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5. Towards an integrated research approach:The problem life-cycle and transdisciplinary frameworks.

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Introduction; Transdisciplinary vs. multi-disciplinary; Holistic vs. black box approach; e-Planning transdisciplinary agenda; Case study: The air quality problem life-cycle (The participatory science method. The data-life cycle); The institutional challenge to host multi-disciplinarity / transdisciplinarity (Case study: A lost opportunity – CAPP-TSG; The need of institutional framework for transdisciplinary research); Between the Why and the How; The e-Planning lab; Conclusion and what is next.

1. Introduction

Learning to make the best of multi-disciplinary / transdisciplinary research environments is a challenge, but it is a critical issue, if we want to take full advantage of its potential.

Typical difficulties are the risk of losing focus, because of competing disciplinary perspectives, as well the danger of insufficient in-depth disciplinary knowledge that may arise as a trade-off for acquiring wide-breadth knowledge.

At the same time, multi-disciplinary / transdisciplinary research environments provide unique opportunities to find different research angles that may "fall between the cracks" with narrow disciplinary methodologies.

Also, many real-life problems have a complex, transdisciplinary nature (Ferraz de Abreu, P. 2009), which may not be easy to breakdown into narrow focus slices, that can be studied as independent projects, leading to valid independent research answers.

This is particularly the case with research engaging both the new generation of information and communication technologies (ICT), and its transversal, in-depth impacts across society, in many dimensions.

The need for such research is more obvious than ever, given the growing evidence of the centrality of ICT in all facets of society, and of the difficulties to fully understand – and control – its development and deployment impact, with traditional disciplinary or even inter-disciplinary approaches.

e-Planning is a new scientific area of inquiry that is emerging to address a substantive part of these issues. Its focus is to study and develop the interaction between ICT and Planning, which requires in-depth research and development on both ICT and Planning domains (Ferraz de Abreu, P. 2008).

This is why we created transdisciplinary research clusters such as "Technology, Society and Governance" (TSG) at the CAPP Research Center - Centro de Administração e Politicas Publicas (CAPP) at ISCSP-UTL – Technical University of Lisbon (2009-12), and then the e-Planning Lab (launched at FC-UL, 2013), to develop an integrated research approach.

This work builds on a previous short paper (Ferraz de Abreu, P. 2011), supported by further research.

2. Transdisciplinary vs. multi-disciplinary

While this is not the focus of this work, it is important to clarify the terminology we use.

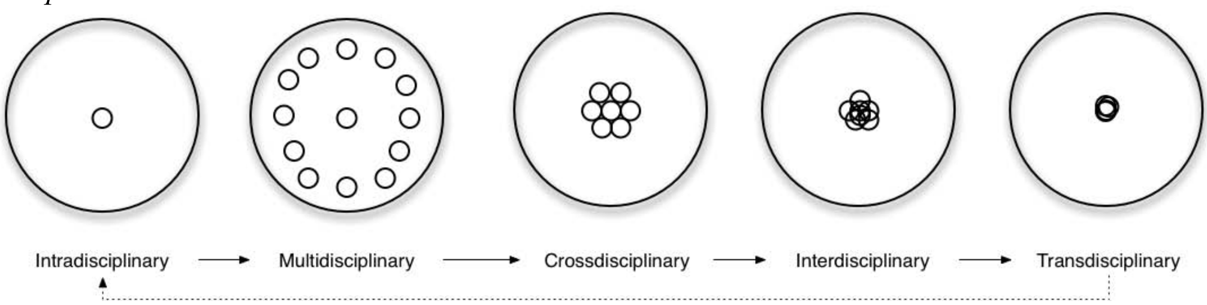
Many authors use indiscriminately the terms inter-disciplinary, multi-disciplinary, or transdisciplinary. Others (Stember, M. 1991), argue there are key differences between all and each one of such terms, and spend considerable time defining them. Some (Hofkirchner, W. 2017) even link these definitions to the "General Systems Theory" (Bertalanffy, L. 1968).

We found, in our research, there were considerable differences between what we called "light multi-disciplinarity" (research combining a couple of domains with close ties, f.i. medicine & biology) and "dense multi-disciplinarity" (research combining several domains, some of which have very different scientific cultures and methodologies – such as engineering & social sciences).

The need to characterize these differences arose, not from any epistemological debate (Edgar Morin's or Piaget's style), but from hard experience, after dealing with very different scales of challenges. We will return later to this issue, after presenting more details on such challenges. But this explains why it became important to standardize our terminology, rather than just adding yet another set of in-house terms.

Alexander Jensenius (Jensenius, A.R. 2012), summarizes this discussion (based on Stember, M. 1991), in an interesting form:

"- *Intradisciplinary: working within a single discipline.*
- *Crossdisciplinary: viewing one discipline from the perspective of another.*
- *Multidisciplinary: people from different disciplines working together, each drawing on their disciplinary knowledge.*
- *Interdisciplinary: integrating knowledge and methods from different disciplines, using a real synthesis of approaches.*
- *Transdisciplinary: creating a unity of intellectual frameworks beyond the disciplinary perspectives.* "



source: Jensenius, A.R. (2012)

In line with this categorization, the closest to our empirical experience in our work (what we called "dense multi-disciplinarity"), is what is here called "transdisciplinarity".

Also the "General Systems Theory" school of thought, defines transdisciplinarity in very similar terms to our reality. Wolfgang Hofkirchner writes, in his paper "Transdisciplinarity Needs Systemism":

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> *"The rationale for transdisciplinarity is global challenges, which are complex.*
> *(...)*
> *given the rise of complex problems, monodisciplinary approaches do not fit the situation any more. Multi-, inter- and transdisciplinary approaches are needed. Transdisciplinarity has been gaining considerable attention since."*
> *(...)*
> *Let us take the relationship of social science and engineering science as an example for how to transcend the borders of both disciplines by making use of a systemic framing and transform their relationship into a true transdisciplinary one"*
> (Hofkirchner, W. 2017)

While we are not particularly concerned here with the debate on "systemism", Hofkirchner's formulation is remarkably on target, when we look at the challenges we face: complex problems where a traditional "disciplinary" approach fails, and the difficult articulation of social science with engineering disciplines. So we feel at home with this definition of transdisciplinarity.

