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Reflexive Practice for Inter and Trans Disciplinary Research in the Third Millennium

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ABSTRACT

This paper is about two of the most challenging themes of the science of this century, namely the interdisciplinary and transdisciplinary research. First, some motivations about the difficulties of making interdisciplinary research are described and analyzed. Then, the paper describes an example of a research activity among scientists of different disciplines, the Computational Sustainability, which involves several different "actors": information and computer scientists, mathematicians, economist, geologist, and biologists. Starting from this experience, a new abstract model for interdisciplinary and transdisciplinary research is presented, with some considerations about the soft skill (especially, communication skills) that an interdisciplinary researcher should develop. Finally, considerations about moving from inter to transdisciplinary research end the paper; they underline the importance to create a common goal among different disciplines to transfer profitably their results into Society, preferably aiming at increasing the quality of life of humans, plants, and animals.

Keywords: interdisciplinary and transdisciplinary research, communication, computational sustainability.

1. INTRODUCTION

In the last centuries, scientific research was characterized by a rigid separation among disciplines, with few points of contact and cooperation. In fact, few disciplines, such as mathematics, were able to cross a bridge among different knowledges. One of the characteristics of the development of research in the third millennium is the recent complexity of the addressed problems and the need to find solutions and create knowledge that goes beyond the individual disciplines. Some well-known phenomena, such as Globalization and the ever-growing interdependence between economic, sociological, and environmental issues, stress the importance of developing real interdisciplinary or transdisciplinary research. Even on the concept itself of interdisciplinary research, the definitions are not unique [1]. Unfortunately, both academic education and research have always been divided into each specialized field, and specialization is steadily growing. Multidisciplinary research brings with it great opportunities, but also some threats.

Among the opportunities, it is a common experience that multidisciplinary research increases the possibilities to meet new colleagues, to face new issues, thus finding new ideas, new founding, new reflections about one's own experience. Unfortunately, the disadvantages also cannot be overlooked: sometimes, the interdisciplinary research is perceived as something less distinctive, less valuable. Moreover, the academic gaps among disciplines are difficult to bridge, owing to the rigid structures of departments and academies. Finally, the interdisciplinary research can be perceived as a threat by other actors, for example policy makers or people who oversee decisions; sometimes they perceive the multidisciplinary scientific research as a limitation to their decision-making power.

Despite this tradeoff between opportunities and threats, to meet the challenges of modern and future world, it is essential to develop new perspectives for boosting the cooperation and communications among different disciplinarians. In this paper, some case studies and considerations coming from reflexive practice based on author's experiences in the case of Computational Sustainability are given (see Section 2), with the aim of abstracting from these experiences general considerations that can be useful in another different multidisciplinary contexts (Section 3). Furthermore, it is necessary to ask it is possible to identify peculiar (soft) skills or predispositions that a scientist can use (or have) to facilitate interdisciplinary research (Section 4). The topic also includes considerations on how to reflect on one's own personal research experience, according to the paradigm of reflexive practice in Second Order Cybernetics. A particular important aspect is related to communication among scientist of different disciplines, as communication is a central issue [2]. This paper tries to answer the question if there are methods and approaches that can improve the efficacy of communication.

The last but not the least important theme is how to move efficiently towards transdisciplinary research, where the effects of research among different disciplines are beyond the disciplines themselves and transferred into Society.

2. AN EXAMPLE: COMPUTATIONAL SUSTAINABILITY

Research in Computational Sustainability [3] is a very complex example of interdisciplinary cooperation among scientist of very different disciplines: computer scientists, information (especially big data) scientists, applied mathematicians, statisticians, economists, biologists, zoologists, geologists, environmental scientists and engineers, and land use and conservation planners, just to name a few.

The complexity of the addressed problems is also evident in the very definition of a *sustainable development*: a development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs (Brundtland Commission, United Nations, 1983).

The author has been working since 2013 on Computational Sustainability, applied to biodiversity preservation and land use estimation [4-5] especially in the analysis of the Italian forest quality evaluation [6] and it is still a very challenging and interesting activity. A new multidisciplinary approach allowed to coordinate a large group of people of different knowledge and cultures for a common goal, i.e., to combine the conservation of nature with the legitimate aspiration of humans to expand their anthropic settlements, without compromising both biodiversity and economic growth. In particular, the last contribution in literature is the result of a strict collaboration between three different disciplines: Botany, Hydrogeology, and Computer Science [7].

