails (92%) in the professional masters' courses; 54% of the academic masters' courses have grade three, 35% have grade four, 8% have grade five and 2% have grade six. Based on such data, it is possible to see room and means to invest to increase the number of doctorates and improve grades.

The scope and cross-cutting features of the research lines of the CACiAmb courses form a broad universe of themes composed of basic expressions that can be grouped according to their identities. The analysis of these groups allows highlighting basic expressions such as: Development + Environment, with a frequency of 58%; Natural Resources + Ecology, with 36%; Management + Planning + Public Policies, with 40%; and Technology + Modelling, with 57%. Among the programmes approved in 2011, there is a predominance of basic expressions related to Technology and Management, which is an increase by respectively 5% and 4% in the frequency of both. Such an analysis allows observing the existence of a balance among the themes of these lines of research, which characterizes interdisciplinarity in environmental sciences.

As for the distribution of courses of the CACiAmb according to the Brazilian regions, the overview is as follows: 18% in the South, 31% in the Southeast, 13% in the Mid-West, 25% in the Northeast and 12% in the North. Considering the programmes approved in 2012, there is an increase by 3% in the Mid-West and 2% in the Northeast.

The 77 courses of the CACiAmb are taught by 54 Higher Education Institutions (IES), distributed in 23 of the 27 Brazilian states, as Acre, Alagoas, Amapá and Rondônia do not offer courses in this area. There is a predominance of public IES (81%), especially federal ones, with 63%. With the new proposals approved, there is an increase by 2% in private and 4% in public state IES. There is a tendency to increase the number of courses in the area with greater expansion potential in the Midwest and Northern regions, as well as in border areas.

The practice of interdisciplinarity

More than ever, the practice of interdisciplinarity is an emerging need. Suffice it to mention the environmental issues involving climate changes

or the recent global financial crisis. These are global crises that need responses that certainly will not come from mere disciplinary treatment.

Accordingly, the recipe to face such crises includes strategies that can be epistemologically placed on a new basis. These are strategies that allow the various areas of knowledge to address their own performances, while the knowledge existing in society is recognized by the scientific community.

Each subject represents and has a form of knowledge, with their own method, which must be respected and valued by the participants of a study with convergent areas, enabling the conception of an integrated methodology incorporating the elements considered positive in each of the subjects. Under that circumstance, whoever enters interdisciplinarity has to be open to review one's paradigms and to leave the comfort of one's acting subject.

In Environmental Science research, with an interdisciplinary perspective, this comfort is placed to the test, even because the consolidated disciplinary position is still highly respected, but it possibly demands putting concepts under perspective. Teaching staff and researchers who work in an interdisciplinary manner with Environmental Sciences may possibly be required to spend more time preparing a project and obtaining answers, bearing in mind the need for more discussions, greater dialogue and, especially, the understanding of the best way to take knowledge then produced to the scientific community, in a common language built from the participants of the work. This is the path of pioneers. Even though it was practiced a long time ago, mankind was driven, in a more recent period of history, to a process of specialization, sometimes an excessive one, which stopped giving responses more compatible with the challenges of modern life, especially in complex themes such as environmental issues.

As regards organisational aspects, it is worth mentioning that a postgraduate survey or programme may have in its formulation the set of subjects that is considered necessary by the group proposing such a survey or program, but without the concern of having all subjects

represented. The risks of having a very large group at the beginning, which may be the source of problems to work, must be considered here. The team may gradually be increased, incorporating new subjects, with the group's increasing familiarity with the methods of scientific work on interdisciplinary bases.

After the team has been formed, the next step is the coordination based on the acknowledgment of leadership. It is essential that the professionals involved in programmes or groups who have an interdisciplinary approach to environmental issues recognise a scientific leading figure in the coordinator, and it should be noted that leadership is essential to the smooth progress of the work.

Also, regarding organisational aspects, it is important to work towards the development of an interdisciplinary writing, suitable for each programme or group. The convergence of knowledge on environmental issues requires comprehensive discussion processes, which impose reflections seen from different angles. The reflection on social sciences must be as important as the objectivity of engineering. The richness of this interaction process may occasionally be overlooked in disciplinary research, since it is from the discussion, reflection and moments of interaction that the knowledge of interdisciplinary character actually emerges. It is no coincidence that interdisciplinarity is understood primarily as an active form to innovation processes. It is the innovation that arises when different perspectives add up and reveal many more nuances of the theme studied than the simple sum of perspectives. It is in this sense that interdisciplinarity is identified as a need of the environmental sciences.

In Environmental Sciences, as in any research project, the research project begins by identifying the problem to be studied, from which the concepts and skills needed to understand it can be established. The next stage must necessarily include reflection, discussion, confrontation, in order to dig up the diversity of perspectives. Convergence becomes possible from diversity, once it is revealed. Otherwise, one runs the risk of building fragile interdisciplinarity based on the superficiality of veiled positions.

From the evidence of differences, it is possible to treat disciplinary perspectives in relation to the concepts dealt with, leading to the establishment of meta-perspectives from which one seeks to organize information and synthesize the conflicts between the different fields of knowledge gathered during the work. At the end of this path, one can identify the research problem in operational terms, and the research work itself can begin, with data collection, bibliography, and all other elements, including the construction of the analysis model to be adopted. However, feedback on the interdisciplinary analysis is not only the relationship with the data and theoretical-conceptual elements of environmental issues. Rather, it involves the tension among the several disciplinary perspectives and their respective contributions, evaluating and re-evaluating learning in order to build results, seeking to eliminate or bring closer remaining gaps in the borders of such subjects in order to produce an integrating knowledge about the understanding and resolution of environmental problems.