Along the same lines, comes the simple interpretation of the meaning of the word, from Flávia Neves, a teacher of Portuguese language:

> *"transdisciplinary requires the definition of an organizing thought, also called complex thinking. Complex thinking is a different way of thinking, which goes beyond the Cartesian division of areas of knowledge. The understanding of transdisciplinarity is complex, because while studying the relationship and the transversalities between the disciplines, it must preserve the peculiarities of each area of knowledge. (...) transdisciplinarity (...) requires not only the addition of disciplines, but the organization and contextualization of knowledge."* (Neves, F. 2019) (my translation, from Portuguese)

Jean Piaget is credited for the introduction of this term (transdisciplinarity) in 1970, at the Ist *International Seminar on Pluri and Interdisciplinarity* (Université de Nice, France), to signify *a unity of knowledge beyond disciplines* (wikipedia). We identify with this concept.

Since then, enthusiasts have engaged in deep elaborations and discussions on the concept - Portugal was actually the host of the 1st *World Congress of Transdisciplinarity* (Convento da Arrabida, Portugal, November 1994). However, our path is different. We don't need to get entangled in the multiple turns and twists of minutia and normative discussions on terminology - a "war of definitions" (sic, Nicolescu, B. 2007).

Some of the most ardent "*transdisciplinary followers*" engage in highly questionable claims, pretending to extrapolate from quantum physics, concepts they state with "*deep conviction*" (sic), but without any visible serious foundation (Nicolescu, B. 2007); or moving to philosophical normative debates on "*Man–God has become a Man–Object*" (*ibidem)*. In our view, these unfounded or exoteric extrapolations, rather than bringing scientific validation to the concept of transdisciplinarity, weaken it.

Furthermore, we have no interest (nor do we see any evidence for such claim) in establishing some kind of "superiority" of transdisciplinarity over multi-disciplinarity (or interdisciplinarity, etc.). In our work, we need both, and even *disciplinarity*. It all depends on the context and the kind of problems that are the object of our study. That, is the point of the argument we are presenting.

Therefore, we chose to stay on solid ground, and embrace the concept of transdisciplinarity, in what is simple, clear and consensual:

1) Complex problems may require more than traditional disciplinary approach, or even more than "light" multi-disciplinary (collaboration between a few connected disciplines);

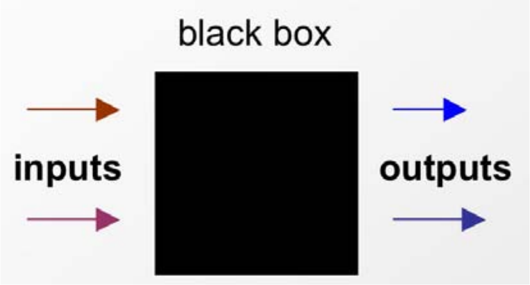
2) Dealing with complexity that engages a wide-breath multi-disciplinary range, such as engineering with social sciences, require more than the sum of the parts: we need also "*organization and contextualization of knowledge",* while preserving *"the peculiarities of each area of knowledge".*

We called it "dense multi-disciplinarity"; but it fits well with this definition of *transdisciplinarity* and it is therefore useful to adopt it.

3. Holistic vs., black box approach

Another characteristic mode of operating multi-disciplinary teams – nothing new and more and more common – is to define clear boundaries of competence within the team, delegating each disciplinary domain to their respective specialists, and articulate their work by setting interface parameters, that allow to glue together all the separate specialized products.

In fact, this corresponds to what is known as "black box" approach. For multi-disciplinary team coordinators, or research aggregators, each specialized domain is viewed as a "black box", meaning, we assume we do not need to know (or understand or describe) what goes on inside (how domain specialists proceed and operate their part of the research or project); as long as we have a clear, well defined set of input / output parameters.



Conceptually, the collective of the team must "trust" each domain specialist(s) to handle, in full autonomy, their part, providing them only with a set of inputs and expecting to obtain from them a set of outputs, without interfering on each other's work.

For practical purposes, the whole team work is in itself a "global black box": for the outsiders (f.i. society, or research contractors), the multi-disciplinary team is expected to deliver a joint set of results (outputs), once mandated with the terms of reference (required specifications) for its mission (inputs).

This *modus operandi* works fine for several classes of problems. But we can anticipate severe

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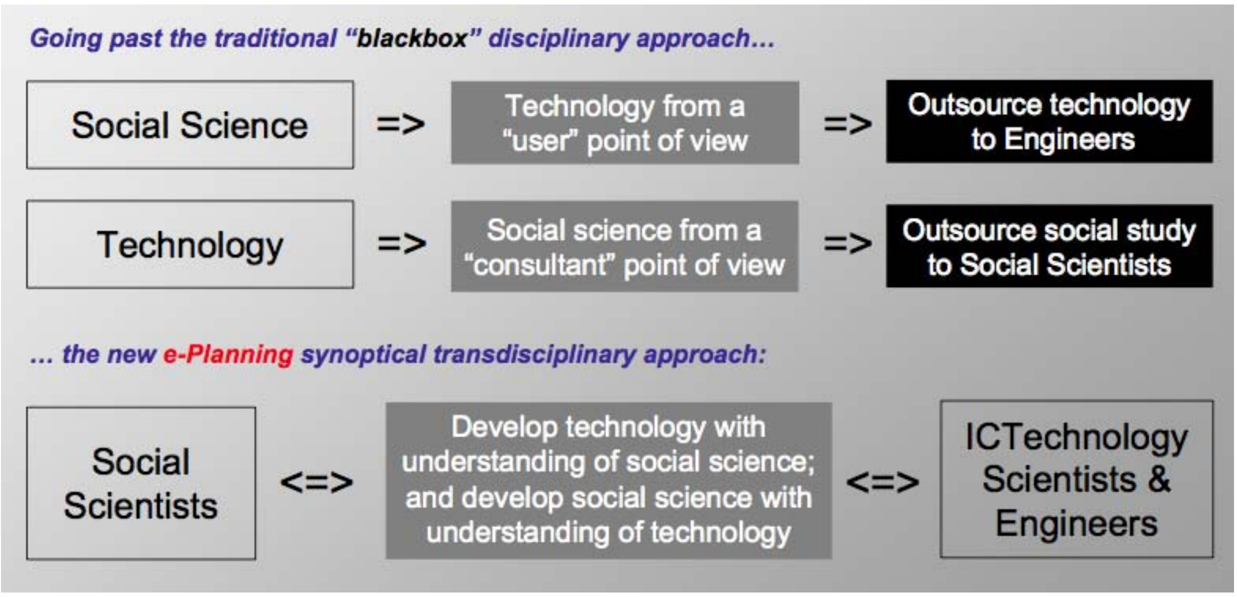
limitations for any class of problems / research questions that don't share a "Cartesian nature", i.e. that we cannot "divide every question into manageable parts" (Descartes, R. 1637).