By reflecting on these experiences, some considerations can be made to describe a general model for multidisciplinary research. It is the main result of this reflexive practice: a hierarchical conceptual map which explains how different disciplines can communicate and share intermediate data and results.

3. A GENERAL MODEL FOR INTERDISCIPLINARY RESEARCH

In the model for multidisciplinary research, each discipline has three different levels, in descending hierarchical structure: knowledge, methods & paradigms, and data. The model is depicted in Figure 1: the first two top levels are specific to each discipline, while the third one (the bottom level) is shared among all disciplines. The model is completely general and can be applied independently on the involved discipline or their number (in the Figure, for clarity, only three disciplines are depicted). The straight arrows identify the communication channels. As can be seen from Figure 1, the model rests on a common base level, the data layer. It is important to share common data; in the most recent contribution [7], common data are represented by GIS databases containing visual maps, labelled with colors, representing georeferenced data. In a more general formulation, shared data can be different, for example, software coding, structured, semi structured data (e.g., HTML Web pages) or unstructured data (repository of audio-video or images).

It is important to point out that data must share a common feature: for example, in [7] all data are strictly linked to the geographic territory, and the various databases reflect the specific knowledge of the disciplines about the territory (in the example, data refer to forests, land use and hydrogeologic risk). This is expressed by the concept that all data are geo-referenced. In fact, georeferencing is a powerful method to share data among different disciplines.

Sharing data, even high structured data sets (e.g., databases, visual maps…), is not enough for a best practice of interdisciplinary research: it is necessary that the various disciplines share a common goal. The common goal may be defined at an operative level, for example the definition of indicators and rules for supporting decisions about territory planning. However, it is most interesting to define a common goal to a higher, abstract level, the inner motivation of all the involved researchers: in [7] the common goal at the abstract level was to preserve both biodiversity of plants and animals and human safety and well-being. The concept of common goal is, in the author's opinion, what allows to pass from a multidisciplinary to transdisciplinary effort in scientific research, as better explained in Section 5.

4. WHICH ARE THE MAIN SOFT SKILLS FOR AN INTERDISCIPLINARY RESEARCHER?

Reflecting on my interdisciplinary research practice, I have identified three main soft skills which are very relevant in this kind of scientific research:

1) Curiosity, inquisitiveness
2) Efficacy in communication
3) Motivation

The three skills are closely related, in the sense that they reinforce each other and can constitute a positive synergy.

