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Annotated bibliography on interdisciplinary science - 2

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Introduction

Interdisciplinarity is a complex process, holding multiple meanings depending on whether the reference is to programs, courses, research areas, modes of teaching and learning, or administrative structures. Klein (2000) states: 'Ask three scientists what interdisciplinarity means, and they will likely give three answers'. To avoid what the author calls the 'jungle of phenomena', Klein (1990) identifies four varieties of definitions for interdisciplinarity, relative to: (1) the form that it takes, (2) why it takes place, (3) interactions between disciplines, and (4) hierarchical terminology. This second literature review on interdisciplinarity allows us to frame the definition of interdisciplinarity according to two different perspectives.

First, as Klein (1990) and other authors propose, interdisciplinarity can be defined relatively to disciplines and institutions. This framing of interdisciplinarity by the disciplinary organisation of science allows the acknowledgement that disciplines bear they own values, research modes and organisational rules. By seeing disciplines as cultures, disciplinary knowledge - its methods and approaches, cannot be isolated either from the history and practice of the field or from its practitioner (Kuhn, 1962). Sill (2001) illustrates Kuhn's assertion by analogising disciplines to 'matrices of thought, each supported by assumptions that are themselves frequently invisible and unquestioned'. Fuller (1993) goes further by claiming that disciplines are even more complex entities, composed not only of a single matrix but of multiple matrices. Some of the matrices involve cognitive functions including disciplinary methodologies and a body of knowledge, while other matrices involve social interactions and professional connections. As a result, when two disciplines come together to collaborate around a single topic, interdisciplinarity leads to the crossing of families of

matrices, some cognitive and some social. Unfortunately, while approaching interdisciplinarity through disciplines gives us a sense of what happens, it does not yet give us an understanding of how it happens. Indeed, we 'vacillate between either a terminology of integration or of transgression: we somehow work with a black-box, knowing something about the input and something about the outcome, whereas we do not know what is happening between them' (Sill, 2001). This is why the second framing perspective on interdisciplinarity proposed hereunder is complementary.

The second framing perspective, mainly based on Sill's work (2001), and on the idea that interdisciplinary dynamics cannot be reduced to a 'transgression' nor an 'integration', approaches interdisciplinarity through the concept of 'research programs' and what the author calls the 'guide-supply relationship'. In this framing perspective, the idea of interdisciplinarity is different from the ways that it is typically conceived. Interdisciplinarity is usually advanced as a basis for overcoming the fragmentation of knowledge and the gaps between disciplines by unifying the diverse kind of knowledge of reality (Mourad, 1997). Here, interdisciplinarity does not 'integrates' divergent perspectives, but uses them to produce compelling ideas that are not limited by the disciplines.

These perspectives seem to be complementary, in the way they form a comprehensive framework that provides detailed insights into (1) what occurs at the boundaries of disciplines, and (2) how this occurs. Indeed, these perspectives acknowledge the complex nature of disciplines, by comparing them to matrices of thought. Interdisciplinarity is hence a meeting of families of cognitive and social matrices, or research programs, in a non-hierarchical basis, where researchers have to be aware on the boundaries, rules and values of their own discipline, and recognise the influence of their home discipline on the relation to other disciplines. In this regard, while disciplines keep their identities during the interdisciplinary collaboration, and have defined and discrete roles, it is a shortcut to consider interdisciplinarity as an integration or transgression process. Hunt (1994) illustrates this point by defining interdisciplinarity as a negotiation, in which disciplines must 'learn to understand each other and give up some territory in the interest of long-term balance, without giving up their individual identities'.

Context of emergence

Hicks, D. M., & Katz, J. S. (1996). Where is science going? Science, Technology, and Human Values, 21(4), 29.

Summary and highlights

Where is science going?: The authors of 'The New Production of Knowledge' (1994), argue that the internal dynamics of science have generated a new way of producing knowledge. The **post-World War II** expansion of the research and education systems led to a method of performing research qualitatively different from the discipline-based academic activity that has dominated science. This new form of research can be called '**mode2**', or **interdisciplinarity**. The paper presents an analysis of the UK science system, to address some aspects of the evolution of science:

- *Interdisciplinarity*: The data support the idea that interdisciplinary research increased more quickly than disciplinary research in the UK during the 1980s.
- *Collaboration*: The data support the idea that collaboration is rising steadily. Research projects combine an ever broader range of skills and resources, indicated by increasing interdisciplinarity and collaboration between individuals, institutions and countries.

Science policy and evaluation methods have adapted to these changes. Knowing how to fund, manage, facilitate, and conduct collaborative research are core scientific and policy competences.

To what extent can it help framing the RAMONS Project?

Reflexivity: As a reflexivity step, it seems important for the GIS CES actors to reflect on the origins of interdisciplinarity, and its context of emergence, to have deep insights into its foundational statements.

Balsiger, P. W. (2004). Supradisciplinary research practices: history, objectives and rationale. Futures, 36, 407-421.

Summary

Historical overview:

- The **debate about integration** in the late **1920s** by the Social Science Research Council already depicts the tensions between those scientists who prefer a disciplinary approach and those scientists who are in favour of a broad scientific approach.
- In his historical search for the **first mention of the term** of 'interdisciplinary', the sociologist David L. Sill (1986) identified the *Sixth Annual Report* of Social Science Research Council, **1929-1930**, where he found the following note: 'It is probably that the Council's interest will continue to run strongly in the direction of these interdiscipline inquiries'.

- The **'General Systems Theory'** by Ludwig von Bertalanffy (1932) formulated a new way of looking at scientific topics and introduced the interdependence of an object and its environment. The single disciplinary approach turned out to be insufficient, and the need for other forms of collaboration between various disciplines increased.
- Another aspect which seems important for the history of supradisciplinary scientific practices is the idea introduced by Klein (1986) in her 'Postscipt'. She underlines the fact that scientific approaches which are truly transgressing disciplinary boundaries are initiated by **unsolved problems within a society**.
- Two further aspects concerning the development of supradisciplinary scientific approaches were discussed by Pierre de Bie, the Belgian philosopher of science, in a UNESCO report (1970). He mentioned (i) that the task of any 'problem-focused research' is the solution of a given problem in a specific context, and (ii) he positioned this research among basic and applied research. The aspect of **solving problems in a social context**, as well as the **broad scope from 'pure theoretical reflection to the planned action'**, were two important reasons for the conceptualisation of any form of supradisciplinary research.
- The Austrian astrophysicist Erich Jantsch (1972) was the first to define the term of **transdisciplinarity**. According to him, transdisciplinarity could be defined as 'the **ultimate degree of coordination**', and would depend 'on the mutual enhancement of epistemologies in certain areas'.
- The emergence of transdisciplinarity is a reaction to the **criticisms** of Karl Popper (and others) unmasking his understanding of **science as being dogmatic**. In his book 'Against Method', Paul Feyerabend (1997) is arguing against those who are 'craving for intellectual security in the form of clarity, precision, objectivity, truth'. The authors of these claims cannot see 'that there is only one principle that can be defended under all circumstances, and in all stages of human development. It is the principle: **anything goes**'. Feyerabend's appeal for the plurality of various scientific views is a **refusal of methodological reductionism**: 'a scientist who wishes to maximise the empirical content of the views he holds and who wants to understand them as clearly as he possibly can must therefore introduce other views; that is, he must adopt a **pluralistic methodology**'. This methodological approach finally ends up by **comparing ideas with other ideas, instead of comparing ideas with 'experience'**, including empirical data.
- Jürgen Mittelstrass (1996) claims that **transdisciplinarity** is, above all, a **principle of research**, and only a principle of theories at a secondary level. This means that the comparison of ideas is more important than the support of a theory by experiential facts. Transdisciplinarity connects those scientists working in their disciplinary research programs together with the real world, which is itself determined by scientific progress. **The way we handle the solving of specific problems of public interest is more important than the dogmatically correct use of rules and tests of theories**.

Distinctions between multidisciplinarity, interdisciplinarity and transdisciplinarity:

- *Multidisciplinarity*: In contrast to the two other forms, multidisciplinarity has **no intention of problem solving**. It is **thematically oriented**. This means that several research programs are only contributing to a given theme from a clearly disciplinary perspective. In this case, **no collaboration is necessary**. The outcome will have **different perspectives** about the given theme; however, the recipient will not find any solution to the problem.
- *Interdisciplinarity and transdisciplinarity*: If a solution is intended at the outset, then the scientists involved would have to work in a collaborative way. This collaborative form could be either an **interdisciplinary** one, then **collaboration is restricted to the scientists** representing various research programs. In contrast, it might be a **transdisciplinary** one, if the striven solution is explicitly meant to **consider experiences from affected persons**. This second form of collaboration not only transgresses scientific disciplines; it will also **implement external expertise in defining a solution** to a given problem.
- *Transdisciplinarity*: Transdisciplinarity can hence be defined as follows: 'A scientific problem transgressing the boundaries of scientific disciplines arises when: (a) the **problem** is generated in an **extra scientific field** (economics, politics, the living world); (b) a **solution** to the problem is **urgently required** in this field; (c) **public opinion** considers these fields relevant; and (d) when it is **brought to science in an institutional way** (financing of projects)'. In this case, **science** may have to adopt the special task if **informing the public**. **Transdisciplinarity remains a scientific concept**, **based on a purely scientific framework**, which means that the base on which transdisciplinary research is performed is a scientific one, and that the process should follow scientific rules. Transdisciplinarity is a specific approach which **does not compete with disciplinary approaches** at all. The goal is to **satisfy the public interest** which drives scientists to solve the given problem.