In fact, we face a growing number of complex problems that can't be sub-divided in separate disciplinary boxes (sub-problems, divided by scientific domain), without losing sight, or degrading / distorting / corrupting, the nature of the whole.

Examples of such problems, and the discussion of the new challenges they bring, is illustrated in this work, with focus on those that motivated the emergence of e-Planning. But they are documented profusely, within and outside the e-Planning research community, as early as 1987 *(Chomsky, N. 1987) (Zuboff, S. 1988) (Marx, G.T. 1990) (Sassen, S. 1994) (Castells, M. 1989) (Wriston, W.B. 1992) (Builder, C. 1992) (Ferraz de Abreu, P. 1992, 1993, 1997, 2000, 2001, 2002, 2008, 2014, 2015, 2020) (Evans, J. & Ferreira, J. Jr. 1995) (Ferreira, J. Jr.. 1998, 2020) (Berners-Lee, T. 2010) (Savoldi, F & Ferraz de Abreu, P. 2012, 2014) (Cadwalladr, C. 2018) (Rawnsley, A. 2018) (Hern, A. 2018) (MIT Tech 2018) (Guterres, A. 2018) (Wylie, C. 2019).*

To overcome the limitation of "black box" approach, we needed a more **synoptical** view, which, as noted by Wriston in his pioneer book (Wriston, W.B. 1992), was already a strong recommendation of Aristotle, concerning city planning (Aristotle, Polit., VII, 1326). And thus was born, from this pragmatic need to create an alternative, a first, novel, methodological construct for the e-Planning approach.



source: Ferraz de Abreu, P. et al 2019, First edition: 2009

More by instinct than derived from any in-depth thought on the issue, we associated this synoptical view, with transdisciplinarity, from the beginning. The "Global Systems" transdisciplinary crowd prefer to emphasize the *holistic* facet. Flávia Neves concurrs:

> *"By breaking the boundaries between one discipline and another, transdisciplinarity seeks to understand phenomena and acquire knowledge in a holistic and contextualized way. Knowledge acquires a transversal characteristic, as it crosses all disciplines in some way."* (Neves, F. 2019) (my translation, from Portuguese)

We tried indeed to acquire a more holistic view, to better understand complex systems. But, in doing so, that allowed us to realize many problems, and corresponding research questions, were not static: their nature evolved and changed, but with some regular patterns. So, we began looking at **problem life cycles**, rather than individual, single-phase problems. We will describe one flag example.

Also, one key part of our experience, is the difficult institutional framework to host multi-disciplinary / transdisciplinarity research. Hence, this is one important part of what is presented in this study.

In summary: for emerging challenges, new types of complex problems, we need a **transdisciplinarity scientific framework**, besides traditional disciplinarity and "black-box multi-disciplinarity"; we need to look at **problem life-cycles**, or even patterns of **problem clusters**, rather than single-minded obsession of ultra-narrow focus on simplified problem formulation; and we need an **institutional framework for transdisciplinarity** that, simply put, does not exist (at least, not in Portugal, and what we know in USA and UE).

The major difficulty is not even to conceptualize transdisciplinary methods and research itself – which is hard enough. The hardest part, as we found at our expense, from tough experience (Ferraz de Abreu, P. et al 2020, Ferreira Jr., J. 2020, MIT Tech 2018), is to **build capacity**, meaning: how do we educate / train the ***actors*** of transdisciplinarity (people and institutions) and in a sustainable process?

We can tell you already: easier said, than done.

4. e-Planning transdisciplinary agenda

Building the e-Planning research agenda, was (and still is) essentially a transdisciplinary challenge.

The new Information and Communication Technologies (ICT) brings new conditions for improving government (including e-Government), public administration and key services of public interest, whether provided by the state, civil society institutions or private enterprises. But new conditions bring also new problems and raise many new questions that go beyond using Internet for public services and re-shaping these services to better adjust to the new reality of the information society.

Planning is a wide-breath discipline, addressing from policy making to implementation, from institutional analysis to regulatory frameworks, from decision-making to public participation.

e-Planning is a new scientific area of inquiry that is emerging to address issues that need to study and understand the interaction between Information and Communication Technologies (ICT) and Planning. e-Planning therefore embodies a new paradigm of research requiring in-depth knowledge of both technology and social sciences. (Ferraz de Abreu, P. 2008).

The process of building the e-Planning Agenda and PhD Program, is highly relevant to anyone interested in pursuing transdisciplinary work. An account of that process can be found

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in several publications (Ferraz de Abreu, P. 2013, 2019). The key stages (2003-2009) engaged a large community at MIT, USA, and 5 major Universities in Portugal (Universities of Lisbon, Aveiro, Coimbra, Technical University of Lisbon and New University of Lisbon).

The e-Planning scientific areas deliberately focuses on areas of work, rather than "traditional taxonomies:

e-Infrastrutures	e-Government	e-Governance	e-City & Territory	e-Citizenship

(full description can be seen on http://www.e-planning.org/agenda_e.html)

An interesting fact, is that the government / state accreditation process, at the time, did not object to this, and even certified and published in "Diário da República" (legislation public registry, 2009) a table mapping these areas, as legal regulation: "*Bearing in mind the strong multi-disciplinary and trans-disciplinary nature of the scientific areas of e-Planning, a relationship between these and the 'traditional' disciplinary areas is included:"*

"Tendo em atencão a forte natureza multi-disciplinar e trans-disciplinar das áreas científicas de e-Planning, inclui-se um quadro relacão entre estas e as "tradicionais" áreas disciplinares:

Áreas cientificas e-Planning	Áreas disciplinares principais	*Summary of key objectives*
Teoria e Métodos de e-Planning *e-Planning Theory and Methods.*	Matemática, Estatística e Investigação Operacional (Métodos Quantitativos), Ciências Sociais (Métodos Qualitativos, Planeamento), Tecnologias de Informação e Comunicação (TIC), Informática.	*Build a common scientific identity for e-Planners.* *Master the boundaries of the e-Planning Agenda.* *Develop core analytical tools and methodologies.*
Infraestrutura do conhecimento para e-Planning *e-Planning Knowledge Infrastructures.*	Ciências Sociais (Ciências da Comunicação e Informação), Engenharia Informática, Telecomunicações, Matemática e Estatística e Investigação Operacional, Sistemas de Informação Geográfica, Sistemas de Informação Urbana.	*Mapping of the knowledge society.* *Mapping of the planning knowledge.* *Develop the new ICT infrastructures and strategic frameworks*
e-Governo *e-Government.*	Engenharia Informática, Ciências Sociais (Ciências da Comunicação e Informação, Ciências Políticas, Gestão, Administração Pública, Relações Internacionais).	*More efficient and responsive government, closer to citizens; better enabling role; better services; two-way G2G, G2C, G2B.*
e-Governação *e-Governance*	Ciências Sociais (Ciências Políticas, Sociologia, Demografia, Economia, Relações Internacionais), Ciências do Ambiente, Tecnologias de Informação e Comunicação (TIC).	*Foster institutional culture towards the common good, more equity and less exclusion; build strategic institutional capacity within globalized world; better institutions; better regulation framework and handling of market failures; better balance of security & efficiency vs. freedoms and liberty.*
e-Cidades e território *e-City and Territory*	Arquitectura e Urbanismo, Ordenamento do Território, Geografia, Ciências e Tecnologias do Ambiente, Ciências Sociais (Economia, Sociologia urbana, Antropologia do Território), Transportes, Energia, TIC.	*Build the cities of the future, as sustainable environments with new functionality that breed innovation; foster cities with better quality of life, more attractive and competitive; better territorial planning, incorporating new structural impacts of ICTs.*
e-Cidadania *e-Citizenship*	Ciências Sociais (Ciências Políticas, Relações Internacionais, Ciências da Comunicação e Informação, Sociologia, Antropologia), Ciências Jurídicas, Humanidades, TIC.	*Enable a better informed and educated citizen, more participative, more critical, more responsible; better balance of technology challenges with ethics & individual freedoms & privacy.*

Diário da República, 2.a série — N.o 225 — 19 de Novembro de 2009"

Regardless of this being an official document of the Republic of Portugal, note that the text of the table is part in Portuguese, part in English.

It says something about the consistency of this e-Planning transdisciplinary design, resulting from a careful and demanding process, that 10 years of research and teaching experience, validated it.

Despite e-Planning being recurrently questioned on its transdisciplinarity, and the joint PhD program periodically under criticism, this table is still in effect, because it works.

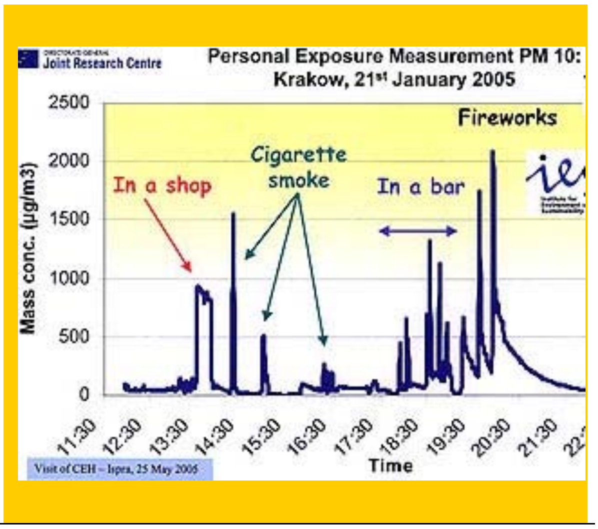
5. Case study: the air quality problem life cycle

Soon it became evident the e-Planning agenda is a rich ground where we can find, and identify, problematic that goes through dynamic cycles, crossing disciplinary boundaries. One of the major issues became a flag research project, and it serves well as a case study for this concept: **problem life cycle**.

We participated in research concerning air quality policies and standards for air pollutants (Ferraz de Abreu, P. et al 2004) (Field, RA. et al 2005) (Ferraz de Abreu, P. 2006).

While our initial motivation was the public participation facet, enabled by the new technologies, our focus changed, with more in-depth engagement in a large, European-wide research project (P.E.O.P.L.E. – Population Exposure to Air Pollutants in Europe, sponsored by the UE Joint Research Center (IES-JRC), and then EuroLifeNet (www.eurolifenet.org).

The electronic nature of the portable samplers allows for easy data extraction, network sharing and analysis by lay citizens and young students. Together with a diary and GPS data, this becames a powerful tool both for scientists and teachers.



source: Ferraz de Abreu, P. (2012) – EuroLifeNet (images from EU's IES-JRC)

Personal exposure brings a very interesting, but very demanding requirement: we need data at individual (personal) level, and we need it with extensive enough coverage, to provide statistically meaningful evidence. In other words, this required many, many citizens carrying out the data gathering devices. This means common, lay citizens and not just hired experts.

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But, on the other hand, only data with top-level scientific standards could be used for any serious purpose.

Gathering such data is therefore usually done by specialized and well-trained staff, hosted in reference labs, and closely supervised by scientists and experts. This high standard requirement seemed therefore to exclude the feasibility of a strategy of data gathering by the general lay citizen at-large.

5.1. The participatory science method

To respond to this challenge, we proposed a participatory science methodology (EuroLifeNet), engaging in a well structured relationship, citizens, scientists, teachers and policy-makers, and corresponding institutions: NGOs, Research Institutes, Schools, Ministries, Public Administration (Ferraz de Abreu, P. 2006).

Through a long and thorough process, including interviews, meetings and joint open conferences, we compiled the critical issues concerning potential conflict of agendas: the scientific need for securing credible high-quality data; the pragmatic conditions for successful mobilization of citizens in data gathering – in particular young people; the realistic requirements for schools and teacher engagement, internalizing this activity in their regular operation; and the priorities of the civic activist agenda (table below).

Table - EuroLifeNet priorities and agenda of the different actors

	Experts & scientists	Teachers	Civic action
What to measure	PM 2.5	No strong preference	PM 10
When to measure	• Seasonal • Also weekend/night	• According to curricula • Day only, no w/e	• When pollution is worse
How long to measure	1 month minimum, at least twice a year	1 or 2 weeks, at most twice a year (2/year)	As long as possible
How to measure	Always same person per period / sampler	Many different students per period	As many students as possible, also adults
Network synchronism	Little sync. value; Concentrate all resources one site at a time	High sync. value; All schools in sync, for short periods of time <= 2/year	High sync. value; All in sync, as frequently as possible
Uses of data	• Correlate with regular monitoring network data; • Environment/health correlations	• Relate with other course curricula; • Curricula update, exciting participatory science methodology; • Student debate/raising awareness.	• Public raising awareness; • Data as political tool for stronger regulation; • Call for more monitoring and pro-active solutions.

http://www.eurolifenet.org

Thanks to this process, we were able to solve these conflicting points, one by one, creating a feasible methodology; not only satisfying the key requirements of all stakeholders, but also even reinforcing them, thanks to a joint, differentiated approach.