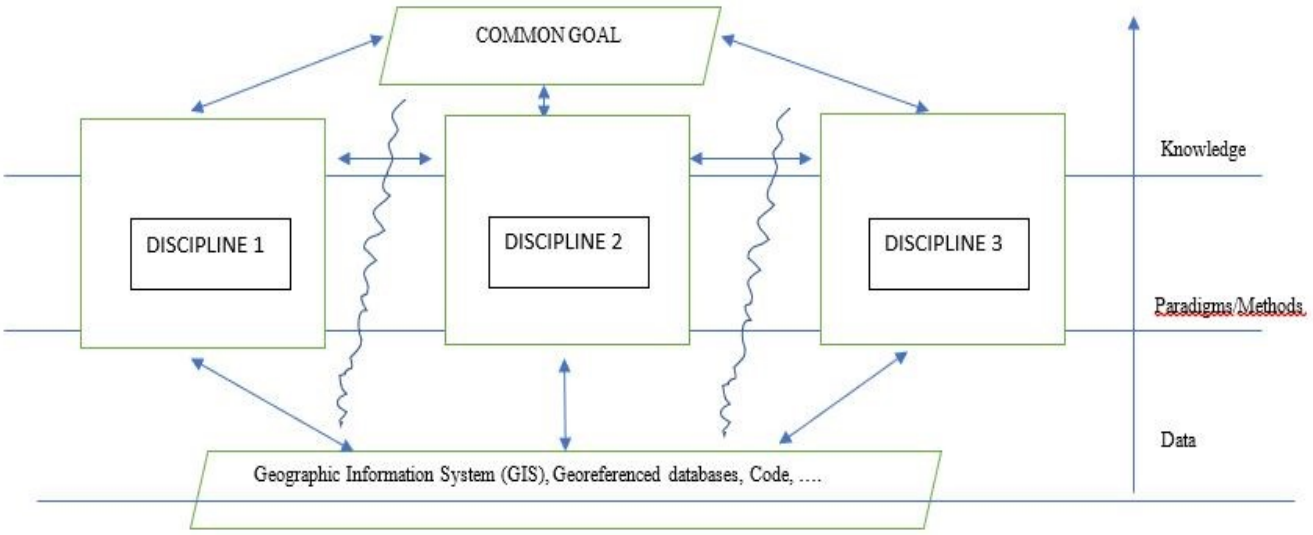

Figure 1: The hierarchical model of inter and trans disciplinary research: arrows underline communication of concepts and goals

Curiosity or inquisitiveness is the ability to observe reality, to ask questions and find answers. Obviously, this feature is a distinctive trait of every scientist, but it is a common experience that inquisitiveness is very high in one's own disciplines but may be very low in other ones. In multidisciplinary research it is fundamental to increase this skill in the scientist, also towards aspects of all the other disciplines which are involved in the research. This can be achieved by participating to lessons, conferences, and other initiatives; this advice is particularly important for young scientists and researchers, and can be a valid approach, in the author's experience, to bridge the cultural gap among different disciplines.

However, perhaps the most important skill for a multidisciplinary researcher is to develop a high ability to communicate knowledge and goals. Communication is therefore one of the crucial issues for both inter and trans disciplinary research.

Communication as a key issue in the science of the third millennium

To build a real cooperations in multidisciplinary research among scientists, it is fundamental to increase the level of communication. In fact, each discipline bases communication on a specific binomial language/terminology. This limit can be exceeded, for example by considering non-verbal communication, which a very powerful method [8], but obviously it is most for communication of emotions, rather than concepts. Also, the attempts of building a new, universal common language have led to poor results, as in the failure of Esperanto [9], whose goal was to overcome communication barriers among linguistic groups by defining a neutral, standard language, with no reference to different cultures.

If a common language is essential and it is not available in interdisciplinary researchers, how can we solve this problem? According to the classical theory of information [10], communication between a source and a destination is achievable if they agree, previously the communication, on common vocabulary and language. However, this consideration is not enough in a multidisciplinary research activity, where very often there is not a previous agree according to a common language. How to increase the efficacy of communication? First, it is important to notice in the hierarchical model of multidisciplinary research (Figure 1) that the communication (blue arrows) must be privileged at the level of knowledge, not at underlying levels. In the communication at knowledge level, it is important to transmit concepts, rather than simple terms, which in most of the cases are not fully understood. According to the author's experience, communication can be boosted by implementing one or more of the following strategies:

1) Identify a sub-set of essential concepts in each discipline and mapping their concepts/terms in such a way they can univocally be understood by all the participants, regardless of their culture. For example, in mathematics the concept *a function belonging to a space norm* L^2 for an engineer means that "the signal represented by the function has a finite energy". The two concepts are expressed by different terms but if the scientists have clear in mind the correspondence between the two concepts, the differences in terminology and languages can be easily overcome and with them, also the feeling of inadequacy, the perplexities, uncertainties, and doubts which often permeate discussions with experts and scientists from other disciplines.
2) Identify a common knowledge coming from basic disciplines, such as chemistry, geometry, etc. The concepts of these common knowledges will be the basis of the shared terminology. For example, chemistry is a common knowledge to botany, mineralogy, and engineering, and it is very useful to share knowledge about chemical compounds.
3) Identify a common language, not for the entire communication, but only for a limit part of it. For example, in the author's experience, in interdisciplinary research in computational sustainability, which involves botany and engineering, Latin has been used intensively to identify properly the names of the botanic species in the common database, according to the classical binomial nomenclature by Carl Nilsson Linnaeus. Using Latin is not only a pure fact of translation, because the Latin name in the form (*Genus species*) puts in evidence the hierarchical taxonomy of plants, e.g., the relationship between species of the same genus (e.g., *Populus alba* and *Populus nigra*). This means that the Latin name not only identifies exactly the plant, but also contains an important concept: the relationship between plants of the same genus, thus carrying more information than a simple translation. Latin is still present in the Italian educational programs, and it is not a problem for Italian scientist to use this common language, even for scientific (and not only humanistic) culture.