Evaluating supradisciplinary practices through discursive evaluation: When comparing a disciplinary research approach with a supradisciplinary one, we can detect a few differences which are relevant in the perspective of an evaluation. First, in a supradisciplinary approach, scientists first **need to reformulate and adapt the problem** in a way that it fits a scientific approach. Second, **scientists** working in a supradisciplinary research approach do not only have **different backgrounds**; they are also led by **different values**. Hence, they also have **different notions about what is right and wrong**. Third, the **contribution** of a research program does not stem from its own disciplinary context, but is **driven by a concrete problem**. Fourth, concerning the traditional view of science, the main target is to produce 'true' knowledge, whereas interdisciplinary or transdisciplinary research processes focus on the **production of solutions for given problems**. Here, the simple alternative 'true or not' does not really fit. It is more a question whether or not the **suggested solution is technically and economically feasible, socially acceptable, and even ecologically sustainable**. Based

on these points, when evaluating a supradisciplinary project, we have to take into consideration: (i) that the structure of the given problem is adequately represented in both the tasks and the structure of the project; (ii) each scientific contribution to the project has to be proven necessary for the solution of the whole project, and (iii) it has to be emphasised that any intended solution can only be reached by using a scientific approach.

Highlights

Framework to define interdisciplinarity: This paper has strong **reservation concerning the reduction of science to the disciplines**. If an author mentions that a disciplinary boundary is transgressed, then we somehow work with a black-box, knowing something about the input and something about the outcome, whereas we do not know what is happening between them: interdisciplinarity or transdisciplinarity are then scientific practices, breaking up the disciplinary entities, and as soon as one has to describe what happens when two such entities come together, then they vacillate between either a terminology of integration or of transgression. Taking a closer look at what really happens when scientists, representing various disciplines, are collaboration, we find out that **neither integration nor transgression occurs**. Here, an epistemological approach based on the concept of research programs, and the mutual 'guide-supply' relationship seems to offer a better description of what happens when scientists are collaborating together to solve a specific problem.

- *Research programs*: **Scientific practice is more adequately depicted by the concept of a research program than by the historical and institutional settings of disciplines.** The concept of research programs was first introduced by the Hungaro-English mathematician Imre Lakatos (1970). It was developed as a reaction to the debate about the **dynamics of science**, in order to mediate between the position of Karl **Popper** (1958), who favoured a model of science that is smoothly but steadily increasing, and the position of Thomas **Kuhn** (1962), who preferred a model which described the dynamics of science as a movement that occasionally had strong twists, especially when a formerly used theory had broken down and a new one was proposed. Subsequently, Lakatos suggested not to base the development of science on the potentials of theories, but to **get a closer look at how scientific practice actually is performed**. He did show that this performance was based on what he then called a **disciplinary research program that described the actual topics and aims** scientists in a particular discipline worked on. Every research program has a **'hard core'**, including methodological rules as well as fundamental empirical assumptions, that are immune to falsification. This hard core is accompanied by a **'positive heuristic'**, that shows how the hard core has to be implemented to obtain new knowledge; and a **'negative heuristic'**, that shows how the hard core can be defended from any attempt at falsification.
    - ➡ This is the conceptual framework with which interdisciplinarity or transdisciplinarity can be defined.

- *The 'guide-supply' relationship*: How can any research involving at least two research programs be managed, in order to achieve either interdisciplinarity or transdisciplinarity? The Dutch philosopher of science Henk Zandvoort (1995) presented a feasible answer to this question. He asserted that in order to apply an interdisciplinary approach, the relationship between the participating research programs should be **non-hierarchical**. However, there will be a relationship which is characterised by the feature of 'guide and supply'. In the **'guide mode'**, a discipline or research program **formulates a task**, which is **adopted** and dealt with by another research program, claimed to be in the 'supply mode': "*Some of the research programmes do not define their own primary problems. Instead, they aim at solving problems arising in and defined by other research programmes. The latter programmes may not themselves have the efficient means to solve those problems."* If necessary, the participating research programs can **switch from one mode to the other** during the research practice.
    - ➡ Scientists have to jointly point out not only which **formulation** is sufficiently **precise**, but also which formulation is sufficiently **operational** in order to satisfy both the guiding and the supplying research programs. Concerning a transdisciplinary approach, the formulation of the given problem has also to be convenient and still understandable to the addressed public.

To what extent can it help framing the RAMONS Project?

Definition of interdisciplinarity: In the future definitions of interdisciplinarity, the RAMONS project should include a reflection on the framework (proposed by this paper) composed of two aspects: the notion of '**research programs**' and the '**guide-supply**' relationship between these research programs. Indeed, this framework provides a deep insight into the processes and dynamics of collaboration that occur at the boundary of several disciplines, that cannot be qualified as 'transgression' nor 'integration'. This must be put in parallel to the paper of Robertson et al. (2003) below, that defines interdisciplinarity through the disciplinary organisation of knowledge.

Mourad, R. P. (1997). Postmodern Interdisciplinarity. The Review of Higher Education.

Summary

Modernism and postmodernism: **Postmodernism** can be understood in large part as a **rejection** of what the philosopher Jürgen Habermas (1983) calls 'the **project of modernity**'. The project of modernity, formulated in the 18th century by the philosophers of the **Enlightenment**, consisted in their efforts to develop **objective science** and **universal morality** and law. Furthermore, the Enlightenment philosophers wanted to use an accumulation of specialised culture for the **rational organisation of everyday social life**. Postmodern challenges reject the modern idea that the intellect can direct human civilisation towards a progressive understanding that is universal, knowable, and achievable through

discoveries and applications in such areas as science, civil governance and aesthetic expression. Indeed, postmodern philosophy asserts that **knowledge is determined**, or at least substantially conditioned, by the social rules that govern discourse. Postmodernism therefore aims to **depart from modern concepts** rather than reforming or enhancing them.

Postmodern thinkers:

- *Jean-François Lyotard* (1984): For Lyotard, the most important aspect of knowledge is that it involves communication between people: '**to know is to discourse**'. This realisation means that **sciences are a plurality of separated and incommensurable truths**, and their object (**reality**) is essentially **unpredictable** and unstable. Therefore, all we can know are local contexts or 'islands of determinism', rather than a complete, consistent whole. Given this complexity, the principle of experimental replication has become increasingly **dependent on sophisticated and expensive technology**. The production of scientific proof costs money, with the result that scientists who can maximise output (proof) while minimising input (energy, costs), get funded. Lyotard claims that this has **demoralised research scientists**. He also alleges that the principle of **optimal performance** affects not only the pursuit of knowledge but the nature of its transmission as well. Higher education has become increasingly defined by its capacity to create and produce skills indispensable to competition in world markets. **Whatever course of action increases the overall efficiency of the social system is legitimated, without decisive regard for its effects on human beings.**
- *Michel Foucault* (1970, 1979, 1980): Foucault alleges that **knowledge** is discourse created by humans in the effort **to attain power**: 'We are subjected to the production of truth through power, and we cannot exercise power except through the production of truth'. Foucault argues that, in the 19th century, the idea of knowledge was profoundly altered in response to the social need for a scientific discourse that could legitimise and direct masses of human beings towards becoming a highly organised society of disciplined, productive individual 'subjects'.

Highlights

Disciplines: **Disciplines** are the manifestation of the **absoluteness of the pursuit of knowledge** for several reasons. First, they are regarded as comprising the foundations of the university. Second, they are primarily concerned with a theoretical knowledge of reality. Third, since theory is expressed in disciplinary terms, disciplines are the **prescribed structure for intellectual activity**. Knowledge within each discipline is unified and forms a unique self-encompassing whole. The increasing depth and diversity of theoretical knowledge within disciplines means that they are expanding, in that they encompass increasing quantities of knowledge. The expansion of disciplinary knowledge can be a sign that disciplines are robust structures. However, this expansion can also mean that they are **increasingly incoherent structures**: the profusion of new, diverse modes of inquiry, leading to the blurring of disciplinary boundaries, suggest that **disciplines are fragmented**, rather than unified, autonomous wholes.