For instance, NGO partners had an activist agenda that, while legitimate and very important to achieve practical results, did not necessarily coincide with the scientist's agenda. For NGO's, it was a priority to obtain data that would feed their fight for raising European Parliament Health standards, and the bill in discussion, up for voting, concerned levels of PM 10; while for scientists, the clear priority was to turn into smaller particulate matter, PM 2.5, because it was less studied and potentially more dangerous to human health.

Another example: for teachers, it was non-realistic to expect a single student to carry out measures and the device, for the whole duration of the mission, while other students had no direct participation in the measure process; they claimed, quite reasonably, that this would likely lead that student to burn out, and to the other students losing interest. But scientists needed a consistent context of "determinant" variables (smoking or non-smoking, traveling by car or walking or bus, long trips or short trips, etc), which, they thought, could only control if it was the same student (in fact, we found an original solution).

And many other examples, resulting of different multi-institutional, transdisciplinary agendas.

So, we had to establish a clear criterion, to build a joint plan that would be satisfactory for all partners. The first criteria was simple, but of utmost importance: we would make serious efforts to find a common ground on each contradiction; but if it was found impossible to accommodate different agendas, the science agenda would prevail above all and any.

It is very significant that all actors involved, accepted this rule without hesitation. For instance, NGO activists understood very well that data would be a much stronger asset in their fight for a cause, if it were validated by a demanding, rigorous scientific procedure. And so, we went through each and every issue, and built many original, creative solutions, and in some cases just accepted science priorities as defined by scientists.

One of the key advantages of this *participatory science method*, by increasing manifold the reach and spread of data collection, is that scientists were able to access unexpected scenarios, leading to new areas of inquiry, that otherwise they would have not met, by following their own specialized methodology.

One example: it was found, against all expectations, high level concentrations of particulate matter in a mostly rural island, in the Açores. Puzzled air quality scientists hypothesized: the salinity in the oceanic air could be the cause. In fact, it was social science methodology – interviews, field observation, economic and urban context, etc. that found the most probable cause: the 2nd largest highschool of Portugal was built next to a major fuel power station, and its chimney was too short, thus heavily polluting the air the students had to breathe.

5.2. The data-life cycle

The EuroLifeNet program was a huge success (Saeger, E. et al 2007), engaging hundreds of young citizens, and a few dozen institutions and their staff. It is well worthy a more detailed analysis of the whole experience. In this study, however, we focus on the fact that, going through the process of making certain the data gathered was scientifically valid, led us to a in-depth understanding of the full nature of the problem, the myriad of complex facets within it, and its life-cycle dynamic.

We tackle the serious problem of rising public health threats, and the need to provide a solid foundation for new, more pro-active policies (Saeger, E. et al 2007) (Field, RA. et al 2005).

As usual, such problem has many different facets and implications. But at the core of it, is good, extensive, hard data on air quality (Field, RA. et al 2005); and the fact that such data is traditionally expensive and resource-hungry (Ferraz de Abreu, P. 2006).

Therefore, if we follow the data, and the way it is used by the different actors, we identify a clear "data life cycle" and its requirements.

Data is required to assess the situation, to support policy making (Fonseca, T. et al 2003) (Ferraz de Abreu, P. 2006). More data will be used in juridical bargaining, f.i. in standard / threshold definitions for EU directives (Field, RA. et al 2005). Data will be required for monitoring legal compliance and policy implementation; and, finally, solid data will be critical for effective policy evaluation.

But some of the data used in each part of this cycle, is the same; much of the remaining data is of the same kind, or very close.

So if we find a good, cost-effective and credible way to provide sustainable stream of air quality data (Ferraz de Abreu, P. 2009), this will impact on all stages of the "data life cycle"; and understanding all these impacts is essential to assess the real benefits of improving the data delivery system. Without such understanding, no real cost-benefit analysis can be argued.

More specifically, by understanding the full cycle of data needs, requirements and applications, together with the understanding of the institutional and regulatory processes that cross many borders (literally, as in country borders, but also the boundaries across different scientific and institutional cultures and jurisdictions), we are in a unique position to design the data standards, gathering and distribution procedures, that will optimize this data use and impact (accuracy, standardization, validation, cost effectiveness, etc).

Maybe more important, this will promote a transversal holistic view of the problem for all actors: scientists, policy makers, and citizens, facilitating integrated, balanced solutions.

6. The institutional challenge to host multi-disciplinarity / transdisciplinarity

With such promising potential, one would expect an easy, or even warm, acceptance and support for such research approach; and, therefore, to multi-disciplinarity / transdisciplinary research clusters like our *Technology, Society and Governance* (TSG) cluster at CAPP, as mentioned in the introduction.

And in fact, we had wonderful congratulatory speeches, wide media coverage (including

TV), and many declarations of strong support. From University Presidents, to the UE Commissar on Science. But then, we were faced with a very different reality. The inadequate institutional framework and its harsh resistance to change and adapt to host multi-disciplinarity – let alone transdisciplinarity.

Many researchers, in particular young ones in their earlier steps, fail to understand that there is no sustainable good science and research without good (and adequate) science / research institutions. And therefore, building, and contributing to these institutions, is a key part of being a researcher.

This is why we came to the conclusion that our institutional experience was – and is – an important one, as much as our field research. An experience that is worth to share with the science and research community, especially those attracted to the promises of multi-disciplinary work, to learn invaluable lessons from it.

6.1. Case study: A lost opportunity – CAPP-TSG

At CAPP-TSG, we had expertise on participatory science, which allowed us to propose the above referred innovative data gathering system on air quality for Project EuroLifeNet (Ferraz de Abreu, P. 2009) (Saeger, E., Ferraz de Abreu, P. 2006, 2007), and Project P.E.O.P.L.E. (Field, RA. et al 2005) (Ferraz de Abreu, P. et al 2004) (Fonseca, T. et al 2003).