Interdisciplinarity in Environmental Sciences

Solid disciplinary knowledge, without which there is no way to develop quality interdisciplinary teaching and research, is an assumption of interdisciplinarity. This is how interdisciplinarity in Environmental Sciences may lead to programmes and projects that will lead to different results as compared to disciplinary research, depending on the training of teams. That is, works carried out on interdisciplinary bases on the environmental theme can take varied paths; however, these paths should be clearly defined by those who intend to work.

While disciplinary studies can be relatively simple, due to the existence of professionals with the same training, common language and often with similar theoretical-methodological perspectives, with regard to interdisciplinarity the starting point is to build understanding, by establishing a common linguistic domain on environmental issues on the agenda, by those who will be part of the process, which will probably require a longer time. Teaching staff and researchers must leave their comfort zone to search for understanding from the perspective of other

subjects. This exercise aims at naturally maximizing the contribution of each subject in understanding and solving environmental problems, which will happen not only from their own worldview, but also considering the worldview of other subjects.

In this context, considering the Brazilian National System of Postgraduate Studies, it is important to differentiate an interdisciplinary postgraduate programme and a disciplinary postgraduate programme. Multidisciplinarity is an aggregation, by means of the coordination of different areas of knowledge around one or more themes, in which each area still preserves its methodology and independence, not necessarily requiring cooperation between subjects.

In turn, in interdisciplinarity the involvement of participants is deeper, generating broader consequences. It requires the convergence of two or more areas of knowledge which may belong to the same category, contributing to the advancement of the frontiers of science and technology, transferring methods from one area to another, and generating new knowledge or new subjects. Biotechnology, Nanotechnology and Environmental Sciences are examples of new fields of knowledge that have arisen from the interdisciplinary practice, occasioned by complex and concrete issues.

Interdisciplinarity emerges as a process in construction for each group, and the teaching and research will be shaped in relation to the elements that will make up the object and research teams.

Final Remarks: some challenges

It must be considered that the process of gradual incorporation of interdisciplinary practices by research groups and by postgraduate programmes is increasing and that it requires increasingly affirmative actions for its adoption, with a view to the challenges in relation to both social and environmental issues such as the urgency to adopt principles associated with the interests of the country's development on a sustainable basis.

In this context, the perspectives for consolidation in the area of environmental science emerge quite clearly as an important and relevant factor for the development of research and postgraduate education geared to the interests of a more just and supportive society and directed to obtaining elements of sustainability effectively leading to the improvement of environmental and living conditions of communities, on the basis of different complexities, several regions and different requirements.

Safely grounded on the National Evaluation System of Postgraduate Education, the development of quality teaching and research will be built by processes, concepts and interdisciplinary methods, offering better conditions for the gradual incorporation of knowledge produced from mechanisms, instruments and processes based on the principles of sustainability.

To be consolidated, such bases involve guidelines and actions to be carried out across the country: mapping universities with potential to implement new programmes; establishing strategic plans for the next three years, aimed at inducing environmental programmes in the regions of the country, in order to contribute to greater regional balance, based on the results of the Triennial Review 2010/2012; fostering the creation of programmes and research that focus on relevant environmental and strategic aspects, such as climate change, impacts of new frontiers of agricultural development, impacts of alternative energy development, ecological economics, strategic environmental assessment, among others; fostering partnerships with the public and private sectors; articulating with funding agencies to promote Environmental Science research projects by means of grant programmes that emphasize the interdisciplinary approach and the application of the principles of sustainability; consolidating the continued evaluation of postgraduate programmes in the area by means of national meetings at Capes, decentralized regional meetings, and increase in follow-up visits; stimulating the creation of new institutional arrangements which contemplate research networks, associations, national and international partnerships and double degree between Brazilian and international IES; and fostering internationalization by means of academic and scientific

exchange with foreign universities, with particular attention to Latin America and Africa.

The question related to why research is done and to whom knowledge is generated must always be remembered. It is necessary to be aware of why something is done, and whom or what it is serving in philosophical terms. Such reflection must be inherent in interdisciplinary research.

Among the contributions of performing interdisciplinarity is the reassessment of values in relation to science and technology in search of an ethical attitude regarding the implications of the knowledge obtained and its advances, as well as with regard to the training of researchers and professionals with a humanist emphasis on teaching and research. It is worth noting again that interdisciplinarity refers to creation, process, and form of knowledge and work, which can be applied with ease in many subject areas.

Accordingly, it must be considered that interdisciplinarity will have a gradually larger space in teaching, research and extension, making Science, Technology & Innovation grow in quality and achieve greater maturity. The Brazilian scientific community has shown commitment in the pursuit of improvement and quality of its programmes, which should contribute to the formation of professionals, researchers and teaching staff with new profile and quality, responding to the challenges posed by the country regarding its development on a sustainable basis.

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Explanatory Notes

ⁱ In this model, Kuhn (1996, p. 13) defines paradigm as “universally recognized scientific achievements that, for some time, provide model problems and solutions for a community of practitioners of an established science”. Kuhn’s notion of paradigm, according to Morin (2010), is a type of revolutionary thought that contrasts with the theoretical evolution

of Popper. Kuhn differentiates what he calls normal science, in which the dominant paradigm still provides an answer to existing phenomena, from extraordinary science, in which the dominant paradigm does not provide an answer to new phenomena.

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