Research programs: The formation of research programs takes its roots in **'intellectual forums'**. Their aim is to take marginal ideas out of their disciplines, to allow them to be pursued **without being constrained by disciplinary assumptions**. A research program is composed of interested individuals from a diverse group of disciplines. The aim is to use the disciplinary differences as points of departure. Researchers seek to create or discover a **dynamic between disciplines, that produces a new concept**. The focus and organising principle of research is the expression of the idea in a new language. **The order, content, direction, purpose, clarity and understanding of the idea do not exist before and independently from the research, but emerge from and are shaped by the course of the inquiry.** Modern **disciplines** function as **points of departure** for new paths of thought rather than as top-down structures that largely determine the nature and course of particular inquiries. Over time, two or more research programs might affiliate. These groupings are highly permeable so that at any point in time, a research program that might be formally located in one grouping could interact with programs in other groupings. Amid this fluidity, the persistence of a particular research program reflects its richness as a basis for the generation of other compelling ideas.

To what extent can it help framing the RAMONS Project?

Definition of interdisciplinarity: Interdisciplinary is usually advanced as an answer to problems linked with disciplinary structures, and as a way of enhancing the disciplinary pursuit of knowledge of reality. In this postmodern framework, the idea of interdisciplinarity is different from the ways that it is typically conceived. It is not a basis for overcoming the fragmentation of knowledge and the gaps between disciplines by unifying the divergent pursuits of knowledge of reality. **Postmodern interdisciplinarity does not synthesise divergent ideas, but uses them to produce compelling ideas that are not limited by the disciplines.** However, liberating the thinking from the absolute foundation of the disciplines does not mean that disciplines would vanish. Their longevity suggests that they are compelling ideas themselves.

Morillo, F., Bordons, M., & Gomez, I. (2003). Interdisciplinarity in Science: A tentative typology of disciplines and research areas. Journal of the American Society for Information Science and Technology, 54(13), 1237-1249.

Summary and highlights

Definitions of multi, inter and transdisciplinarity: The **most commonly accepted definitions come from the OECD** (1998), in which multi, inter and transdisciplinarity are used to refer to increasing levels of interaction among disciplines. This, in multidisciplinary research, the subject under study is approached from different angles, using different disciplinary perspectives. Integration is not accomplished. Interdisciplinary research leads to the creation of a theoretical, conceptual and methodological identity, so more coherent and integrated results are obtained. Finally, transdisciplinarity goes one step further and refers to a process in

which convergence among disciplines is observed, accompanied by a mutual integration of disciplinary epistemologies.

Bibliometric study: The bibliometric methodology of this paper provides a general overview of all scientific disciplines, with special attention to their interrelations. The most relevant results of the study are:

- Differences in the degree of interdisciplinarity are observed, with biomedicine and technology at the upper range of the scale, and humanities at the lower one. The independence between basic/applied level of research areas and interdisciplinarity is an important finding. Mathematics appears as the less interdisciplinary area of the hard sciences.
- New emerging disciplines are highly interdisciplinary.
- Engineering and technology ply an important role in interdisciplinary research, as stated by Van Raan (2002): 'technology acts as a bridge between the different scientific disciplines, and without technology domains of human knowledge would remain largely isolated'.

To what extent can it help framing the RAMONS Project?

Reflexivity about the disciplinary origin of the actors: A map of the scientific landscape, showing the facilities of disciplines to interact with other could be a reflexive tool to help the GIS CES actors to reflect on their disciplinary origins. Nevertheless, a reflection on the disciplinary origins seems to be incomplete, and must be accompanied by a deeper reflection on what happens at the interface of two (or more) disciplines.

Definitions

Robertson, D. W., Martin, D. K., & Singer, P. A. (2003). Interdisciplinary research: putting the methods under the microscope. BMC Medical Research Methodology, 3(20), 5.

Summary

History and origins of interdisciplinarity: To understand the world it has seemed necessary to analyse it by breaking it into many pieces (i.e., the disciplines and their own divisions). But to act in the world, we need to somehow reassemble all the pieces. When, in the 1810s, Magendie brought together organic chemists and physiologists to investigate the importance of nitrogen in animal nutrition, he helped catalyse the birth of **biochemistry**. During the early 20th century, Delbrück's and Szilard's application of physics to cell reproduction proved led to the discovery of the **DNA double helix**. Moreover, many **interdisciplinary institutions** such as California Institute of Technology, Harvard's Bauer Centre for Genomics Research have been established to foster interdisciplinary research.

Fuzziness around the methods of interdisciplinarity: While the desirability of interdisciplinary inquiry has been widely acknowledged, the methods of interdisciplinary collaboration are opaque to outsiders and generally remain undescribed.

Definition of interdisciplinarity relatively to disciplines and institutions: Many have analysed interdisciplinarity, especially in relation to the **creation of new disciplines** and **institutions**.

- *Disciplines*: Disciplines are defined by their conceptual specificity. One perspective on interdisciplinarity is to assess **sharing and merging between disciplines**. Patricia Rosenfield (1992) claims that this level of collaboration has the most **potential for originality**, but occurs least often because developing a common language is difficult. Peter Galison (1997) analyses the competing traditions of researchers who collected microphysical data by imaging high-energy phenomena, and those who collected them by subatomic events. Galison argues that fruitful collaboration between these groups occurred only when they began to **share** not only language but **practices** – **methods** – thus creating a **'trading zone'** in which 'commerce of ideas and methods' could occur. A more recent illustration is the field of biophysics, in which physicists, computer programmers, chemists, and biochemists have learned each other's conceptual vocabulary and methods in order to collaborate in exploring problems such as the function and mechanism of membrane proteins. All these examples show that a **commonly understood language and set of rules and methods are key to overcoming the ontological (nature of reality) and epistemological challenges of interdisciplinary research**.
- *Institutions*: Perhaps the most important environmental condition favouring interdisciplinarity is the building of an **institutional 'platform'** for collaboration. The Rockefeller Institute during the 1950s brought together researchers from a broad spectrum of sciences. The Pasteur Institute was as well reorganised around cross-disciplinary research programs intended to maximise links between scholars from disparate fields.

Highlights

Facilitators to interdisciplinarity: Participants must **agree-upon a research template** from the beginning. They must acknowledge that each participant's contribution would occur within that interdisciplinary framework, and agree that only through this type of interdisciplinary approach, could the research issues be adequately addressed. Frequent **electronic communications** and **face-to-face meetings** occur to enhance opportunities for dialogue and information exchange.

'Logbook' and reflexivity: Researchers have an obligation to make their procedures transparent, but interdisciplinary teams – while they report methods of data collection and analysis – seldom report the methods they employ in the process of achieving interdisciplinary collaboration itself. Because the process of collaboration itself determines the premises of a research project, not reporting the methods of collaboration can make it difficult for others to **assess the validity and reliability** of data collection and inferences, and

to **build on the methods of earlier groups**. Other researchers should be able to follow the process of collaboration and the decisions made during inquiry; this allows them to think out how they might attempt to **replicate findings, or choose to carry out collaboration differently**.

To what extent can it help framing the RAMONS Project?

Origins of the participants: This paper makes the distinction between the participants to interdisciplinary projects that are selected because their **disciplinary expertise** is obviously necessary to address the research issues, and the participants **self-selected** because of their own interest in the issues. An inquiry on the origins of the participants presence was led within the HUMBOLDT project. It will be interesting to see whether the various origins influence the interdisciplinary dynamics and motivations.

Qualitative and quantitative methods: The paper shows that **qualitative research** methods seem to facilitate the **identification and analysis of key ethical, environmental, legal and social concepts**. The **empirical and theoretical analyses** then feed into explicit consensus building **methods that help focus the different disciplinary perspectives** on a common consensus-building task. This aspect could be investigated in the CCTV project, where social and climate sciences meet, to see whether their respective contributions translate into this above-cited scheme.

Reflexivity: Literature on participatory action-research have shown that **explicitness** allows other researchers to **replicate the work, make different design choices, and learn from the evaluation of the process**. To this aim, the collaborative work between the RAMONS and CCTV / HUMBOLDT projects tries to encourage researchers to more thorough consideration of important methodological questions such as:

1. Which **fields** are included, or excluded, in the research project? **Why**?
2. How rigorously want the researchers exploit the **opportunity** for interdisciplinary collaboration? (Were a new common vocabulary and new methods devised?)
3. How important are **institutions** in facilitating or foiling the interdisciplinary collaborations?
4. How key is the **integration** of disciplinary perspectives in shaping a more comprehensive explanation of the phenomenon?

Especially with HUMBOLDT, an effort is led to foster the interdisciplinary researchers to document and reflect on their collaborations, through focus groups (inaugural contract, writing breaks) and semi-directed interviews. The participants are encouraged to record how it was recognised that an interdisciplinary approach was necessary, how the participating disciplines were chosen, how the disciplines' strengths were combined, and how the combination contributed to the methods, data, and results.