We had CITIDEP (www.citidep.net). But because TSG was within CAPP, we could benefit from CAPP researchers' key knowledge on public policy-making, on juridical contexts (in EU. f.i.), on policy implementation and also on policy evaluation.

Furthermore, we could also benefit from important bodies of knowledge within the Institute where CAPP resided (ISCSP-UTL), like social policies, in particular public health policies and systems. This was a great advantage, with the potential to bring a competitive edge over other research approaches.

There is more to it. Data gathering does not exist, in a sustained way, without institutions. Therefore, resident knowledge on institutional analysis and public administration, together with the former scientific areas, would allow us to better study and understand collateral impacts that otherwise would be easily neglected.

As a consequence, we could make the best of such multi-facet scientific environment to provide an integrated research of these classes of problems, and this is why CAPP had optimal conditions to provide a special edge, to support the development of unique and innovative research approaches.

In fact, TSG group productivity (absolute, as well relative / per PhD), was recognized as one of the best at CAPP, in its board 2011 report (see table below).

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CAPP 2011

Title of Research Group	Principal Investigator	Publications in peer review Journals	Other international publications	Other national publications	Ph.D. thesis completed	Organization of conferences	Internationalization	Government/Organization contract research	Industry contract research	Patents/ prototypes	Integrated researchers with PhD	FTEs (30% research)
Public Policy Decision-Making, Implementation and Evaluation	Maria Engrácia Cardim	6	12	22	1	2	19	3	-	-	8	2,4
Social Policies	Fausto Amaro	10	3	1	2	2	-	-	-	-	14	4,2
Communication and Media	Paula Cordeiro	2	7	7	-	4	9	2	1	-	7	2,1
Technology, Society and Governance	Pedro Abreu	✓ 10	✓ 18	12	✓ 2	11	✓ 14	✓ 7	-	✓ 8	7	2,1
Sociology	Fernando Serra	7	3	4	2	22	10	-	-	-	11	3,3
African Studies	Pedro Graça	1	-	15	-	10	3	1	-	-	4	1,2
Strategy and Intelligence	Pedro Graça	5	6	14	-	15	9	-	-	-	10	3
Contemporary Territory Planning and Administration	Julián Aliseda	8	18	19	2	11	11	-	-	-	21	6,3
Mixed Methods Applied to Social and Health Sciences	Jaime Fonseca	-	16	-	1	4	-	-	-	-	8	2,4
Public Administration Research Group	Elisabete de Carvalho	8	12	20	1	9	23	3	-	-	21	6,3
		57	95	114	11	90	98	16	1	8	111	33,3

source: CAPP Board Report for Evaluating Committee, 2011

Another challenge, was the referree review process.

With a multi-disciplinary / transdisciplinary research group, and with transdisciplinary research agenda, who are our peers, that can act as referees, to review and evaluate performance? Where do you apply for funding and scholarships – engineering or social sciences?

This was – and still is – one of the major hurdles we face.

Yet, we were able to develop winning strategies.

For instance, for student scholarships, we concluded it was best to advise students to apply to a jury close to their strongest academic background of origin, meaning, before they joined the e-planning transdisciplinary doctoral program.

But a most important step, was also to build a joint publishing record / curricula with their PhD advisors, so that a distance between the academic backgrounds of Advisor / Advisee / Jury members, would not disqualify the application in the eyes of the Jury.

This strategy, together with high quality research, led to significant success, as illustrated below.

FCT - DEPARTAMENTO DE FORMAÇÃO DE RECURSOS HUMANOS

Concurso para a atribuição de Bolsas Individuais de Doutoramento e Pós-Doutoramento 2010

Charlotte Yolande Luce J. De Kock
Referência: SFRH/BD/71493/2010
Bolsa avaliada na área de **Ciências da Comunicação e Informação**
Orientador: Pedro Ferraz de Abreu
Unidade de Investigação : CAPP-TSG

Mérito das condições de acolhimento
(considerar tanto a Instituição como o Responsável pelas actividades)

Classificação (min=1;máx=5) 5

Centro de Investigação (5), Orientador (5)

Francesca Savoldi
Referência: SFRH/BD/69221/2010
Bolsa avaliada na área de **Arquitectura, Urbanismo e Design**
Orientador: Pedro Ferraz de Abreu
Unidade de Investigação : CAPP-TSG

Mérito das condições de acolhimento
(considerar tanto a Instituição como o Responsável pelas actividades)

Classificação (min=1;máx=5) 5

Centro de Investigação (5), Orientador (5)

FCT - DEPARTAMENTO DE FORMAÇÃO DE RECURSOS HUMANOS

Concurso para a atribuição de Bolsas Individuais de Doutoramento e Pós-Doutoramento 2011

Lanka Elvira Horstink
Referência: SFRH/BD/80126/2011
Bolsa avaliada na área de **Ciência Política**
Orientador: Pedro Ferraz de Abreu
Unidade de Investigação : CAPP-TSG

Mérito das condições de acolhimento
(considerar tanto a Instituição como o Responsável pelas actividades)

Classificação (min=1;máx=5) 5

Centro de Investigação (5), Orientador (5)

Marta Ferreira Mendes de Sousa Rocha
Referência: SFRH/BD/79928/2011
Bolsa avaliada na área de **Geografia**
Orientador: Pedro Ferraz de Abreu
Unidade de Investigação : CAPP-TSG

Mérito das condições de acolhimento
(considerar tanto a Instituição como o Responsável pelas actividades)

Classificação (min=1;máx=5) 5

Centro de Investigação (5), Orientador (5)

source: CAPP-TSG (Technology, Society & Governance Research Cluster), 2012.

> "*One of the greatest challenges faced by a multi-disciplinary research unit such as the e-Planning Lab (LabTec TS), is scientific evaluation. Referee Panels, both national and international, are always organized by specialized scientific domain. To which should we submit for e-Planning evaluation?*
>
> *The (rare) qualification, for obtaining "top grade" (5 in 5) from juries with international referees, in multiple areas (such as 'Communication Sciences', 'Architecture, Urban planning & Design', 'Political Science', 'Geography') was demonstrated by the Lab team and its coordinator, Prof. Pedro Ferraz de Abreu.*" (ibidem, 2012)

Unfortunately, despite the success and good performance, CAPP & ISCSP predominant culture (and ISCSP leadership), rather than understanding and encouraging these synergies, closed itself to this approach. In what amounts to an interesting contrast, the main argument presented by the new ISCSP President to CAPP Researchers in 2012, was that "*Technology was not part of ISCSP 'core business'* (sic)". ISCSP is the "Superior Institute of Social and Political Sciences", albeit in the Technical University of Lisbon.