The third soft skill that a multidisciplinary scientist should take care of is motivation. Motivation is a strong element which can influenced both professional and personal life: it has been intensively studied in psychology [11], in economy [12] and educational activities [13]. However, in the author's experience, one of the most effective methods of increasing motivation is to identify a common and well-defined goal (the highest level in the interdisciplinary research model, see Figure 1). Why is a common goal so important? There are multiple answers:

1) It increases motivation (what contributes to the behavior and choices of an individual).
2) It helps in overcoming difficulties of communication.
3) It helps to make the collaboration lasting over time, because a strong motivation sustains the effort even for years, as it does not fade in a short time.

We can define motivation as the glue that cemented the collaboration among scientists of different disciplines. For example, in the research about Computational Sustainability involving botany, computer engineering and geology, the common goal was to preserve biodiversity in botanic species, around human settlements, as a key factor to also reach a high quality of life and safety for human beings and animals. The equilibrium between a sustainable development of human activities and the preservation of some natural ecosystems (in the specifics, forests) has been the common goal which highly motivated (and still is going on) botanists, computer engineers, geologist, and environmental engineering since the beginning of the interdisciplinary activity.

There are many common goals that can be identified: obtaining new founds, increasing scientist visibility and academic prestige, creating a novel interdisciplinary high-level education. However,

in the author's opinion, the most effective common goals are the ones which go beyond the interdisciplinary research itself, projecting toward the concept of transdisciplinary research.

5. FROM INTERDISCIPLINARY TO TRANSDISCIPLINARY RESEARCH

Transdisciplinary research is mainly characterized by the fact that the effects of research among different disciplines is beyond the disciplines themselves, but they are transferred into Society. This concept is linked to that of "common goal" previously described. In fact, what better common goal can there be than to see the results of one's research transferred to some aspect of society (economy, environment, psychology, education) to improve it?

In the author's point of view, the considerations by Teresa Langness are the best way to express this concept: "research may matter most when it sustains life, improves the quality of life or otherwise enhances the cohesion and destiny of humans and other species" [14]. In the case of Computational Sustainability, the north star pole of the research has been really the improvement of quality of life of humans, plants, and animals in one of the most challenges of the third millennium, namely the conservation of the health of our planet, especially for the new generations.

6. CONCLUSIONS

In the paper, a general model for interdisciplinary and transdisciplinary research is proposed. The model can be applied in different context and is focused on the skill of sharing a common paradigm for boosting communication and increasing motivation and interest among scientists. By reflecting on my personal practice in transdisciplinary research, I have applied this model in most of my research activity since 2013 and it is still a very satisfactory activity. Among the several reflexions (*reflexive practice* according to Second Order Cybernetics, [15]) I would like to share with the reader, perhaps the most important is the awareness of engaging together with people of different knowledge and cultures for a common goal. I was honored to collaborate with scientists from different disciplines for a better future that combines environmental protection and human well-being of individuals. Therefore, the model here described allowed me to reflect on three essential points:

1) The real goals of my research effort
2) The effect on real life of people, plants, or animals for genuine transdisciplinary research
3) The method I use to communicate enthusiasm around the common goal

The last reflexion is about the fact that, by observing scientists from other disciplines, I was able to change my way of seeing the world. For example, thanks to the possibility to observe a botanist at work, I have changed my personal way of considering plants: for sure, I will never look at a tree as before! From these reflexions, a new idea arose, perhaps a little assumptive: a new interpretation of principles of quantum mechanics:

The observation of a phenomenon modifies the reality of the phenomenon itself.

which can be changed in:

By observing scientists from other disciplines, you change your way of seeing your own discipline and the world around.

I therefore developed the deep conviction that interdisciplinary or transdisciplinary research can increase our ability to analyze reality and enrich our talents, both personally and professionally. The wish, especially for young scientists, is to find their own *common goal* and increase the ability to observe reality with new perspectives!

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