Price, R. Interdisciplinarity: how many researchers does it take to change a light bulb? Centre for Rural Social Research, Charles Sturt University.

Summary

Disciplines: From a simple perspective, disciplines are an **institutionalised category of organised knowledge**. They are distinctive areas of knowledge, recognised by their professional titles, institutes, journals, as well as their means of experimentation, observation, analysis and extrapolation (Ziman, 1997). According to complexity theorists, specialisation is both natural and an arbitrary circumstance; a standard property of an evolving, self-organised system (Cohen & Stewart, 1994). **Specialisation** reflects the **need to be original**, and so to know all about a limited field. The **reward systems** of promotion, **peer recognition** and **publication** all reinforce this.

Drivers for interdisciplinarity: Changes that have taken place in science over the past twenty years are described by Gibbons et al. (1994) as a transition in the production of knowledge from a Mode 1 to a Mode 2 approach. In their analysis, **Mode 1** is organised on **disciplinary** lines, characterised by **homogeneity**, is **hierarchical** and focused on problems largely set by **academic interests** or the scientific community. **Mode 2,** on the other hand, is characterised as being carried out in the **context of application**, with a tendency to be more **heterogeneous** and **transitory** in its organisational forms. These changes in science can be attributed to four factors:

- *Economic rationalism*: Science has not escaped the universal economic and policy debate about **efficiency** and **effectiveness**. These choices lie both within competing fields of science, and between science and other activities of the government and private sectors.
- *Accountability*: New structures for funding research have drastically changed who and what determines scientific agendas and pursuits, and the methodologies and approaches used. Moreover, society demands that science must resolve its problems. A consequence of these expectations is an increase in **applied research** where quality assurance is achieved through social accountability, at the cost of basic science where quality assurance is achieved through peer review.
- *Complexity*: While academic and other scientific institutions may be characterised by disciplines, the problems of the world are not. **Contextually specific problem solving** requires solutions beyond the scope of any single discipline to offer (Shove & Simmons, 1997).
- *New forms of satisfaction*: **Researchers** are **stimulated** by the opportunity of working in interdisciplinary teams and across organisational boundaries. Perhaps some are aware of the work of Thomas Khün, who suggests that scientific revolutions tend to occur at the boundaries of disciplines, and see working at the interface of disciplines as presenting their **best opportunity for originality**.

Another way at looking at the modern transition of science comes from the work of Funtowicz and Ravetz (1991). There are three modes of scientific practice that have evolved: normal science, expert science and post-normal science. In **normal science**, scientific activity involves **solving puzzles** in accordance with agreed rules and under a quality assurance system of **peer review**. Uncertainties involved in this process can be accommodated by scientific methods, but the outcomes of the scientific activity do not have direct influence on the greater interests of society. As problem driven science has evolved, reflecting both greater societal interests and scientific uncertainty, so too has the interaction of scientists with other problem solving professions, such as economists and policy advisers. Thus the phenomenon of the 'expert' has arisen. An **expert** is regarded as 'someone who has demonstrated within his field that he have the quality required to deal with problems with far-reaching consequences' (Van Latesteijn & Schoonenboom, 1997). Finally, **post-normal** science evolves where the problems that society wants answered, and the uncertainties involved, are too complex for the experts to resolve.

Degrees of cross-disciplinary interaction: Boden (1997) distinguishes a number of forms of organisation structure, presented here in ascending order of cross-disciplinary interaction:

- *Encyclopaedic interaction (pluridisciplinarity)*: Structures that contain distinct components, representing a range of disciplines, but with no need for communication between them. **Universities** are a good example, with most ensuring that they have the basic disciplines compartmentalised into different faculties.
- *Contextualising interaction*: Structures that ensure that at least some of their disciplines take into account other disciplines in setting goals and objectives, but still with no need for active research cooperation.
- *Shared interaction (multidisciplinarity)*: Structures in which **different aspects of a complex problem** are tacked by different disciplinary sub-structures with complementary skills. They **share their findings without bringing them together to form an understanding of the broader system**.
- *Cooperative interaction*: Disciplinary sub-structures with complementary skills working towards a **common goal** and cooperating throughout the process. It does not only encourages communication of findings, but also communication of **progress** and **problems**. However, the **findings are aggregated rather than synthesised** (for instance: resource management research institutes).
- *Generalising interaction*: Not only do teams of researchers from different disciplinary perspectives share **common goals** and **problems**, they share common **guiding philosophies**. A very high level of communication and coordination is required.
- *Integrated interaction (interdisciplinarity)*: A range of disciplines interacts to integrally **define problems, philosophical positions and methodological approaches**, and to implement **methodological tasks** and **evaluation procedures**. They must work together to solve problems holistically.

Highlights

Objectives of interdisciplinarity: Interdisciplinary research should **not be an end in itself**, or the only legitimate way of resolving problems. The appropriate level of cross-disciplinary interaction should be chosen by precisely defining the character of the problem. **The more complex and uncertain the problem, the more disciplines should be involved in the problem definition.**

Obstacles to interdisciplinarity:

- *Institutional design and culture*: Most research institutions are based on structures and reward systems that discourage interdisciplinary research (Scott, Skea, Robinson, & Shove, 1999). Departments, faculties and other sub-structures tend to be discipline-based. **Prestige** is attached to publishing in recognised **disciplinary journals**. Within academia, promotion procedures favour **disciplinary loyalty**, quality and **peer recognition**.
- *Skills, training and leadership*: The distinct aspects of the world apparent to independent researchers from different disciplinary backgrounds do not automatically merge into a comprehensible whole. Managing interdisciplinary research therefore requires an **ability to break down the mental barriers between scientists ruled by different paradigms**.
- *Costs*: From a **time** perspective, greater effort is required at all stages of the research process (listening, understanding, debating and negotiating; defining the research problem and the appropriate methodological approach). For most, a **true understanding** may never eventuate, but **appreciation** of, and **respect** for, other perspectives may be sufficient to establish and maintain interdisciplinarity. From an **energy** perspective, interdisciplinarity demand **personal commitment and belief**, and constant **intellectual contribution and flexibility**. The need for this effort may be greatest during the initial problem definition phase.
- *Disciplinary incompatibility*: The test of interdisciplinarity is whether or not **Kühn's concept of incommensurability** breaks down. Incommensurable theories are pairs of theories in which not a single descriptive term of either theory can be adequately defined by means of the descriptive terms of the other, and in which the use of the concepts of either one of the theories makes the concepts of the other inapplicable (Feyerabend, 1981). The greater the divergence in disciplines from their theoretical and methodological basis, the more likely they are to be incommensurable.

To what extent can it help framing the RAMONS Project?

Definition of interdisciplinarity: This paper will contribute in many aspects to the building of a new, more comprehensive, definition of interdisciplinarity within the RAMONS project, by adding a deeper reflection on the various levels of cross-disciplinary interactions, and by proposing formalised obstacles to interdisciplinarity. Furthermore, the global context, highlighting the changes that occurred in science during the last 20 years, will add further explanations to the origins of interdisciplinarity. An evaluation framework for

interdisciplinary research, based on this second literature review, will be proposed by the RAMONS project.

Initial phase: Some researchers (Foster, 1997) argue that there is a need for this phase to include the establishment of a common language. However, the iterative and unpredictable nature of interdisciplinary research is such that a common language is better to emerge and adapt over the duration of the research activity. Too formalised a process at the commencement of a project could inhibit the unforeseen inspiration required to resolve problems of great uncertainty. This assertion, whether an initial phase is necessary or not, should be discussed within the RAMONS' analysis of the CCTV project.

Freymond, N., Meier, D., & Merrone, G. (2003). Ce qui donne sens à l'interdisciplinarité. A contrario, 1(1), 3-9.

Summary

Fragmentation des savoirs: L'exigence scientifique de nommer avec rigueur et précision les objets de la recherche suppose une **fragmentation des savoirs**, processus historique qui fut nécessaire à l'essor des démarches scientifiques. Cette **science moderne**, dont l'un des élans initiaux prétendit fonder la connaissance sur une raison libre de toutes les traces de pensée religieuse, mythique ou magique, incarne un processus tout autant scientifique que politique, non seulement pour ce que le politique peut imposer dans l'orientation de la recherche, mais aussi pour ce que ce processus engendre par son mouvement propre de **connaissances qui s'agrègent autour d'identités scientifiques**; autant de frontières qui finissent par **développer un sens aigu de la conservatio**n ou qui, face à la mouvante **complexité** du monde, tentent de **la réduire par une spécialisation toujours accrue**, fuite en avant définissant davantage de sous-objets et de sous-spécialités. Concernant les sciences sociales, la parcellisation du savoir s'est essentiellement réalisée dès la seconde moitié du XIXe siècle (Révolution Industrielle). Les pratiques scientifiques s'intègrent alors à un processus historique de **division sociale du travail** au terme duquel elles sont objectivées dans des structures institutionnelles (facultés, départements, instituts). Les corpus de connaissances spécialisés se cristallisent en disciplines. La situation actuelle qui résulte de ce processus donne à voir un univers des sciences sociales où foisonnent nombre de théories et de connaissances partielles, et l'on doit s'interroger sur leur **capacité à rendre compte de la réalité sociale**.