Despite the solid contribution of the group research productivity, and top evaluation indicators, ISCSP began shutting down support (literally, by closing down the TSG Lab rooms, ending ISCSP participation in the joint doctoral program on e-Planning, etc.), which led to the TSG team exiting CAPP-ISCSP-UTL, by 2013.

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Part of this negative process had to do with local idiosyncrasies and circumstances, which are not particularly worthy of analysis. But another part is, unfortunately, a recurring phenomena: a cultural choc between engineering and social sciences, as well the resistance of disciplinary-based departments and clusters to host transdisciplinary teams, often seen as "outsiders".

6.2. The need of institutional framework for transdisciplinary research

The non-existing institutional framework to handle and support multi-disciplinary / transdisciplinary efforts, leaves such research, and its teams, out in the woods, dependent of transitory arrangements, in a perpetual instability.

This paradox (advantage of an environment with several disciplinary departments to facilitate multi-disciplinary / transdisciplinary approaches vs. institutional "unfriendliness" to multi-disciplinary teams and agenda) is an interesting one and requires an adequate solution, if we want to implement the powerful approach of looking at problem life cycles.

This is why it is useful to distinguish between what we can call "light" multi-disciplinary and "dense" multi-disciplinary research, which we call transdisciplinary.

Under "light" multi-disciplinary research, falls an easier, "natural" connection between two disciplines, with a narrow focus. Such is the case of bio-medical research, or mathematics-physics research, for instance. While linking social sciences and engineering, as in the case of e-Planning research, clearly faces more difficult adjustments, for the gap is wider.

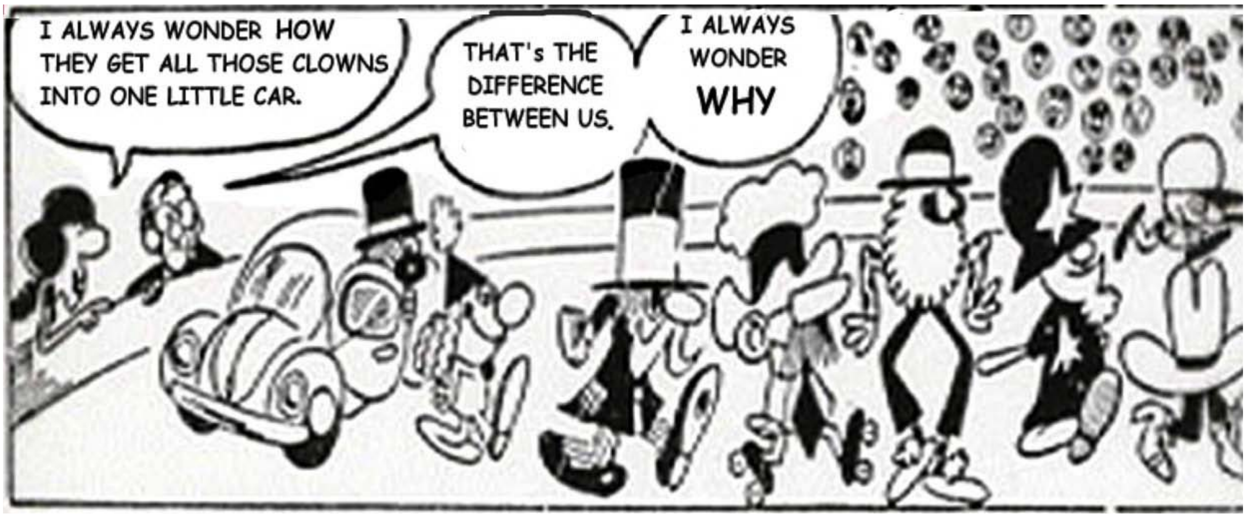
It is enough to remind ourselves that within academia, social sciences and engineering / "hard sciences" belong to different colleges, often in different buildings, or even different cities (for instance FCT-UNL, in Almada and FCSH-UNL, in Lisbon, separated by river Tejo).

But more importantly, faculty and research evaluation and funding is separated, and that means transdisciplinary projects and teams are often forced to chose one side or another, to anchor their work, disregard of the fact that such choice is *contra-natura* and seriously misrepresents the nature of their research.

We clearly need some form of institutional framework for multi-disciplinary research, in the latter case of "dense" multi-disciplinary (transdisciplinary) teams.

7. Between the Why and the How

The background of many of these difficulties can be grounded in the natural cultural differences between, for instance, engineering and social sciences.



Woody Allen: The How and The Why
source: Gary Marx, e-Planning Seminar slides, 2003

Engineers are supposed to solve problems - therefore, look for solutions. While social scientists are encouraged to identify the key questions that will provide good, relevant answers, to look at the "why's".

In fact, we can easily equate a link between these pairs: "research question – answer", vs. "problem – solution". We actually developed a PhD e-Planning method for such purpose (The "*Altamira Method*" (Ferraz de Abreu, P. 2014). But nevertheless, they often correspond to a different approach to science and research.

One of the important roles of multi-disciplinary and transdisciplinary studies might be to build methodological bridges between these two important bodies of knowledge, and these two valuable scientific cultures.

Hofkirchner makes an interesting argument on this issue:

> *"Let us take the relationship of social science and engineering science as an example for how to transcend the borders of both disciplines by making use of a systemic framing and transform their relationship into a true transdisciplinary one. (...) In order to combine social science with engineering science, representatives of the latter might be inclined to reduce that which is human to that which is engineerable: man is deemed a machine. (...) Or representatives of social sciences—not unlike those of other disciplines—might share a predilection to understand the whole world, including artifactual mechanics, by projecting characteristics of the social world onto the former: the machine is deemed man-like." (Hofkirchner, W. 2017)*

We found that, often, social scientists regard engineers as only able to see "nuts and bolts", and therefore miss "the big picture". While many engineers think of social science as "fluff blabber" as compared with "real", "concrete" science performed by them (Ferraz de Abreu, P. 1998).