Disciplines: Une discipline, pour exister, se **construit contre les disciplines instituées**, dans le but de faire valoir et reconnaître sa **nature distincte** et sa **pertinence**. Il s'agit d'un processus conflictuel articulé autour d'enjeux. Les efforts consentis pour conquérir une légitimité sont en partie investis dans la **lutte pour l'appropriation de portions de réalité**, fondements de l'autonomie revendiquée. Une discipline s'affirme donc par l'exclusion d'autres perspectives disciplinaires et la déclaration d'une exclusivité dans l'étude d'une certaine classe d'objets, d'une portion de réalité empiriquement définie. Seulement, **oublier que c'est le point de vue qui crée l'objet** conduit à enfermer la pratique scientifique dans des

limites qui ne jouissent d'aucune pertinence théorique. Si l'on peut donc parler d'œillères disciplinaires, c'est que les disciplines font voir le monde social comme un ensemble de secteurs hermétiquement cloisonnés et ajustés aux formes institutionnalisées de la division du travail scientifique.

Highlights

Interdisciplinarité: Ce terme ne renvoie en fait ni à une démarche, ni à une méthode, ni à une théorie particulière, pas plus qu'il n'est assimilable à un postulat, un axiome ou un présupposé. **Affirmer la non-pertinence des frontières disciplinaires pour l'analyse de la réalité sociale résulte avant tout d'une prise de conscience réflexive des conditions sociales de la production scientifique.** L'interdisciplinarité apparaît dès lors comme une **mise en garde**, un **'principe de précaution' contre** le danger que représentent les impensés sociaux et les représentations naturelles du monde scientifique institutionnalisé qui contribuent à la **pré-construction des objets d'analyse**. Ces préjugés constituent un obstacle épistémologique. Ils sont d'autant plus difficiles à objectiver qu'ils résident dans l'environnement direct et quotidien des chercheuses et des chercheurs. Prise en ce sens, **l'interdisciplinarité contribue à réaffirmer le principe d'unité du réel et la nécessaire rigueur intellectuelle.**

Méthodes et défis de l'interdisciplinarité: Cette interdisciplinarité n'en recouvre pas moins un certain nombre de pratiques dont deux sont parfaitement identifiables:

- La première consiste à **emprunter des concepts, des méthodes et des théories** forgés au sein d'autres disciplines pour les faire travailler sur des objets censés relever de la discipline importatrice
- La seconde englobe des tentatives d'**élargissement du champ d'application** de théories forgées au sein d'une discipline précise à des objets relevant d'autres disciplines.

Les emprunts faits à une autre discipline posent quatre problèmes:

- Il faut **être en mesure de s'approprier le concept**, c'est-à-dire disposer des connaissances nécessaires à la maîtrise de son usage, voire à sa redéfinition ou retraduction.
- L'**exigence de cohérence épistémologique**. Ni les sciences naturelles, ni les sciences sociales ne peuvent se prévaloir d'une objectivité absolue. Il en découle que toute réflexion sur le réel est fondée sur des principes, implicites ou explicites, par définition indémontrables, qui doivent former un ensemble cohérent. Cela signifie qu'ils ne peuvent se contredire sous peine d'invalider les propositions qu'ils fondent. C'est pourquoi le **processus d'appropriation doit inclure une étude critique de tels fondements, non seulement pour évaluer la validité intrinsèque de ces outils, mais également pour s'assurer que leur intégration à un cadre théorique préexistant n'entraîne pas de telles contradictions.** Par un effet de miroir, cela conduit à faire subir à la théorie réceptrice un examen critique du même ordre.

- L’exigence épistémologique de rigueur est indissociable de l’**exigence éthique de probité intellectuelle** : on ne peut s’arroger le droit de produire un discours sur un objet ou une classe d’objets sans même être en mesure de **fournir une critique informée des connaissances existantes**.
- Les confrontations qui s’ensuivent mettent en scène des configurations complexes d’agents, très variables en fonction des disciplines et de leur histoire. Les enjeux de ces **luttes** ne sont pas purement scientifiques, mais renvoient souvent à des intérêts sectoriels : luttes pour le prestige, pour l’obtention de crédits de recherche, pour conquérir des positions institutionnelles, etc.

To what extent can it help framing the RAMONS Project?

Definition of interdisciplinarity: This paper presents interdisciplinarity as a reflexive awareness of the social conditions and scientific production of knowledge. It is hence a means to underline the irrelevance of the disciplinary boundaries for the analysis of the social reality. Interdisciplinarity is a caution, a precautionary principle against the pre-construction of research objects by social unthought and natural representations of the scientific world. These prejudgement are difficult to make explicit, because they belong to the direct environment of researchers. In this sense, interdisciplinarity contributes to emphasise the unity principle for reality, and reminds the importance of intellectual rigourousness.

Cantin, S. (1999). Interdisciplinarité et transdisciplinarité chez Fernand Dumont. Laval Théologique et Philosophique, 55(1), 49-63.

Summary and highlights

Définition : Selon le rapport de l'OCDE (1972), l'interdisciplinarité postule une interaction entre disciplines, qui peut aller de la simple communication des idées jusqu'à **l'intégration mutuelle des concepts directeurs, de l'épistémologie, de la terminologie, de la méthodologie, des procédures, des données et de l'organisation de la recherche et de l'enseignement** s'y rapportant. De ce point de vue, l'interdisciplinarité représenterait une **pratique collective** exigeant de la part de celui qui choisit de s'y engager une certaine attitude d'esprit qui serait faite de **curiosité**, d'**ouverture**, de sens de l'aventure et de la **découverte** ; et aussi de l'**intuition** qu'il existe entre toutes choses des relations qui échappent à l'observation courante, des analogies de comportement ou de structures (Michaud, 1972).

To what extent can it help framing the RAMONS Project?

Définition de l'interdisciplinarité : L'interdisciplinarité suppose l'interaction entre disciplines par opposition à leur simple juxtaposition ; la complémentarité hiérarchique entre la recherche et l'enseignement interdisciplinaires ; le caractère collectif de la recherche interdisciplinaire et l'ouverture d'esprit, sinon l'humilité, qu'elle suppose de la part de ses participants.

Practice and methods

Roos, V., & Lombard, A. (2003). Interdisciplinary collaboration: an ongoing community narrative. Journal of Community Psychology, 31(5), 543-552.

Summary and highlights

Prerequisites: **Trust** enables members of an interdisciplinary project to share and to focus not only on the content, but also on processes. An atmosphere of mutual trust and **respect** between members is necessary to interdisciplinary collaboration.

Community narrative: The identity as an interdisciplinary team is acknowledged by the fact that members move from context-bound knowledge to a **generalist approach** (Lifschitz & Oothuizen, 2001). The focus in interdisciplinary collaboration should be on the **commonalities** and not the differences between people and disciplines. The community narrative approach creates the opportunity for **meta-communication** through listening to the stories of others with respect.

Identity: Most people develop and express **identities** that are shaped by the communities in which they function and, as such, are limited by the communities' associated **norms** and **values** (Rappaport, 1995). This is also supported by Greenberg and Pascual-Leonne (2001) who state: 'in deciding who they are, people are strongly influenced by the sources they use in generating explanations and self-evaluations that constitute their identities'. One of the challenges of interdisciplinary collaboration is that every member in an interdisciplinary team should **become aware of his own professional communities' norms and values and how they contribute to or limit the process of interdisciplinary collaboration**.

To what extent can it help framing the RAMONS Project?

Identity: The question of identity, membership, community is a crucial reflexive issue for interdisciplinarity. Identified as a reflexive prerequisite according to the analysis of the first GIS CES interviews of March 2009, a reflection of the personal and professional identities must be achieved in order to understand how they influence the relations to other researchers and other disciplines (i.e. other research values, thinking modes, rules, etc.).

Bronstein, L. R. (2003). A model for interdisciplinary collaboration. Social Work, 48(3), 297-306.

Summary and highlights

Definition: Berg-Weger and Schneider (1998) define interdisciplinary collaboration as an **interpersonal process** through which members of different disciplines contribute to a common product or goal. Interpersonal processes gather together processes such as **cooperation**, **communication**, **coordination** and **partnership** (Bruner, 1991; Graham & Brater, 1999; Kagan, 1992; Mailick & Ashley, 1981).

Components of interdisciplinary collaboration:

- *Interdependence*: Each professional is dependent on the other to accomplish his goal and tasks. Characteristics of interdependence include formal and informal **time** spent together, oral and written **communication**, and **respect** for colleagues' opinions and input. An advantage of teamwork is that merging the expertise and knowledge from different disciplines **maximises creativity with complex problems** (Londsdale, Webb, & Briggs, 1980; Webb & Hobdell, 1980).
- *Newly created professional activities*: They refer to collaborative acts, programs, and structures that can achieve more than what could be achieved by the same professionals acting independently.
- *Flexibility*: Refers to **role-blurring**. Behaviour that characterises flexibility includes reaching productive **compromises** in the face of disagreement. As a component of collaboration, flexibility in role demands **less hierarchical relationships**.
- *Collective ownership of goals*: Refers to **shared responsibility** in the entire process of **reaching goals, including joint design, definition, development, and achievement of goals.** Each professional must take responsibility for his part in success and failure, and support constructive disagreement and deliberation among colleagues. Successful collaborative efforts include clearly defined and realistic goals, a shared vision, agreed-on mission, objectives and strategy, broad-based involvement in decision-making, and collaborators with the ability to compromise.
- *Reflection on process*: Refers to collaborators' attention to their process of working together. This includes collaborators' thinking and talking about their working relationship and process, and **incorporating feedback** to strengthen collaborative relationship and effectiveness. Soler and Shauffer's (1993) study identified successful service integration as incorporating a commitment to **self-evaluation**. Billups (1987) included openly addressing intrateam conflict and use of feedback to reflect on collaborative interactions as critical components of successful interdisciplinary teams. Kane (1980) defined an integrative team as one that allocates time for reflecting on process. Last, Abramson (1990) specified the importance of a procedure whereby teams examine the **ethical dilemmas** that confront them and how these dilemmas are approached.

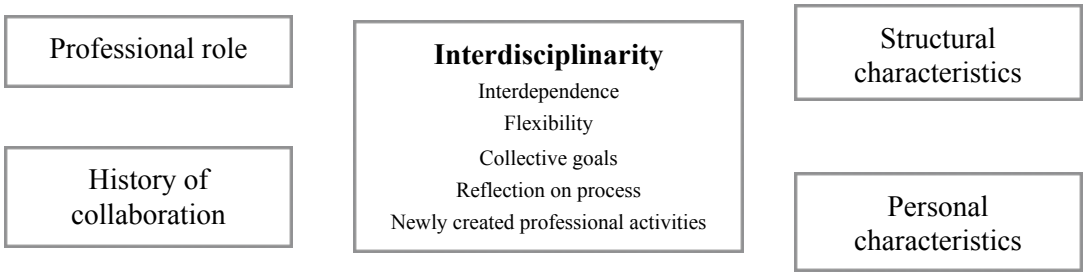
Interdisciplinarity =
Interdependence
Flexibility
Collective goals
Reflection on process
Newly created professional activities

Influences on interdisciplinary collaboration:

- *Professional role*: A strong sense of professional role includes **holding the values and ethics of the profession**, **respect** for colleagues, and a perspective that is similar or complementary to collaborators' perspectives. **Each profession socialises its members differently with regard to roles, values and practice.** Understanding the socialisation, and with it the **expectations** and **heritage** of a profession, are

prerequisites for understanding a group of professionals' skills, attitudes, and abilities to collaborate with other disciplines (Lee & Williams, 1994).

- *Structural characteristics*: They include **administrative support**, **professional autonomy**, and the time and space for collaboration to occur. Mattessich and Monsey (1992) found that collaboration is supported when agency leaders advocate for it and when adequate **financial base** exists.
- *Personal characteristics*: They include the ways collaborators view each other as people, outside of their professional roles. They include **trust**, **respect**, **understanding**, and informal **communication** between collaborators.
- *History of collaboration*: Refers to earlier experiences in interdisciplinary settings with colleagues. They are a **factor of success** in many interdisciplinary projects.



To what extent can it help framing the RAMONS Project?

Model for interdisciplinary collaboration: A model for interdisciplinary collaboration will be proposed on the base of this literature review and the first one. This model will illustrate the GIS CES experience, and be based on the literature reviews. It will be addressed to the GIS CES scientists and other researchers and practitioners involved in interdisciplinary processes,and will emphasise the link between reflexivity and interdisciplinarity.

Jollivet, M., & Legay, J.-M. (2005). Canevas pour une réflexion sur une interdisciplinarité entre sciences de la nature et sciences sociales. Natures Sciences Sociétés, 13, 184-188.

Summary

Pour une science du dialogue entre les disciplines : L'interdisciplinarité est une démarche de recherche construite en **assemblant de façon méthodique des connaissances, des points de vue, des techniques de travail** provenant de disciplines scientifiques différentes. Ces aspects renvoient au dialogue entre les disciplines : c'est à travers ce dialogue que peut se construire une **démarche méthodique**, c'est-à-dire l'association d'une problématique de recherche, d'une stratégie de recherche, et d'objets de recherche. Parler de dialogue suggère un **travail d'équipe** associant des chercheurs de différentes spécialités.

Méthode = évaluation, validation et généralisation : Il s'agit d'une interdisciplinarité ayant vocation à associer toute la palette des disciplines, des sciences de la Terre aux sciences sociales en passant par les sciences de la vie. L'exigence et la tâche premières sont de **mettre**

les problèmes d'ajustement entre disciplines en évidence, et de poser clairement la question de la façon de les traiter. C'est en ce sens que toute recherche fondée sur une interdisciplinarité étendue a nécessairement une **dimension méthodologique**. On évoque souvent des incompatibilités d'échelles d'espace et de temps, ainsi que des décalages dans les vocabulaires. De plus, il existe à l'intérieur même des disciplines des **postures de recherche différentes**, plus ou moins favorables à l'ouverture et au dialogue entre disciplines. Mais il faudrait **aller au-delà du constat**, et **apprendre à utiliser positivement les décalages d'analyse** qui en résultent. Ainsi, une construction interdisciplinaire étendue est-elle possible sans recours à une théorie ou à une méthodologie qui en fournisse les règles ? Ou bien est-il possible d'en rester à un bricolage aussi raisonné et éclairé que possible ? Ce **choix** doit être **argumenté**, car c'est toute la question de la **généralisation**, et donc de l'**évaluation** et de la **validation** de la démarche qui est en cause.

Highlights

Le rapport à l'action comme source de connaissance : Le rapport à l'action de l'interdisciplinarité étendue renvoie à son origine la plus récente : dans la mesure où elle dérive d'une **demande sociale**, c'est qu'il s'agit d'une question posée à la recherche en vue d'agir. S'il est une notion qui contraint à penser le face-à-face entre les dimensions naturelles et sociales des problèmes de société en vue d'agir, c'est celle du **développement durable**. L'interdisciplinarité étendue est la seule voie de recherche qui permettre de prendre globalement en charge les attentes qu'elle induit, car ces attentes sont nécessairement au carrefour des dimensions écologiques et sociales des problèmes. C'est aussi la seule voie de recherche qui puisse permettre de comprendre aussi bien les opportunités qu'elle ouvre que les contradictions qu'elle contient.

To what extent can it help framing the RAMONS Project?

Méthodes pour l'interdisciplinarité - réflexivité : **Il n'est pas dans les habitudes ni considéré comme légitime qu'une discipline reprenne à son compte une question qui lui vient d'une autre.** Ainsi, prendre en charge dans sa globalité un problème qui comporte des dimensions naturelles et des dimensions sociales dans une perspective d'action, c'est, pour un chercheur :

- Accepter de **s'interroger sur la place et le rôle de sa discipline** dans un schéma d'analyse d'ensemble de ce problème ;
- S'intéresser à une **réflexion** méthodologique et théorique **sur les rapports entre sa discipline et les autres** disciplines ;
- Contribuer à la conception, à l'expérimentation et à la validation de méthodes et de techniques destinées à intégrer les apports de sa discipline dans un schéma explicatif global.

Il s'agit tout à la fois de chercher à tirer le bénéfice maximum des apports spécifiques et de **maintenir les exigences de rigueur de sa discipline**, mais aussi d'**accepter d'en soumettre les paradigmes à la critique extérieure**. Ces tâches spécifiques du chercheur entrant dans une démarche d'interdisciplinarité étendue ne sont pas suffisamment objet d'attention et de réflexion. On tend en général à les passer sous silence, car on en reste au schéma selon lequel

il n'y a que le résultat qui compte. Mais la **méthode** compte aussi, surtout lorsqu'elle met en jeu des questions de fond. **La faire progresser est donc aussi un résultat**.

Sill, D. S. (2001). Integrative thinking, synthesis, and creativity in interdisciplinary studies. The Journal of General Education, 50(4), 129-151.

Summary

Introduction: This paper develops a model for integrative thinking by using models for creativity, an approach suggested by Klein (1990) when stating that future tasks for **understanding interdisciplinarity include exploring the connections among creativity, problem solving, and the interdisciplinary process**.