I could witness myself anecdotal evidence of this. For instance, in our joint e-Planning PhD program, I invited one of my faculty colleagues to present, in my class at ISCSP (a Social &

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Political Science Institute), the optional courses offered by his Faculty of Sciences (FC-UL). He did so, and at the end, he told the students: "so, if you want to take real science courses, now you know where to find them". He was not joking. My students, that knew that I also have two degrees in engineering, besides my PhD (classified as applied social sciences, urban & regional planning), found this funny. But some of my colleagues were outraged.

It is interesting that Hofkirchner seems to be faced as well with this phenomena, and links it to the discussion on transdisciplinarity:

> *"Segregation might be made for the sake of either the identity of social science or that of engineering science: anthropocentric or, better, sociocentric positions traditionally distinguish the investigation of man as exclusive and belittle engineering undertakings, whereas trans- and post-humanistic positions argue for an imminent advent of a technological singularity that will make machines outperform man and thus the human race obsolescent. (...) No one of these options does establish true transdisciplinarity. In the case of technomorphism, social science gives up any autonomy and is invaded by engineering science. In the case of anthroposociomorphism, any autonomy of engineering science is forfeited, as social science projects its autonomy onto engineering science."(ibidem)*

His view for a solution corroborates Neves assertion that it is important to preserve the autonomy of each discipline:

> *"A way out can be seen through an approach that assumes an interrelation of both disciplines in a systemic framework that grants (relative) autonomy to each of them according to their place in the overall framework. Both disciplines complement each other for the sake of a greater whole. (ibidem)*

Our own experience leads us to agree with the relevance of this autonomy requirement.

8. The e-Planning Lab

The described process at ISCSP-UTL led the original team from CAPP-TSG, together with other colleagues sharing this concern and research interests, to create an e-Planning Lab campus at FC-UL in 2013.

The e-Planning Lab investigates, develops, tests, prototypes, and transfers knowledge in ICT (Information and Communication Technologies) in the planning context (Ferraz de Abreu, P. 2008). It was designed at CITIDEP, 2007, as a network of campus with different "flavors".

Our research activities are developed within a framework that considers new social and technological paradigms advanced with the pervasiveness and impact of ICT on social models and processes.

This state of affairs implies a demanding transdisciplinary approach, which also requires a sustained and stable supporting institutional environment. Such institutional environment is still lacking, at least in the Portuguese landscape. This new research campus, that combines engineering, exact and social sciences, was born in this context, and ended in the same one:

in 2014, a leadership change at FCUL led to a new migration, first with a tentative creation of an e-Planning Lab at UA, and now, at FA-UL.

The e-Planning lab has the following general goals:

- To develop ICT in the public interest and on its behalf;
- To investigate the impact of ICT and its diffusion processes;
- To build capacity for sustainable development and use of ICT;
- To foster entrepreneurship and social capital.

But given the aforementioned challenges, visible in a range of areas of knowledge, we have experienced a considerable number of difficulties in pursuing a truly transdisciplinary agenda in a scientific environment that is progressively centralized and narrowed in specific areas (as a natural requirement of the disciplinary research).

One good example: the scientific areas (CNAEF standard) we are forced to select, for the evaluation of the e-Planning Lab, are only a feable approximation to our core disciplines, and not a good match with what we actually do.

The experience of preparing and consolidating the e-Planning agenda (originated at MIT and at CITIDEP) and the Doctoral Program in e-Planning (offered since 2009 by four Universities – UL, UTL, UNL, UA – in collaboration with MIT) stimulated a research community that is strongly international and still presents a high cohesion and identity around this research agenda: e-infrastructures, e-government, e-governance, e-city & territory, and e-citizenship.

For the e-Planning Lab start-up campus, the 3 main Research Lines adopted, are:

— ICT, Inclusion & e-Literacy
— Smart Cities, Urban regeneration and Local Participation
— Internet Governance, Security and Privacy

In these three Research Lines, we find many instances where the problem-life-cycle approach is a clear advantage, over more traditional methods. In each case, to define research questions only from the technology point of view, without closely linking them to the institutional and political context, or vice-versa, is bound to miss real-life interdependencies and impacts, and therefore severely limit the reach and usefulness of the research.

The e-Planning Lab was thus created to facilitate and accommodate transdisciplinary research and academic activity that crosses various departments and even various universities, giving structure to a set of activities that lack a formal framework. The rationale for this lab comes, therefore, from the need to provide a unifying framework for the transdisciplinary work of the e-planning community.

9. Conclusion and what is next

We presented the advantages of transdisciplinary methods to face problems that have life cycles, and therefore are difficult to tackle with static research questions.

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We discussed the difficulties that arise from the absence of a clear institutional framework for multi-disciplinary / transdisciplinary agendas, and teams, illustrating with the case of CAPP and CAPP-TSG.

Finally, we presented our response to these difficulties, with the creation of the e-Planning Lab, at FC-UL, in 2013, and now migrated to FA-UL campus (2020).

Is the e-Planning Lab the solution to the aforementioned problems? Not by far. We faced a lot of similar obstacles, at FC-UL. We were often requested to explain, to which department, after all, does the e-Planning Lab “belong”; why should FC-UL be the host of such Lab, and not some other College, like a…Social Science Institute.

These are natural and legitimate interrogations, given the way academia is structured. But it only further proves our point, since there is a kind of poetic symmetry. At a Social Science Institute, we are told we would be better of at an Engineering / “hard sciences” Institute; and vice versa.

While it is true that we find a more solid ground for our transdisciplinary agenda at “hard-science/engineering” institutes, this arises more from our experience rather than some rationale.

We observed that it is often easier to mobilize the social sciences in the “planning” part after we consolidated research resources for the ‘e” part, than when we follow the reverse path. Why, it is not entirely clear. But in any event, it remains the fact that we have not yet found a stable, consensual institutional framework for hosting our transdisciplinary agenda.

Possibly, a better solution will be a dedicated Institute or Center, with a mission of hosting such multi-disciplinary / transdisciplinary agendas. But if such Center is not tightly connected with “both sides”, meaning, with Technology-oriented Departments / Institutes (engineering, “hard” sciences) as well with Social Science Departments / Institutes, the optimal environment to tackle problem life cycles, with close access to relevant, in-depth disciplinary knowledge, is diluted or lost. This is why we agree it is important to preserve disciplinary autonomy, within whatever transdisciplinary framework solution.

Most likely, there is no perfect solution, and that is in the natural order of all things that are on the frontier of knowledge. Maybe this is the permanent challenge for those who face the uncharted territories of “dense” multi-disciplinary research": **the transdisciplinarity blues...**

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