Definitions of interdisciplinary studies: Interdisciplinarity holds **multiple meanings**, depending on whether the reference is to programs, courses, research areas, modes of teaching and learning, or administrative structures. Klein (1990) identifies four separate varieties of definitions for interdisciplinary: (1) the form that it takes, (2) why it takes place, (3) interactions between disciplines, and (4) hierarchical terminology. As will be developed in the creativity model for integrative thought, it is the tension between interacting, separate disciplines that provides the impetus for synthesis.

One type of interdisciplinary program exists under such heading as **Women's Studies, Environmental Studies, and American Studies**. However, most consist of collections of courses, but which lack integration. Hausman (1979) and Newell and Green (1982) define this type of program as **multidisciplinary**. A second type of interdisciplinary program exists under headings such as **biochemistry** or **biophysics**. While the program may have interdisciplinary roots, they no longer function in interdisciplinary ways. Rather, they function as **newly formed disciplines**. In the creation of the 'transdiscipline' (Hausman, 1979), integration mediates the confrontation between originating disciplines, but, once complete, a new discipline emerges. Richards (1996) refers to the process whereby the disciplines themselves are altered or reformed as strong synthesis. The two extremes above lie on the ends of a **continuum as constructed by Paxson** (1994), which shows increasing amounts of disciplinary integration.

Drawing from Newell and Green (1982), interdisciplinary studies are here defined as 'inquiries which draw upon two or more disciplines and which lead to an **integration** of disciplinary insights'. This integration of disciplinary insights is what Richards (1996) terms **'weak' or 'instrumental' synthesis**, in which the **disciplines dynamically interact** through interdisciplinary connections, **but the disciplines themselves remain unchanged**.

Definitions of creativity: **Objectives for interdisciplinary studies such as the integration of knowledge, freedom of inquiry, innovation** (Kavaloski, 1979), and **synthetic thinking** (Hursh, Haas, & Moore, 1983; Newell & Green, 1982) **involve aspects of creative thinking skills**. Getzels and Csikszentmihaly (1964) identify three distinct approaches to defining creativity that rely on different aspects of creativity: (1) original production, (2) cognitive-

problem solving, and (3) subjective experience. Original production refers to the ability to produce something new. It is a process measured through evaluation of the creative products.The cognitive problem-solving process refers to trial, error, thought and discussion, to achieve integrated results. Subjective experience defines a process that cannot be caught by a test or measured by a process.

Creativity relies on **non-logical and non-linear thought processes**, filled with **digressions** and **diversions** (Koestler, 1964). Creativity is a **messy**, **complex** process, and therefore difficult to confine within a simple, precise definition. Simonton (1993) points out that no single, simple model for creative processes can explain creativity, but that all models reveal a piece of the whole. In Simonton's view, creativity is a complex combination of thought processes.

Highlights

Creativity Model of Integrative Thought

Bisociation and disciplines: Koestler (1964), whose work provides the starting point, crafts a model of **creativity** that encompasses both **humour** and **discovery**. Koestler uses the term '**bisociation**' to refer to the integrative thought that is central to humorous insights and artistic creation. In higher education, the **disciplines** represent **matrices of thought**, each supported by **assumptions that are themselves frequently invisible and unquestioned**. Fuller (1993) points out that disciplines are complex organisations, composed not only of a single matrix but of **multiple matrices**. Some of the matrices involve cognitive functions including **disciplinary methodologies** and a **body of knowledge**, while other matrices involve **social interactions** and **professional connections**. As a result, by bringing two disciplines together in the study of a single topic, the bisociative thought in interdisciplinary studies involves the **intersection of families of matrices, some cognitive and some social**. Koestler (1964) illustrates the importance of bisociation to creative thought and discovery: 'Historically speaking, the frames of reference of physics and chemistry developed separately and independently until the frontiers broke down. This breakdown was caused by the amalgamation of two realms as wholes, and the *integration of the laws of both realms into a unified code of greater universality*. Multiple discoveries and disputes do not diminish the objective, historical novelty produced by these major bisociative events - they merely prove that the time was ripe for that particular synthesis'. It is this amalgamation and integration of two realms as wholes that Koestler means by bisociative thought. In this, bisociation provides a powerful model for understanding creative and integrative thought. Unfortunately, while understanding bisection gives us a sense of what happens, it does not yet give us an understanding of how it happens. With bisociation alone, the model is incomplete.

Ripeness: Koestler (1964) introduces the concept of '**ripeness**'. It is interesting to note that some of our most creative societies have occurred at times when societies redefined the understanding of what it means to be a human in the cosmos. The ripe society is filled with a **fundamental attitude of questioning - the idea that not all answers are known, or, the idea that the current answers to basic questions are inadequate**. The idea that creative

societies derive some of their creative energy from the emergence of unanswered and unanswerable questions reinforces the importance of the creative question to generating creative activity. Furthermore, the connection between creative and integrative thought suggests that creative questions can encourage integrative thought.

Preparation: Preceding the moment of discovery must come preparation in order for the discovery to become ripe. Koestler quotes Pasteur: 'Chance only favours invention for minds which are prepared for discoveries by **patient study** and **persevering efforts**'.

Suspension of conscious controls: Once the mind is fully prepared, discovery is ready to happen. Nevertheless, the process of **discovery involves an open irrationality**. Underlying cognitive processes that may be **subjective** and **irrational** are indeed essential for discovery to occur. Because creativity draws from the richness of the subconscious, the understanding of creativity requires study of thought processes that lie below conscious awareness. Finke, Ward and Smith (1992) suggest the concept of '**preinventive structure**' existing in the subconscious as a way of understanding the generation of creative ideas. Preinventive structures can be ideas, images, or concepts that have yet to be tested and that reside in memory or emerge in the imagination. The key, according to Koestler (1964), is the suspension of conscious controls, allowing **freedom from habits and disciplines of thought**, a freedom that is necessary for creative leaps across restricting boundaries. Unfortunately, the relationship between freedom and creativity is frequently overplayed: freedom is a necessary but not sufficient condition for creativity.

Iteration: We must consider the iterative nature of the creative process. In constructing their model for creativity, Finke, Ward, and Smith (1992) distinguish between generative and cognitive processes. The generative phase uses preinventive structures that promote discovery. The cognitive exploration phase consist of testing the preinventive structures against limitations and constrains. In this view, creativity is an **iterative process** that works towards solution through an interweaving of generative and cognitive processes, **not a big bang that comes all at once, then not again.**

Time bound: Stein (1975) assumes that creativity is time bound, not instantaneous. Stein's stages include: **forming hypotheses, testing hypotheses, and communicating results,** with a **preparation stage** that is necessary for creativity to happen. Science develops through a continual repetition of these stages.

Alternation of work and relaxation periods: May (1975) refers to the combination of intense engagement and relaxation as essential for creativity. Poincaré (1952) agrees in that he sees the unconscious work of creativity as only being of value if it is preceded by an intense period of work.

Implications for interdisciplinary studies: The major characteristics of the **creativity model** for integrated thought are **bisociation**, **ripeness**, **creative tension**, **preinventive structures** including **subconscious** ideas and images, active imagination, **iterative process**, and **complexity**. The important role that separate matrices of thought play in the bisociative process suggests the need to maintain the integrity of the disciplines in order to encourage

integrative thought. De Bono (1992), Edwards (1986), and Stein (1975) claim that creativity is natural and teachable. Amabile and Tighe (1993), and Simonton (1993) point out that **environmental factors can either encourage or discourage creativity**, in both the individual and group settings. Edwards (1986) emphasises the **importance of imagery** and visual thinking in creativity. It can indeed help to consider something in a different way. De Bono (1992) affirms that the requirements of empowering discovery include **quiet, reflective time**. He suggests using the **creative pause**, planned and intentional thinking time, to encourage creativity. For Koestler (1964) **where matrices of thought are envisioned as rules of a game, the ability to change the rules is fostered**, or in the terms of interdisciplinary studies, the **crossing of disciplinary boundaries** is encouraged. The design by Hursh et al. (1983) suggests **generating disequilibrium through disagreements between disciplinary insights, a strategy which generates creative tension** and contributes to complexity of thought.

To what extent can it help framing the RAMONS Project?

Skills developed with interdisciplinarity: Newell (1994) identifies the positive outcomes of interdisciplinary courses to include the development of **tolerance** and **respect**; an **inquisitive attitude**; an appreciation of, even seeking out, perspectives other than one's own; tolerance of, even a **preference for ambiguity**; more **sensitivity to ethical issues**; the ability to **synthesise** or **integrate**; **enlarged perspectives** or horizons; more **creative**, **original**, or **unconventional thinking**; more **humility** or listening skills; and **sensitivity to disciplinary, political or religious bias**. These outcomes of interdisciplinary studies involve higher order thinking skills such as integration, creativity, and evaluation.

Reflexivity: Why create?: Because discovery has both constructive and destructive aspects, the question arises: why create?, or for interdisciplinary studies, why integrate? As Koestler points out, our **natural thought processes strive to construct order out of disorder**. To do that, we naturally avoid novelty because order requires stability. Habits of the mind are comfortable. In this model, the answer to the question **'why create?'** is found in the concept of **creative tension**. When two or more ordering systems (i.e. matrices of thought) contradict or conflict, then the mind feels tension until the conflict is resolved through the creation of a new order. Such resolution is an integrating thought process.

Challenges

Wear, D. N. (1999). Challenges to interdisciplinary discourse. Ecosystems, 2, 299-301.

Summary

Interdisciplinarity needed to explore environmental problems: Many of the **world's critical problems** involve human interactions with nature. These problems are complex, defined by the collective behaviours of people as well as by the structure and function of ecosystems, suggesting that both the **social** and the **natural sciences** should focus efforts on dimensions of these problems, in order to fashion solutions to environmental problems.

Need for interdisciplinary journals: If interdisciplinary research is needed to solve critical problems, **interdisciplinary research journal** would be forthcoming. Indeed, it is only with **credible platforms** for communication that any scientific effort can persist. For interdisciplinary research to be successful as a science, it follows that refereed outlets are needed to certify its discussions. Such a journal is a venue for discussions among participants who speak very **different languages**.

Highlights

Challenges to interdisciplinary discourse:

- *Metaphors*: A taxonomy of metaphors proposed by Klamor and Leonard (1994) progresses in degree of complexity from the merely **pedagogical**, through the **heuristic**, to what they call **constitutive metaphors**. At the first two levels, the meanings are relatively visible. They help connect new situations with existing knowledge. Metaphors of the constitutive type are difficult to see because they form the very context of the science. **Constitutive metaphors often** become **invisible** to the practitioners of the science and generally **provide foundations that are rarely challenged** - they define constellations of maintained hypotheses as well as methodological norms (i.e., positivism, deductive reasoning), that are necessary to focus the work of the discipline. If sometimes transparent to practitioners, constitutive metaphors can be completely invisible to outsiders. The fundamental challenge to interdisciplinary communication is hence the **different ways we see the world**, that is, our constitutive metaphors. The greater the divergence between these foundations, the more difficult it is for communication to be effective.
- *Divergent perspectives regarding humans*: Another challenge facing interdisciplinary discourse is **divergent perspectives** that various disciplines hold **regarding humans** and their decisions. While social scientists are schooled to separate individual values from the study of social behaviour, this is not the case in other disciplines. In studies of important ecological issues, it is easy to draw a direct connection between discovery and knowledge of environmental impacts and social prescriptions. But **knowledge rarely prescribes action. Rather, knowledge can inform decisions**, and

this defines the crucial interface between social and natural sciences in the study of environmental problems.

- *Interfacing social and natural sciences*: Problems often arise at this juncture between social and natural sciences. To explore the social implications of an environmental issue, the economists may compress the ecology into a **simple production function** equation. On the other hand, the ecologists may **jump from knowledge to prescription** without considering the institutional context of decision-making. In either case, the work of one discipline can easily be rejected. This is not generally an obstacle to publication, but it does define a challenge for an interdisciplinary research publication.

Feasibility of interdisciplinary journals: Because members of the audience are **not all participants in the same science dialogs**, the **presentation of models, methods, and data should be built from the ground up**, rather than rely on oblique citations to other papers. Knowing that disciplines have unique dialects (in the case of ecology and economics, common language with different meanings) suggests emphasising exposition of basic premises to a greater extent than usual. A **clearer description of framing theory and methodology** (maybe some insights into the constitutive metaphors) is expected. One way to encourage broader communication is to assign referees from different disciplines to check the clarity of the language.

To what extent can it help framing the RAMONS Project?

Links between interdisciplinarity and interface science-society: By publishing in a common forum, scientists of different disciplinary backgrounds can 'keep each other honest' by making sure that the natural and social science dimensions of environmental problems are adequately addressed. The returns from such an effort could have a high relevance in policy or other decision processes. Perhaps the **best way to accomplish policy-relevant research is to jointly conduct and publish the research**.

Metaphors: A reflection on and analysis of the **constitutive metaphors** of each disciplines involved in the CCTV and HUMBOLDT project could help evaluate whether they impede the interdisciplinary collaboration or not, by instilling misunderstandings in the cross-disciplinary dialogues.

Horlick-Jones, T., & Sime, J. (2004). Living on the border: knowledge, risk and transdisciplinarity. Futures, 36, 441-456.

Summary and highlights

Transdisciplinarity in retrospect: **Transdisciplinary** research is necessary in order to engage with a range of **real-world problem** issues. But the idea of investigating the world in ways that cut across the domains of orthodox disciplinary-based inquiry has a long and obscure history (J. T. Klein, 1990). It is appropriate to trace this perspective back to the **1970s**, to the work of Jantsch (1972) and Piaget (1973). Both were concerned with the future: Jantsch with

technological forecasting and 'futurology'; Piaget's analysis arising from a UNESCO study into identifying 'the paths on which the sciences of tomorrow may embark'. This **preoccupation with finding ways of managing future risk** has played an important role in motivating, shaping, and thinking about cross-disciplinarily. The recent growth in academic interest in cross-disciplinary work appears to stem in part from certain conceptual developments, in particular, the intervention by Gibbons et al. (1994; 1994), who claim to have identified a fundamental **shift in the global nature of intellectual production**. The more profound influence has been **increasing pressure on the academy to demonstrate a capacity to generate knowledge that can address social problems and contribute to economic competitiveness**. Such research creatively draws upon both orthodox disciplinary-based and non-disciplinary sources of knowledge. It is a dynamic activity, producing knowledge of temporary interest to its owners, and driven by the specific needs of application. **Risk**, by virtue of its character which brings together the social and the material in dynamic way, inevitably poses difficulties for discipline-based knowledge (Freudenberg, 1988; T. Horlick-Jones, 1998).

Risk and knowledge: Over thirty years ago, Ravetz (1971) drew a crucial distinction between 'technical' problems that can be addressed using resources within disciplinary boundaries, and **'practical' problems** that are open-ended, necessitating exterior sources of specification and judgement. In order to address this new class of problems, where facts are **uncertain**, **values in dispute**, **stakes high** and **decisions urgent**, the integration of an extended range of types and sources of knowledge is needed, to enhance the quality of associated decision making (1992; 1993). The work of Funtowicz and Ravetz suggests that such knowledges are generalised and decontextualised - they claim to have universal applicability, yet requires exterior inputs of non-disciplinary knowledge in order to address concrete practical problems. Hence, it is necessary to develop connections not only across the boundaries between disciplines, but also between scholarly inquiry and the sphere of experiential knowledges.

To what extent can it help framing the RAMONS Project?

Links between interdisciplinarity and interface science-society: Engaging with the spheres of practice and experience, and associated informal knowledges, provides access to the real-world character of human reasoning and interaction. However, transdisciplinary inquiry poses important questions about issues like quality control, institutional structures and resource allocation. Moreover, a range of institutional factors serve to 'guard' disciplinary approaches and limit the extent of cross-disciplinary collaboration.

Case studies

Abramson, J. S., & Mizrahi, T. (1996). When social workers and physicians collaborate: positive and negative interdisciplinary experiences. Social Work, 41 (3), 270-281.

Summary

Introduction: The article focuses on positive and negative collaborative experiences between social workers and physicians to identify factors that facilitate successful collaboration and factors that impede it.

Impediments to collaboration: **Conflict among collaborators** as a result of varying professional or personal perspectives can undermine collaborative efforts (Sands, Stafford, & McClelland, 1990). **Role competition**, **role confusion**, and **territory issues** also cause interdisciplinary tensions because each discipline must sacrifice some degree of autonomy for collaborative problem solving to take place (J. S. Abramson & Rosenthal, 1995).

Strengths of collaborative approaches: Interdisciplinary collaboration also directly benefits collaborators. Individuals expand knowledge and expertise through exposure to other professionals.

Highlights

Results of the case study: **Physicians generally give lower priority to collaboration than social workers, whose interaction with physicians is central to carrying out their functions.** Whereas social workers emphasised their interaction with physicians, physicians saw the competence of the social workers as more important than interactional factors. **Social workers seemed to seek validation from social workers**. One aspect of the social workers' concern with interaction - their emphasis on **shared responsibility** as highly desirable feature of positive collaborations - was quite telling. They clearly valued this form of collaboration with its implication of **equality**, **mutuality**, and **interdependence**.

To what extent can it help framing the RAMONS Project?

Different perceptions of collaboration according to different disciplines: This papers seems to highlight that there is no universal collaborative factors, but that each discipline has distinct and separate priorities in evaluating collaborative experiences. This aspect is important to take in account in the future analysis of the GIS CES results.

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